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ORIGINAL

Innovative Learning Model: Problem-Based Learning Based on Naturalistic Intelligence Towards Scientific Literacy

Modelo de Aprendizaje Innovador: Aprendizaje Basado en Problemas con Enfoque en la Inteligencia Naturalista hacia la Alfabetización Científica

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ABSTRACT

This study investigates the effectiveness of the Problem-Based Learning (PBL) model integrated with naturalistic intelligence to enhance scientific literacy among elementary school students. Conducted in six elementary schools in Magelang, Indonesia, this experimental research involved 120 fourth-grade students. A pre-test and post-test experimental design was used to measure scientific literacy before and after six instructional sessions. The PBL model incorporated naturalistic intelligence, allowing students to interact directly with the natural environment and solve real-world problems related to scientific concepts. The results showed a significant improvement in students' scientific literacy, with average pre-test scores of 55 and post-test scores increasing to 72. Statistical analysis using a paired sample t-test confirmed that the improvement was significant ($p < 0{,}05$). This integration of PBL with naturalistic intelligence not only enhanced students' conceptual understanding but also developed their critical thinking and problem-solving skills. Students engaged in activities such as experimenting with renewable energy sources, exploring biodiversity, and addressing environmental challenges, fostering a deeper connection between natural phenomena and scientific principles. This innovative approach also encouraged students' environmental awareness and responsibility, aligning with the goals of 21st-century education to prepare scientifically literate and environmentally conscious citizens. The findings suggest that combining PBL with naturalistic intelligence provides a powerful pedagogical framework for elementary science education, offering contextual and meaningful learning experiences that significantly improve students' scientific literacy. Future research could further explore its application across different subjects and educational levels to maximize its potential impact.

Keywords: Problem Based Learning; Naturalistic Intelligence; Scientific Literacy; Elementary School.

RESUMEN

Este estudio investiga la efectividad del modelo de Aprendizaje Basado en Problemas (PBL, por sus siglas en inglés) integrado con la inteligencia naturalista para mejorar la alfabetización científica entre estudiantes de educación primaria. Realizado en seis escuelas primarias en Magelang, Indonesia, esta investigación experimental involucró a 120 estudiantes de cuarto grado. Se utilizó un diseño experimental de prueba previa y prueba posterior para medir la alfabetización científica antes y después de seis sesiones de instrucción. El modelo PBL incorporó inteligencia naturalista, permitiendo que los estudiantes interactuaran directamente con el entorno natural y resolvieran problemas del mundo real relacionados con conceptos científicos.

Los resultados mostraron una mejora significativa en la alfabetización científica de los estudiantes, con puntajes promedio de la prueba previa de 55 y de la prueba posterior incrementando a 72. El análisis estadístico mediante una prueba t para muestras relacionadas confirmó que la mejora fue significativa ($p < 0,05$). Esta integración de PBL con inteligencia naturalista no solo mejoró la comprensión conceptual de los estudiantes, sino que también desarrolló sus habilidades de pensamiento crítico y resolución de problemas. Los estudiantes participaron en actividades como experimentos con fuentes de energía renovable, exploración de la biodiversidad y abordaje de desafíos ambientales, fomentando una conexión más profunda entre los fenómenos naturales y los principios científicos. Este enfoque innovador también alentó la conciencia y responsabilidad ambiental de los estudiantes, alineándose con los objetivos de la educación del siglo XXI para preparar ciudadanos alfabetizados científicamente y conscientes del medio ambiente. Los hallazgos sugieren que la combinación de PBL con inteligencia naturalista proporciona un marco pedagógico poderoso para la educación científica en primaria, ofreciendo experiencias de aprendizaje contextualizadas y significativas que mejoran significativamente la alfabetización científica de los estudiantes. Investigaciones futuras podrían explorar su aplicación en diferentes materias y niveles educativos para maximizar su impacto potencial.

Palabras clave: Aprendizaje Basado en Problemas; Inteligencia Naturalista; Alfabetización Científica; Educación Primaria.

INTRODUCTION

Science literacy is an important foundation for advanced education and effective participation in a science-based society.[1] Scientific literacy includes not only understanding scientific concepts, but also the ability to apply this knowledge in the context of everyday life, think critically, and make data-based decisions. Raman argues, the level of scientific literacy of students in Indonesia is still in low level, which indicates the need for fundamental improvements in the approach to science education in elementary schools.[2] Scientific literacy is a critical key competency in basic education, which not only provides students with scientific knowledge but also fosters the critical thinking skills necessary to understand and interpret natural and technological phenomena. Scientific literacy encompasses the comprehension of scientific concepts, the ability to conduct scientific research, and the awareness of how science and technology impact society and the environment. This form of literacy lays the foundation for the development of analytical and logical thinking that will continue to evolve throughout a student's education and life.[3,4]

One of the main strengths of scientific literacy at the elementary school level is its ability to increase student engagement and motivation, learning approaches that encourage scientific literacy through exploration and experimentation which can make science more interesting and relevant for young students.[5] By presenting science in a context that is close to everyday life, students are more motivated to learn and feel more connected to the subject matter. Additionally, scientific literacy at the elementary level helps develop important cognitive skills, such as problem solving, critical thinking, and the ability to conduct analysis and synthesis of information. However, scientific literacy also faces a number of significant weaknesses and challenges in its implementation in elementary schools. One of the main challenges identified is lack of adequate resources and training for teachers. Many teachers in elementary schools may not have a strong background in science or sufficient training to teach scientific literacy effectively.[6,7] This can result in a lack of confidence and competence in teaching complex scientific concepts to young students. In addition, dense curricula and limited time for science lessons often make it difficult for teachers to integrate scientific literacy as a whole.

