

Developing Science Learning through a Hydroponics Project to Improve Students' Science Literacy Skills

Submitted 20 November 2025, Revised 24 November 2025, Accepted 31 January 2026

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Abstract

The purpose of this study was to build science learning based on a hydroponic project as an effort to enhance junior high school student's scientific literacy in Banten Province. A descriptive quantitative design included thirteen ninth grade students. Scientific literacy was measured during pre-test/post-test, which was reinforced with engagement and attitudes towards science observation. Results demonstrated significant increases in average scores from 66.92 to 95.38 and an average improvement of 44.2%. Learners with low pre-knowledge gained most (66.67%). The hydroponics program offered real life experiences, reinforced thinking like a scientist, promoted teamwork and nicely built scientific literacy and 21st century skills in students.

Keywords: Science Learning, Hydroponics, Scientific Literacy, Project Based Learning, Contextual Learning

INTRODUCTION

Due to advancements in digital technology such as AI (artificial intelligence), IoT (the Internet of Things), robotics, and high connectivity, the world is now in the era of the fourth international revolution, characterized by changes in how people live and work. This is because all information can be obtained without recognizing space and time (Setyaningsih et al., 2019); it can be accessed via the internet anytime and anywhere (Anwas, 2015). These technological advancements have a significant impact on the education sector in Indonesia, especially on 21st-century skills, namely ICT and digital literacy as tools for working (Griffin et al., 2012). One of the digital literacies that impact learning activities is science literacy.

Science literacy is the ability of students to understand scientific concepts and processes to identify a question, explain a phenomenon in everyday life scientifically, and make conclusions based on the data obtained to make decisions. More than that, science literacy involves a deep understanding of the characteristics of science, awareness of the impact of science and technology on the physical, intellectual, and cultural environment, and encourages active participation in issues related to science (Nudiati & Sudiapermana, 2020). Mastery of science literacy provides significant advantages, both at the individual and collective levels. At the personal level, those who possess proficient science literacy skills can overcome various.

Issues by applying the scientific principles they have mastered (Rahmadani et al., 2022; Bagasta et al., 2018). For students, science literacy is important to understand various aspects of modern life, ranging from the environment, technology, economy, health, to social aspects

(Utami et al., 2022). The goal of developing science literacy in the current generation is not to produce researchers, but to build an understanding of science and technology that enables them to make decisions that impact sustainability in the present and future (Putri et al., 2026).

The ability of science literacy among students in Indonesia has not reached the expected level, based on the results of the 2022 PISA assessment data, Indonesia ranked 67th out of 81 participating countries in the science aspect, with an average score of 383 (OECD, 2023). The analysis of this data shows that the level of science literacy in Indonesia over time has not shown change or tends to be stagnant; in 2022, the science literacy score obtained tended to decline compared to 2006. Based on this data, strategic and sustainable efforts are needed to improve the science literacy skills of Indonesian students. One effective step is to develop contextual science learning through hydroponic projects. Contextual learning enables students to correlate science concepts to their applications in real life, moreover, hydroponic projects give students hands-on experience in applying scientific knowledge to tackle the problems of modern agriculture and the environment. Students gain not only the theoretical knowledge of the growth of a plant, the process of photosynthesis, and the functions of nutrients, but also the practical skills of critical thinking, the making of scientific observations, data analysis, and evidence-based conclusions, skills that define science literacy, through hydroponic projects.

Besides, educators are instrumental in creating evaluations and inquiry-based learning tasks and STEM (Science, Technology, Engineering, and Mathematics) that compel students to investigate, test, and come up with new ideas. Thus, the implementation of hydroponic projects as a contextual science learning medium in one of the junior high schools in Banten Province is expected to be a concrete strategy to improve students' science literacy skills, while also fostering environmental awareness, responsibility, and collaboration in the learning process.

METHOD

This study used a descriptive quantitative approach to determine the effect of implementing a hydroponic project in science learning on the development of students' scientific literacy at a junior high school in Banten Province. This approach was chosen because it can provide an objective picture of the improvement in students' scientific understanding and attitudes after participating in project-based learning. According to Oktariyani et al. (2025), quantitative research design is a systematic framework used to collect, analyze, and interpret numerical data objectively to answer research questions, so it is suitable for use in the context of empirical data-based learning.