Furthermore, interestingly, the assessment of scientific literacy is also something that needs attention. Traditional assessment tools are often insufficient to comprehensively measure students' scientific understanding and skills. Evaluations that only focus on memorizing scientific facts do not reflect students' abilities to think critically or apply scientific knowledge in different contexts. Therefore, it is necessary to develop a more holistic and authentic assessment method to truly assess students' scientific literacy.[8] Despite facing challenges, scientific literacy has great potential to provide a positive impact in the long term. Strong scientific literacy at an early age can influence students' attitude and interest in science in the future.[9] Students who have a solid foundation of scientific literacy are more likely to continue their studies in science and technology fields, as well as participate in scientific activities outside of the classroom. This is very important factor in forming a generation that is ready to face complex global challenges, such as climate change, public health and technological developments.

Despite challenges in terms of resources, teacher training, and assessment methods, the long-term benefits of good scientific literacy are significant. Investments in qualified science education and comprehensive approaches to increase scientific literacy will equip students with the skills and knowledge necessary to the succeed in a developing scientific and technological world.[10] Studies show that good scientific literacy at an early age is essential for forming a strong foundation for more complex understanding later in life. This is in line with the finding that students with good scientific literacy tend to have higher critical thinking skills and are better prepared to face increasingly complex global challenges.[11] In addition, good scientific literacy is also associated with increasing students' interest and motivation to learn, which in turn can improve overall academic achievement.

Existing curricula still often focus on memorizing facts and provide little space for the development of essential scientific skills, such as investigation and problem solving. This is exacerbated by limitations in teacher training and educational resources, which make science learning less effective and unattractive for students.[12] Therefore, there is an urgent need to update curricula and teaching methods, and improve teacher competence in teaching science. Increasing scientific literacy in elementary schools is also closely related to the use of innovative pedagogical approaches. Approaches such as problem-based learning and contextual learning have proven effective in improving students' understanding of science concepts and critical thinking skills.[13] The use of technology in science learning can also have a positive impact, especially in providing a more interactive and interesting learning experience. On the other hand, the support from surrounding environment, including parents and the community, is very important in increasing scientific literacy. Programs that involve parents' active participation in their children's learning process can strengthen students' understanding and interest in science. In addition, collaboration with various parties, including research institutions and industry, can provide additional resources and broader learning opportunities for students.[14]

Thus, increasing the scientific literacy of elementary school students is a priority that must be supported by various educational policies and initiatives. There are many strategies to develop scientific literacy skills in elementary schools, one of which is Problem-Based Learning. Problem Based Learning (PBL) has been recognized as an effective pedagogical approach in developing students' critical thinking and problem solving skills. PBL engages students in the learning process through solving real problems, encouraging them to think critically, working collaboratively, and applying their knowledge in relevant contexts.[15] In problem-based learning (PBL) which used globally, students are engaged in discussions about issues relevant to their professional fields. This method strengthens their ability to apply and integrate knowledge. The main goal is to encourage students to adopt deep learning approach, in which they are naturally interested and strive to truly understand the material being studied.

Philosophically, Problem Based Learning integrates the principles of constructivism, pragmatism, humanism, progressive education, and contextual learning. This approach not only improves students' critical thinking and problem-solving skills but also emphasizes the importance of direct experience, contextual relevance, and the development of individual potential. Thus, PBL offers a comprehensive and holistic framework for more meaningful and applicable education, which is relevant to the challenges and needs of the 21st century. Problem Based Learning is a pedagogical approach that has been proven effective in a variety of educational contexts. The history of its development and distribution shows and has wide benefits of this model. PBL syntax, with its systematic stages, helps students developing important skills such as critical thinking, collaboration, and problem-solving abilities, all of which are highly needed in an ever-changing and complex world.[16] Problem Based Learning (PBL) is a learning model that prioritizes the use of real world problems as a context for students to develop critical thinking skills, solve problems, and acquire basic knowledge and concepts from learning material. Problem Based Learning places students at the focus object of the learning process, aiming to develop their abilities in dealing with challenges and complex situations. This model has been widely researched and implemented in various educational contexts, including medicine, engineering, and secondary education.

According to Dolmans, Problem Based Learning is a method that focuses on relevant and authentic problems as a stimulus for learning. Students work in small groups to solve given problems, which encourage them to be actively involved in the learning process.[17] Adding that Problem Based Learning not only helps students understand lesson material, but also develop interpersonal skills through collaborative work. In Problem Based Learning, teachers act as facilitators who guide students through their learning process, helping them to identify needed information and encourage critical reflection on the knowledge gained. It is different from the traditional approach where the teacher is the main source of knowledge and students passively receive information.[18,19]

Problem Based Learning can increase students' learning motivation because they feel more responsible for their own learning. By facing complex and real problems, students become more motivated to find solutions and understand the material being studied. Problem Based Learning is effective in increasing knowledge retention and application of skills in real-world contexts. However, implementing Problem Based Learning is not without challenges, one of the main challenges is students' readiness to learn independently. Students accustomed to traditional learning methods may have difficulties in adjusting to their new role as active learners. Important role of teachers in providing adequate support and ensuring all students are actively involved in the learning process.[15,20]

Research by Duch et al. (2021) shows that the success of PBL is highly dependent on the problem design used.[21] Problems should be challenging enough to stimulate critical thinking but not so difficult that they prevent students from finding solutions. Dolman et al. (2016) added that effective evaluation in Problem Based Learning must include an assessment of learning processes and outcomes, including students' abilities to think critically and work together in teams.[17]

Technology can play an important role in supporting PBL implementation. Technology can provide rich resources and easy access to relevant information, as well as support collaboration between students. The technology integration in Problem Based Learning can increase student engagement and learning quality. Overall, Problem Based Learning is an innovative and effective learning approach that has been proven to improve various aspects of student learning. With careful planning and implementation, as well as adequate support from teachers, Problem Based Learning can provide rich and meaningful learning experiences for students at various educational levels. However, to maximize the effectiveness of Problem Based Learning, it needs to be integrated with other approaches that can enrich students' learning experiences, such as naturalist intelligence. Naturalist intelligence, one of the intelligences identified by Howard Gardner in his theory of Multiple Intelligences, refers to an individual's ability to recognize, classify, and understand natural phenomena. A naturalist intelligence-based approach on learning can increase student engagement and motivation with certain subject matter in the natural environment and their daily experiences. Recent research shows that the integration of naturalistic intelligence in Problem Based Learning can improve students' understanding of science concepts and scientific skills.

Combining Problem Based Learning with naturalist intelligence provides the opportunity to create more holistic and contextual learning. Students are not only invited to solve problems that are relevant to their lives, but are also given the opportunity to engage directly with the natural environment, make observations and experiments that strengthen their understanding of scientific concepts. For example, students can be given assignments to solve problems related to the environment or biodiversity, which not only enrich their knowledge of science but also grow environmental awareness. Problem Based Learning approach based on naturalistic intelligence can significantly increase students' learning motivation, engagement and academic achievement in science subjects. This finding is in line with other research that emphasizes the importance of relevant and contextual learning in improving scientific literacy and critical thinking skills.[13,22] Apart from that, this approach can also help students develop positive attitudes towards science and the environment, which is essential in forming a generation that cares about and is responsible for the natural environment. Therefore, this research aims to explore, identify the effectiveness and develop a PBL learning model based on naturalist intelligence in the context of science education in elementary schools. It is hoped that by adopting this approach, students will not only understand scientific concepts more deeply but will also be more motivated to learn and more aware of the importance of protecting the environment. It is hoped that this research can make a significant contribution to improve the quality of science education in Indonesia and offer a learning model that can be applied in various global educational contexts.

As of 2025, combining Problem-Based Learning (PBL) with naturalistic intelligence to improve scientific literacy is a promising yet relatively new area of research. While Problem-Based Learning (PBL) has been widely studied and used, its integration with naturalistic intelligence—part of Howard Gardner's multiple intelligences theory—provides a fresh approach to helping students better understand science. Recent studies show that Problem-Based Learning (PBL), especially when linked to naturalistic intelligence, can positively impact students' scientific literacy. Engaging students in real-world problems that connect with their natural affinity for the environment can make learning science more meaningful and effective. For example, research has found that Problem-Based Learning (PBL) models that include naturalistic intelligence help students improve their understanding and application of scientific concepts. In general, Problem-Based Learning (PBL) is already recognized for enhancing scientific literacy. Research shows that incorporating real-world issues, like socio-scientific challenges, into Problem-Based Learning (PBL) improves students' problem-solving and science skills. This highlights the potential of combining Problem-Based Learning (PBL) with naturalistic intelligence to make learning more impactful. However, the specific use of Problem-Based Learning (PBL) based on naturalistic intelligence is still underexplored. More studies are needed to understand how this approach can be applied effectively in different educational settings and how it influences students' scientific literacy. In summary, combining Problem-Based Learning (PBL) with naturalistic intelligence is an innovative and exciting direction for education. This approach not only enhances scientific literacy but also nurtures a deeper connection to the natural world, a skill that is increasingly important in addressing today's environmental challenges.

METHOD

This research is a form of experiment carried out in 6 elementary schools in Magelang City with a total of 120 students. This study employs statistical tests to analyze the data, starting with a normality test to ensure that the data are normally distributed. Subsequently, the improvement in scientific literacy is analyzed using a paired sample t-test, while the improvement in each indicator of scientific literacy is examined descriptively by highlighting the differences in treatment across each indicator. The independent variable in this study is an innovative learning model, specifically Problem-Based Learning (PBL) based on naturalistic intelligence.

This model is implemented as an intervention for elementary school students to observe its effects on the dependent variable. The dependent variable is scientific literacy, which is measured to determine the extent to which the application of this learning model enhances students' ability to comprehend, utilize, and analyze scientific concepts.

The focus of this research is learning innovation using the stages of the Problem Based Learning model based on natural intelligence with the aim of increasing the scientific literacy of elementary school students. Learning is carried out using the combination of Problem Based Learning Model and naturalist intelligence. This research was carried out with six treatments. This research aims to increase the scientific literacy of elementary school students. This research approach uses an experimental approach. This approach involves one or more independent variables to measure their effect on the dependent variable.

This research was carried out in 6 treatments, the first stage was a pre-test followed by 4 treatments and ended with a post test. At the first meeting, students were given a pre-test to determine the initial conditions of social literacy. At the second to fifth meetings, students were given treatments using the Problem Based Learning model syntax based on naturalist intelligence using 4 different innovative learning media with the themes of energy change. At the final meeting, students were given a post test on students' scientific literacy. The data analysis technique applied in this research is a descriptive statistical technique using the T test hypothesis test. To determine the results of scientific literacy, this research uses descriptions and indicators used in the PISA 2019 measurements, namely as follows[23]:

Table 1. Science Literacy Indicators

Number	Criteria	Indicator
1	Context	National and global issues, both current and historical, that require an understanding of science and technology
2	Knowledge	An understanding of the key facts, concepts, and explanatory theories that constitute the foundation of scientific knowledge.
3	Competence	The ability to explain phenomena scientifically, interpret data and evidence scientifically, as well as promote and design scientific explanations.
4	Attitude	A set of attitudes toward science demonstrated by interest in science and technology, respect for scientific approaches to inquiry when appropriate, and perception and awareness of environmental issues.