The participants of this research were 13 ninth grade students from one junior high school in Banten Province. Subjects were chosen by purposive sampling since they took part in the hydroponic project as part of their science learning. Firmansyah et al. (2022) mentioned purposive sampling as a sampling technique which is based on the researcher's judgment in selecting the individual or case that was considered relevant to be studied.

The research tools included written tests, a pre-test and a post-test, to measure changes in students' scientific understanding and literacy. The pre-test had five multiple-choice questions with explanations on hydroponic principles, nutrients, water circulation, and environmental factors. The post-test included 12 questions that assessed conceptual understanding, the application of science in real life, and scientific attitudes after the hydroponics project. These tools effectively captured students' learning gains and development of scientific literacy.

Data collection techniques were carried out by administering a pretest to the students before the project began with a view to ascertaining the initial level of their knowledge. Students were given a post-test after the hydroponic project was completed, with the intent of measuring knowledge and conceptual understanding regarding hydroponic systems. Besides the written test, researchers also directly observed students throughout the project on their engagement, collaborative skills, and application of scientific attitude during learning activities. The use of more than one data collection method can strengthen the validity of the research results because the test results can be confirmed by observational data (Rifa'i, 2023)

The data obtained were then analyzed using quantitative descriptive analysis. The scores from the pre-test and post-test results calculated the average value, and then compared to determine how much an increase the students' scientific literacy level achieved. The results of the analysis were categorized into four levels of achievement, which are as follows: excellent (81-100), good (61-80), sufficient (41-60), and poor (40). Meanwhile, observation data were analyzed qualitatively descriptively to describe the change in student behavior and interest in learning science through the hydroponic project.

RESULTS AND DISCUSSION

This hydroponic project research was conducted to improve the scientific thinking skills and scientific literacy of class IX A students through an approach. Project-Based Learning (PjBL). The activity was carried out in several stages, starting from introducing the concept of hydroponics, assembling simple tools, planting seeds, observing growth, and reporting results. Scientific thinking skills and scientific literacy were measured using a pre-test and a post-test. This hydroponic project was conducted to improve the scientific thinking skills and scientific

literacy of ninth-grade students through an interactive approach. Project-Based Learning (PjBL). Scientific thinking skills and scientific literacy were measured using a pretest and a posttest. The data can be seen in Table 1.

Table 1 Pre-test and Post-test Scores of Grade IX Students' Scientific Literacy

No.	Student Name	Pre-test Score	Post-Test Score	Improvement
1	F	60	90	50%
2	R	70	100	42,86%
3	F	70	100	42,86%
4	C	80	100	25%
5	A	50	80	60%
6	M. N	60	100	66,67%
7	Z	70	100	42,86%
8	M. F	70	80	14,29%
9	M. K	70	100	42,86%
10	K	80	100	25%
11	B	60	100	66,67%
12	Y	70	90	28,57%
13	S	60	100	66,67%

The percentage increases obtained by students ranged between 14.29% and 66.67 %. The highest scoring students were MN, B, and S, all with a percentage increase of 66.67%. This suggests that students who started with a poorer conceptual understanding gained more from context based learning as they were participant in the science process rather than spectator. At the same time, the student with the least gain from the hydroponics project was an ESL student, there is conceptual reinforcement is provided by the hydroponics project, just not as great as other students. This result supports the idea that initial levels of student which's learning project learning capacities before differences energetic. This increase is similar to that of the Mardani (2025) research, which reports that project-based learning can raise students' levels of scientific literacy as students participate in real world solutioning of problems. In hydroponic experiments, students are not merely given theories, they are allowed to cultivate the whole scientific process, including preparing the layout, growing seeds, monitoring growth, plus collecting data which affects the successful or failed growth of plants. Active engagement enables students to develop a fuller understanding of scientific principles, including photosynthesis, nutrition, and light's role. Barokah et al. (2025) attests that experience is the best way to develop one's scientific literacy since students get to relate abstract ideas to realworld phenomena. This is reflected in students' gained ability to describe the correlation between light and water to nutrients and plant growth. During pre-test, however, such students as John, James and Mary all had bad scores. Most of the students

could not make sense of these relationships. But when the students took part in the project, they could observe that light makes leaves go pale, that plant growth is hindered by a lack of nutrients, and that an excess or lack of water can result in root rot or wilting.