The Problem-Based Learning (PBL) model, combined with naturalistic intelligence, offers an innovative approach to enhancing students' scientific literacy. PBL encourages active student engagement in solving real-world problems relevant to their environment, while naturalistic intelligence enables them to observe, understand, and utilize elements of nature in the learning process. By engaging directly with the natural world—such as studying renewable energy through solar panel observations or exploring the process of making briquettes from coconut waste—students not only learn scientific concepts but also develop a sense of responsibility for environmental preservation. This integration helps students cultivate critical thinking and problem-solving skills, as well as the ability to connect natural phenomena with scientific principles. Additionally, interactions with the living environment stimulate curiosity and awareness of global issues such as energy sustainability and waste management. By blending real-world experiences, scientific inquiry, and reflective practices, the combination of PBL and naturalistic intelligence plays a vital role in shaping students who are scientifically literate, critical thinkers, and environmentally conscious. Presented in the table 2 below.

RESULTS AND DISCUSSION

The initial stage of this research was to conduct pre-test activities to assess students' initial scientific literacy abilities. The subsequent stages of the research were conducted in 6 elementary schools in Magelang Regency, involving a total of 120 students in the 4th grade. This research was carried out in 6 stages, all of which utilized the Problem Based Learning (PBL) syntax based on Naturalistic Intelligence. The six stages in detail are as follows:

First Stage: Science Literacy Pretest

The first stage in this research is a pretest which aims to measure students' scientific literacy levels before the learning intervention begins. At this stage, students are given a series of questions designed to illuminate their understanding of basic science concepts. In addition, observations were carried out for one day to observe students' learning behavior and their ability to apply scientific knowledge in everyday life. The data collected from this pre-test will be used as a basis for comparison to assess the effectiveness of the learning provided in the following stages.

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Table 2. Problem Based Learing syntax combined naturalistic intelligence

No	Syntax	Teacher's Activities	Students' Activities
1	Orientation to the Problem	- Explain the learning objectives and introduce a problem related to the environment, such as solar energy or coconut briquettes. -Stimulate students' curiosity with guiding questions about natural phenomena.	- Listen to the teacher's explanation. - Identify and comprehend the presented problem. - Express curiosity about the topic.
2	Organizing Learning Activities	-Form student groups. -Provide directions for observation or experimentation in the surrounding environment. - Supply tools or guidelines for the activity.	- Work collaboratively in groups. - Analyze group tasks related to energy, environmental issues, or ecosystem observation.
3	Independent Investigation	-Guide students in conducting field observations or simple experiments (e.g., testing renewable energy sources). - Provide assistance when needed.	- Conduct field observations or experiments, such as creating coconut briquettes or surveying solar panel locations. - Document the findings from observations.
4	Problem Solving and Group Discussion	- Facilitate group discussions to analyze data from their investigations. - Guide students to develop solutions for the problem.	- Engage in group discussions to interpret data. - Develop innovative solutions, such as small-scale solar panel models or briquette prototypes.
5	Presentation of Findings and Solutions	- Provide opportunities for each group to present their findings and solutions. -Offer constructive 6feedback on the presentations.	- Present the results of observations and proposed solutions to the class. - Respond to questions and accept feedback from peers.
6	Analysis and Reflection	- Lead a class discussion to evaluate the effectiveness of solutions and connect them to scientific concepts. -Encourage students to reflect on the learning experiences.	- Assess their solutions to the given problems. - Reflect on the learning process and its implications for environmental understanding.

Second Stage: Learning with Problem Based Learning (PBL) Based on Naturalist Intelligence on Solar Cell Material. After the pretest, the second stage is the learning process using the Problem Based Learning (PBL) model which is based on naturalistic intelligence. The first material taught is about energy changes with a focus on how Solar Cells work. Students are invited to understand how solar energy can be converted into electrical energy through a process that involves discussions, experiments and practical activities.

Figure 1. Solar Cell Experiment

This approach not only helps students understand scientific concepts, but also develops critical thinking and problem-solving skills. Students learn through hands-on experience, which can increase their interest and motivation in studying science.

Third Stage: Learning with Problem Based Learning (PBL) Based on Naturalist Intelligence Electric Generator Material The third stage includes discussion of material about electric generators and how wind energy can be converted into electrical energy. In this activity, students learn the working principles of wind generators through compression and experiments involving the use of generator models.

This activity is designed to provide an in-depth understanding of the physical concepts underlying energy change, as well as the practical application of renewable energy technology. By understanding how wind generators work, students are able to see how energy can be converted from one form to another, which is a key concept in scientific literacy.

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Figure 2. Electric Generator Experiment

Fourth Third Stage: Learning with Problem Based Learning (PBL) Based on Naturalist Intelligence Power Bank Energy Storage Material

In the fourth stage, the focus of learning is on energy storage using a power bank. Students are invited to understand how electrical energy can be stored and then used to power devices such as mini fans.

Figure 3. Power Bank Energy Storage Material Experiment

This activity involves a hands-on experiment, where students use a power bank to drive a fan, which illustrates the process of converting electrical energy into mechanical energy (wind). This lesson not only strengthens students' understanding of energy concepts, but also teaches them about energy storage technology and its uses in everyday life.

Fifth Stage Learning with Problem Based Learning (PBL) Based on Naturalist Intelligence Learning Materials Using Gas Energy and Coconut Briquettes

The fifth stage in the learning series is the use of gas energy and coconut briquettes for the cooking process. Students learn how chemical energy from gas and coconut briquettes can be converted into heat energy used for cooking.

Figure 4. Learning Materials Using Gas Energy and Coconut Briquettes

This activity involves exposure and experimentation where students can see firsthand how this fuel is used in the cooking process. Apart from understanding energy concepts, students are also taught about the efficiency and environmental impacts of using various energy sources. This learning emphasizes the importance of choosing sustainable and environmentally friendly energy sources.

Sixth Stage: Science Literacy Posttest

The final stage is giving posts with the same criteria and conditions as the pretest in the first stage. This post-test aims to trigger the development of students' scientific literacy after following a series of learning

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using a PBL model based on naturalist intelligence. Data from this posttest will be compared with data from the pretest to assess the effectiveness of the learning that has been carried out. In this way, it can be seen to what extent students' understanding of the science concepts taught has increased, as well as how the learning approach used can improve students' overall scientific literacy. Each stage in the process is designed to build students' knowledge and skills gradually, using an approach that emphasizes practical experience and relevance to everyday life. The main aim of this research is to increase students' scientific literacy through interactive and contextual learning methods, as well as to develop positive attitudes towards science and technology. The pretest and posttest results are detailed in the following table:

Table 3. Description of Pretest and Posttest Results.

Sample Description	**Prates**	**Post**
The number of students	120	120
Maximum Score	84	94
Minimum Score	23	25
Average	55	72

Before testing the hypothesis, the next stage is testing the normality of the data to find out whether the data is normal. The results of the Normality test can be seen in table 3 below:

Table 4. Normality Test

	Kolmogorov-Smirnov			**Shapiro-Wilk**		
	Statistics	**f**	**signature**	**Statistics**	**f**	**signature**
Pre test	0,113	20	0,001	0,973	20	0,117
Post	0,121	20	0,000	0,951	20	0,032

Based on the results of normality test calculations, the significance value obtained in the pre-test was 0,117, while the post-test was 0,032. The results of this calculation are greater than 0,05, so it can be concluded that the data is normally distributed. Normally distributed data will then be calculated for the hypothesis test using Paired Samples T Test with the following results:

Hypothesis testing

Table 5. Statistical Test for Paired Samples

		Means	N	Std. Deviation	Std. Meaning of Error
Pair 1	Prates	55,2	120	16,704	1,525
	Post	72,2	120	18,898	1,725

In this table there is an average student pre-test score of 55,2, while the average student post-test score is 72,2. The average score on the post-test (72,23) > pre-test (55,20), meaning that there is a difference in the average score between the pre-test and post-test.

Table 6. Paired Sample Correlation Test

		N	**Correlation**	**signature.**
Pair 1	Pre-test and post test	120	0,637	0,000

Based on this table, it can be seen that the correlation value is 0,637 with a significance value of 0,000. Because the significance value is 0,000 < 0,05, it can be concluded that there is a relationship between the pre-test and post-test.

Based on the table above, it can be seen that the sig (2-tailed) value is 0,000 < 0,05, so there is a significant difference between students' scientific literacy before and after being treated using a Problem based learning model based on naturalist intelligence. Therefore, the hypothesis states that the effect of using a problem-based learning model based on naturalistic intelligence on students' scientific literacy is declared acceptable and has been proven to be true. From the results of the research and stages carried out, scientific literacy experienced an increase from the pre-test to the post-test stages with the following details:

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Table 7. Paired Sample Test

		Means	Std. Deviation	Meaning of Std Error	95% Confidence Interval of the Difference Lower	Upper	t	f	Signature (2-piece)
Pair 1	Pretest - PostTest	-17,025	15,302	1,397	- 19,791	-14,259	-12,188	19	0,000

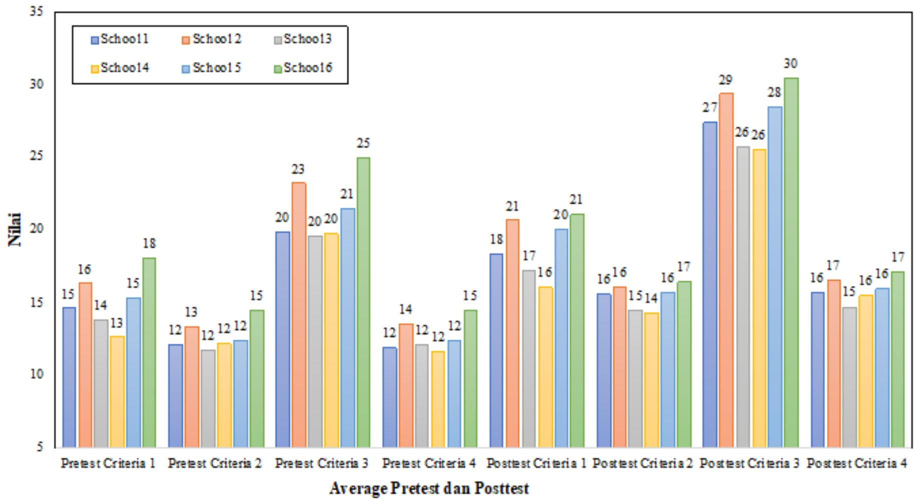

Figure 5. Distribution of Improvement in Science Literacy Criteria.