This evidence-engaged knowledge is a good marker for being more scientifically literate. From the viewpoint of experiential learning, the enhancement of student scientific thinking abilities can also be interpreted. According to Halim & Wulandari (2024), experiential learning because its able to make students science skills to be more effective since they have experienced the whole cycle of concrete experience, reflection, conceptualization and decision-making.

During the hydroponics units, students execute the steps in very obvious order. They learn how to plant and nurture them, and then change or reflect on the results, and make decisions such as more nutrition or more light if they need. This cycle enriches their appreciation of science and enhances their analytical thinking skills. Besides the scientific concepts and processes, the hydroponic experiment positively influenced the attitude of science. This result was in line with the research result of Rahmawati et al. (2013) that revealed investigative activities based on project are potential to build scientific attitude especially in terms of accuracy, curiosity, responsibility, and cooperation. Students were accurate when taking weekly measurements of the height of the plants, curious questioning occurred during discussions about growth variation among the groups, and responsible attitudes toward daily watering and nutrient monitoring of the plants were shown. During this scientific attitudes are necessary components in contemporary scientific literacy which promulgates the value of participation and scientific vigilance. The result of the present study supported the findings of Pratama et al. (2024) that, among others, observing, measuring, analyzing data, and drawing conclusion were steps of the science which should be considered as one of the indicators of scientific literacy. Students had the chance to study data on plant growth, build simple apparatus, and make intergroup comparisons. During the project, students were able to analyze plant growth data, build simple apparatus, and make intergroup comparisons. These exercises were crucial in developing critical thinking skills, not only for the benefit of supporting conclusions with proof but also for the process of thinking about whether conclusions could be considered or discarded based on evidence, as opposed to having memorized theorems from books. This evidence-based way of thinking is important to be developed in advanced level of scientific literacy, which is one of the main goals in 21st century education. In line with contextual learning, the project's findings also support Ridwansyah et al. (2025) findings, which affirm that real world investigation can

improve one's understanding of abstract ideas. In the project on hydroponics, students had the opportunity to discover what nutrients are involved in photosynthesis, the rate of growth is influenced by light, and the role of water as a medium in hydroponic culture. This instructional approach is advantageous to learning difficult concepts, such as when students are able to observe the effects of each variable on the growth of a plant. To add, the hydroponics project exposes students to real-life applications of contemporary agricultural techniques. This finding is in line with research by Fadilah et al. (2022) who states that the science application in everyday life can be known through project based stem activity. Students are aware that hydroponics is a productive and sustainable agricultural technology that can be practiced in a small place. This understanding expands their view of what science is in today's world. In general, this section shows that the hydroponics project makes students not only more knowledgeable but also more scientifically literate with respect to scientific processes, scientific attitudes, and transfer of concepts to real-life situations. This approach to learning allows for an all-inclusive experience that meets the demands of contemporary science curriculum and challenges students with science-related activities at the subsequent tier.

CONCLUSION

In Banten, a junior high school has conducted a Project Based Learning (PBL) hydroponics which has enhanced students' scientific thinking and scientific literacy skills by 46.2% while students' direct involvement such as, in assembling the installation, planting, and observing, as well as analyzing not only connects students to real-world experiences but also helps with the subject of science. This activity also promotes and develops positive scientific skills and attitudes as well.

SUGGESTIONS

According to the results of the study, contextual science learning through hydroponic projects has been proven effective in improving scientific literacy and scientific thinking skills. Thus, teachers and schools are suggested to integrate the Project-Based Learning model further into other materials of science and provide simple facilities that support practical activities. Moreover, students are expected to keep scientific attitudes that have been developed during the project, such as curiosity, accuracy, and responsibility, because these skills are important in learning and life. Further researchers can expand this research by involving larger participant numbers, comparing hydroponic projects with other learning models, or conducting further research to see the sustainability of improvements in scientific literacy. This paper also recommends the development of learning media such as interactive

modules or videos of hydroponic practices that would strengthen conceptual understanding and support students in their independent learning.

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