DISCUSSION

The implementation of the Problem-Based Learning (PBL) model based on naturalist intelligence in basic education has shown significant potential in increasing students' scientific literacy. PBL is a learning approach that places students at the center of the learning process through solving real problems, while naturalist intelligence refers to the ability to recognize and categorize natural objects, such as plants, animals and other natural phenomena. The combination of these two approaches can provide a more contextual and relevant learning experience for elementary school students, which in turn can improve their understanding of scientific concepts. The PBL learning model consists of several structured stages, namely: problem orientation, independent search, group search, and presentation of results and reflection. In the problem orientation stage, students are introduced to relevant and contextual problems, which encourages them to ask questions and identify what they know and what they need to learn further.(24) Independent inquiry allows students to search for information and collect data related to the problem, while group research involves collaboration between students to share findings and develop solutions together.

The final stage, presentation of results and reflection, provides an opportunity for students to convey their solutions and reflect on the learning process they have gone through. This reflection is important to help students internalize the knowledge and skills they have acquired during the PBL process.(25) In the context of PBL based on naturalist intelligence, the problems presented are usually related to the natural environment, such as ecosystems, conservation, or weather phenomena, which can take advantage of students' natural interest in the natural world. Naturalist intelligence, as part of the theory of multiple intelligences proposed by Howard Gardner, emphasizes a person's ability to recognize, classify and understand natural phenomena. Children with high naturalistic intelligence often show a deep interest in animals, plants, and their environment.(26) The implementation of naturalist intelligence-based learning in PBL means that the problems given to students must be relevant to nature and require direct observation or interaction with the natural environment. Naturalist intelligence encourages students to develop curiosity and concern for the environment. This is especially important in science education, as students not only learn about scientific facts, but also develop positive attitudes towards nature conservation and well-being.

Thus, the integration of naturalist intelligence in science learning in elementary schools not only enriches the learning process but also shapes students into individuals who are more environmentally aware and responsible. Using learning strategies that utilize this intelligence can help teachers create a more holistic and relevant learning experience for students, when students learn through natural contexts, they not only increase their scientific knowledge but also develop better observation and analyzing skills. In addition, learning that utilizes naturalistic intelligence can increase students' learning motivation because they feel more connected to the material being studied.[27] Scientific literacy consists of several key components, including knowledge of scientific concepts, the ability to carry out scientific explanations, and an understanding of the nature and processes of science. Knowledge of scientific concepts includes students' understanding of the facts, principles and theories underlying various natural phenomena. In a naturalist intelligence-based PBL context, students might learn concepts such as food chains, air cycles, or animal adaptation in certain environments.

The ability to carry out scientific explanations is the other important component of scientific literacy. This involves skills such as framing questions, designing and conducting experiments, collecting and analyzing data, and drawing evidence-based conclusions.[28] PBL provides an ideal framework for developing these skills because students are actively engaged in a real and relevant inquiry process. Understanding the nature and processes of science refers to students' awareness of how science works, including the scientific method, ethics in research, and the relationship between science and technology. Students involved in PBL have a better understanding of the scientific process because they experience firsthand the steps in the scientific method.[29]

The implementation of the PBL model based on naturalist intelligence has been proven to provide various benefits in increasing the scientific literacy of elementary school students. First, this approach increases understanding of scientific concepts because students learn through direct and contextual experience. For example, students who study ecosystems through direct observation in parks or forests tend to have a deeper and longer-lasting understanding compared to learning through textbooks alone. Second, PBL based on naturalistic intelligence encourages the development of scientific skills. Students are trained to observe, record, and analyze natural phenomena, which are important skills in scientific literacy. Students involved in nature-based projects showed significant improvements in their scientific inquiry skills.

Third, this approach also increases students' awareness of the importance of science in everyday life and summarizes global environmental issues. By studying issues such as climate change, conservation, and biodiversity, students not only learn about scientific concepts but also develop positive attitudes and values towards the environment. The implementation of innovative learning media has an important role in increasing the scientific literacy of elementary school students. Innovative learning media includes the use of digital technology, interactive tools, and visual and kinesthetic approaches to help students understand complex scientific concepts. Innovative learning media allows students to learn actively and interactively. This approach is in line with constructivist theory which states that effective learning occurs when students are directly involved in the learning process and build their own knowledge. The use of computer simulations and virtual laboratories, for example, provides opportunities for students to conduct experiments that may be difficult or dangerous to carry out in the real world. Simulations and virtual laboratories can improve students' scientific learning skills, including their ability to design experiments, collect data, and analyze results.[30,31]

In addition, innovative learning media can be adapted to various student learning styles. For example, learning videos and animations can help students who learn visually, while educational games and interactive applications can interest students who learn kinesthetically. The study by Liu et al. (2005) showed that the use of interactive learning videos in science classes significantly increased students' understanding of scientific concepts and engagement compared to traditional teaching methods.[32] The role of innovative learning media in increasing scientific literacy is also manifested in students' ability to apply scientific knowledge in different contexts. For example, the use of visual aids such as diagrams, graphs, and concept maps can help students organize and integrate scientific information. Furthermore, innovative learning media also play an important role in developing critical thinking and problem solving skills. Through the use of a problem-based learning (PBL) platform supported by technology, students are invited to identify problems, find solutions, and communicate their findings. PBL supported by digital technology improves students' critical thinking skills and makes them better prepared to face real-world challenges.[33] However, the application of innovative learning media also faces certain challenges. One of the main challenges is the need for adequate training for teachers to effectively integrate technology into learning. Underscores the importance of ongoing professional training to help teachers develop the technological and pedagogical skills necessary to use innovative media effectively. Apart from that, limited access to technology and resources in some schools is also an obstacle to implement innovative learning media evenly.

Overall, innovative learning media have great potential to improve the scientific literacy of elementary school students by making learning more interactive, interesting and relevant. Through the use of technology and visual aids, students can develop a deeper understanding of scientific concepts, improve scientific teaching, and develop critical thinking skills. However, the success of implementing innovative learning media depends on teacher readiness and adequate access to technology and resources. However, there are also challenges in implementing Problem Based Learning based on naturalist intelligence. One of the main challenges is the need for adequate resources, including access to the natural environment and relevant teaching materials. Additionally, teachers need to have a strong knowledge of science and the ability to facilitate inquiry-based learning. The Syntactic Problem Based Learning (PBL) model has a dominant role in the success of elementary school students' learning process from a psychological perspective. PBL syntax, which includes problem orientation, task organization, independent investigation, development and presentation of results, as well as analysis and evaluation processes, is designed to activate students' active involvement and intrinsic motivation in learning. First, problem orientation in PBL encourages students to think critically and creatively. By facing real problems that are relevant to their lives, students feel more challenged and motivated to find solutions, which psychologically increases their sense of self-confidence and independence. Second, the organization of tasks and independent inquiry in PBL provides space for students to develop self-regulation skills. Students learn to plan, organize, and manage their time, which is important for the development of their executive skills and adaptability. It also helps students to feel controlling over their learning process, which increases intrinsic motivation and learning satisfaction. Third, developing and presenting results encourages students to work together and communicate effectively. Through collaboration, students learn to respect others' opinions, build empathy, and develop important social skills. Presenting results in front of classmates also strengthens communication skills and confidence in conveying ideas. Fourth, the analysis and evaluation process in PBL allows students to reflect on their learning experiences. This reflection helps students identify their strengths and weaknesses, develops better learning strategies, and increases their self-awareness about the learning process.

From a psychological perspective, PBL syntax not only improves students' academic knowledge and skills, but also supports their emotional and social development. PBL helps shaping individuals who are more independent, self-confident and able to work collaboratively, all of which are important aspects of successful and holistic learning at the primary school level. In this research, it was found that students' scientific literacy could be significantly improved through outdoor learning activities involving hands-on experiments.[34] Outdoor activities provide students with the opportunity to engage directly with the natural environment, allowing them to observe natural phenomena in real life and relate them to the science concepts learned in class. This kind of learning creates contextual and relevant learning experiences, which can improve students' understanding and retention of knowledge.

Involving experiments in the learning process also plays an important role in increasing scientific literacy. Through experimentation, students can develop critical thinking and problem-solving skills by designing, implementing, and initiating their own experiments. This hands-on experience allows students to see the connection between theory and practice, strengthening their understanding of scientific concepts and how they are applied in real life. Additionally, outdoor experiments and activities increase students' motivation and interest in science. When students are involved in challenging and interesting activities, they tend to develop curiosity and enthusiasm for science learning. This is important for forming a positive attitude towards science and encouraging them to continue learning and exploring further. In the context of science learning, outdoor integration activities and hands-on experiments not only enrich students' learning experiences but also help develop deeper and more meaningful scientific literacy. In this way, learning becomes more effective and students are better prepared to face real world challenges that require understanding and application of scientific knowledge. The limitations of this study are as follows: (1) the implementation of the problem-based learning model based on natural intelligence was focused on the aspect of science literacy; (2) the science learning in elementary schools was concentrated on the topic of energy transformation; (3) the research subjects were limited to fourth-grade elementary school students

CONCLUSIONS

Implementation of a Problem Based Learning Model based on naturalist intelligence in elementary education offers an effective approach to increase students' scientific literacy. By integrating natural contexts into the learning process, students not only increase their understanding of scientific concepts but also develop scientific understanding skills and awareness of the importance of science in everyday life. Despite challenges in terms of resources and teacher training, the long-term benefits of this approach are significant, making it a valuable strategy in science education in elementary schools.

REFERENCES

1. Fausan MM, Susilo H, Gofur A, Sueb, Yusop FD. The scientific literacy performance of gifted young scientist candidates in the digital age. Cakrawala Pendidik. 2021;40(2):467–98.

2. Raman Y, Surif J, Ibrahim NH. The Effect of Problem Based Learning Approach in Enhancing Problem Solving Skills in Chemistry Education: A Systematic Review. Int J Interact Mob Technol. 2024;18(5):91–111.

3. Bahtiar, Ibrahim, Maimun. ANALYSIS OF STUDENTS’ SCIENTIFIC LITERACY SKILL IN TERMS OF GENDER USING SCIENCE TEACHING MATERIALS DISCOVERY MODEL ASSISTED BY PhET SIMULATION. J Pendidik IPA Indones. 2022;11(3):371–86.

4. Laugksch R. Scientific Literacy : A Conceptual Overview. Sci Educ. 2017;(December).

5. Dewi CA, Erna M, Martini, Haris I, Kundera IN. Effect of Contextual Collaborative Learning Based Ethnoscience to Increase Student's Scientific Literacy Ability. J Turkish Sci Educ. 2021;18(3):525–41.

6. Dengan D, Tata NO, Pendaftaran C. Pengumuman ujian skripsi. 2021;2021–2.

7. Suryawan A, Suyanta S, Wilujeng I. Problem-Based Learning Model Based on Naturalist Intelligence to Realize Student's Science Literacy: Needs Assessment Survey. 2021;

8. Auerbach AJ, Schussler EE. Curriculum alignment with vision and change improves student scientific literacy. CBE Life Sci Educ. 2017;16(2):1-9.

9. Dewanti BA, Santoso A. Development of 21st Century Learning Skills Assessment Instruments in STEM-Based Science Learning (Science, Technology, Engineering, and Mathematics). Prism Sains J Pengkaj Ilmu dan Pembelajaran Mat dan IPA IKIP Mataram. 2020;8(2):99.

10. Wilujeng I, Dwandaru WSB, Rauf RABA. The effectiveness of education for environmental sustainable development to enhance environmental literacy in science education: A case study of hydropower. J Pendidik IPA Indones. 2019;8(4):521–8.

11. Smith KV, Loughran J, Berry A, Dimitrakopoulos C. Developing Scientific Literacy in a Primary School. Int J Sci Educ. 2012;34(1):127–52.

12. Suryanti. STEAM-Project-Based Learning: A Catalyst for Elementary School Students' Scientific Literacy Skills. Eur J Educ Res [Internet]. 2021;10(3):1199–213. Available from: https://www.researchgate.net/profile/Ebru-Eren/publication/348382981_Education_Policies_in_the_Context_of_Political_Communication_in_Turkey/links/5ffc2aeba6fdccdcb846cc03/Education-Policies-in-the-Context-of-Political-Communication-in-Turkey.pdf

13. Merritt J, Lee MY, Rillero P, Kinach BM. Problem-based learning in K-8 mathematics and science education: A literature review. Interdiscip J Probl Learn. 2017;11(2):5–17.

14. Malmia W, Makatita SH, Lisaholit S, Azwan A, Magfirah I, Tinggapi H, et al. Problem-Based Learning As An Effort To Improve Student Learning Outcomes. Int Educ Stud. 2019;11(September).

15. Reed SS. Problem-based learning in elementary school: what strategies help elementary students develop? Education 3-13. Springer; 2023. 1–2 p.

16. Tan S. IMPROVING STUDENT CREATIVE THINKING ABILITY WITH PROBLEM BASED LEARNING APPROACH USING HAWGENT. J Educ. 2020;02(04):303–12.

17. Dolmans DHJM, Loyens SMM, Marcq H, Gijbels D. Deep and surface learning in problem-based learning: a review of the literature. Adv Heal Sci Educ. 2016;21(5):1087–112.

18. Kesumawardani AD.) Model : How Does It Influence Metacognitive Skills and Independent Learning ?Problem-Based Learning (PBL. 2021;1(1):27–32.

19. Hung W, Moallem M, Dabbagh N. Social Foundations of Problem - Based Learning Introduction. 2019;1966:51–79.

20. Marnita, Taufiq M, Iskandar, Rahmi. The effect of blended learning problem-based instruction model on students' critical thinking ability in thermodynamic course. J Pendidik IPA Indones. 2020;9(3):430–8.

21. Demirçalı S, Selvi M. Effects of Model-Based Science Education on Students' Academic Achievement and Scientific Process Skills. J Turkish Sci Educ. 2022;19(2):545–58.

22. Latifah N, Fauzia U, Kelana JB. Natural Science Problem Solving in Elementary School Students Using the Project Based Learning (PjBL) Model. J Ilm Sekol Dasar [Internet]. 2020;4(4):596–603. Available from: https://ejournal.undiksha.ac.id/index.php/JISD/article/view/28377

23. OECED. PISA 2018 Results. Vol. I. 2018.

24. Marina Vargas-Rodríguez Y, Eduardo Obaya Valdivia A, Ivteh Vargas Rodríguez G. Problem Based Learning: Barrow and Bloom Taxonomy. Int J Educ. 2021;9(4):19–29.

25. Hmelo-silver CE. Problem-Based Learning : What and How Do Students Learn ? 2004;16(3):235–66.

26. Gardner H. Multiple Intelligences, Kecerdasan Majemuk Teori dalam Praktik. Tangeran Selatan: Interaksara; 2013.

27. Wulandari AP, Salsabila AA, Cahyani K, Nurazizah TS, Ulfiah Z. Pentingnya Media Pembelajaran dalam Proses Belajar Mengajar. J Educ. 2023;5(2):3928–36.

28. Osborne J. Science Education in an Age of Misinformation. 2023;

29. Markula A, Aksela M. The key characteristics of project-based learning: how teachers implement projects in K-12 science education. Discip Interdiscip Sci Educ Res. 2022;4(1).

30. Abdullah ENW, Sutrio, Ayub S, Doyan A. Pengembangan Perangkat Model Problem Based Learning Dengan Google Classroom Untuk Meningkatkan Penguasaan Konsep Suhu Dan Kalor Peserta Didik. J Penelit Pendidik IPA. 2024;10(6):2906–15.

31. Falk J, Storksdieck M. Using the Contextual Model of Learning to understand visitor learning from a science center exhibition. Sci Educ. 2005;89(5):744–78.

32. Min L. Motivating Students Through Problem-based Learning. Austin: University of Texas; 2005.

33. Brata DPN, Mahatmaharti AK. The implementation of Problem Based Learning (PBL) to develop student's soft-skills. J Phys Conf Ser. 2020;1464(1).

34. Salimi M, Hidayah R, Wahyudi ABE, Zainnuri H, Wijayanto S, Fauziah M, et al. The Implementation of Problem-Based Learning with Multimedia for Improving Scientific Process Skills. Salud, Cienc y Tecnol - Ser Conf [Internet]. 2025;4. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85208971216&doi=10.56294%2Fsctconf20251247&partnerID=40&md5=4aa5cb6dbce8ac01b40acd2ad9529068

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