JPPIPA 9(3) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Analysis of Students' Scientific Literacy Ability by the Implementation of Case Method Learning

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Received: August 12, 2022
Revised: March 17, 2023
Accepted: March 25, 2023
Published: March 31, 2023

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DOI: 10.29303/jppipa.v9i3.2250

Abstract: This study aims to analyze the increase in students' scientific literacy by implementation of case method learning. This is a quasi-experimental research using a one group pretest-posttest design. The research sample is the first semester students of the Chemistry Education Department at Universitas Samudra in the odd semester of the 2022/2023 academic year. This research consists of four stages, namely material analysis, development of tools and instruments, implementation, and data analysis. The scientific literacy test instrument was used to measure students' scientific literacy. Students' scientific literacy skills are presented according to content, science process, and context aspects. The increase in students' scientific literacy skills was analyzed based on the N-gain and paired sample t test. The results of the study found that students' scientific literacy skills in all content, science process, and contexts, were higher in the posttest than the pretest except for content energy that accompanies changes in material and context of natural resources. The average scientific literacy ability of students at the posttest (74.33) was higher than at the pretest (57.08). The N-gain value of 0.40 indicates an increase in students' scientific literacy skills with implementation of case method learning in the medium category. Analysis with paired sample t test indicates a significant difference in the pretest and posttest scores. Thus, it can be concluded that case method learning can improve students' scientific literacy skills in the three domains of scientific literacy.

Keywords: Case method; Content; Context; Science process; Scientific literacy

Introduction

Very fast changes in the era of globalization need to be anticipated by mastering 21st century skills (Redhana, 2019). Science education and scientific literacy has gained enormous attention in the global educational scenario (Jatsho & Dorji, 2022). In the industrial revolution 4.0 era, scientific literacy skills are very important to be mastered by preservice teacher students. Scientific literacy can improve a person's way of thinking which is known as understanding science and can answer problems in various aspects of life (Sumanik et al., 2021). Scientific literacy is the ability to understand scientific knowledge to acquire new knowledge, explain scientific phenomena, and conclude based on scientific evidence. Scientific literacy is the ability to engage with issues related to science and with scientific ideas, as a reflective citizen (OECD, 2019a). Ironically, the 2018 PISA puts the scientific literacy of students in Indonesia in the 70th rank out of 78 countries with an average score of 396 (OECD, 2019b). Research by Seprianto et al. (2017) found that the literacy skills of chemical education students at four universities in Aceh were still low.

PISA examines scientific literacy based on four dimensions, namely aspects of context, content, process, and scientific attitude. The scientific process, science content, and the context of science application are measurements of the large dimensions of scientific literacy (Fuadi et al., 2020). From the aspect of the process, science education serves to prepare future citizens, namely citizens who are able to participate in a society that is increasingly affected by advances in science and technology. Therefore, science education needs to develop students' ability to understand the nature of science, scientific procedures, and the strengths and limitations of science (Arlis et al., 2020).

Based on observations, most students still have difficulties in developing scientific literacy skills such as

How to Cite:
Seprianto, S., & Hasby, H. (2023). Analysis of Students' Scientific Literacy Ability by the Implementation of Case Method Learning. *Jurnal Penelitian Pendidikan IPA*, *9*(3), 1143–1148. https://doi.org/10.29303/jppipa.v9i3.2250

difficulties in applying scientific concepts to everyday life. In general, students have difficulty in applying chemical concepts in everyday life because teachers do not train and develop students' science. This causes students' scientific literacy related to knowledge about science issues in accordance with PISA demands, to be low so that chemistry learning is less meaningful (Izzatunnisa, 2019). Students' chemical literacy can be developed through an innovative learning strategy that explicitly direct student learning to aspects of chemical literacy (Fadly et al., 2021). One of the efforts to improve the scientific literacy of prospective teacher students is through improving the learning process carried out, which not only emphasizes mastery of concepts, but also pays attention to other aspects such as the application of case method learning (Novitasari, 2018).

The case method is a widely used education tool that puts students in front and centre of the learning process (Puri, 2020). The case method is a method that emphasizes the process of solving a case or problem faced scientifically, where the case or problem learning process is the key word. The implementation of the case method is carried out by teachers and lecturers by choosing lesson materials that have cases that can be solved. The case method is a form of learning in which students repeatedly experience playing the role of a decision-maker. A case is a description of an event or series of event that lead to need for a decision (Mu & Hatch, 2019). The case method is practiced in the following order: a self-study of the case before class, a small group discussion before or during class, and an in-class large group discussion with the entire class (Ito & Takeuchi, 2020).

While the case method is often mistaken for case studies, they are not the same; the former is a teaching and learning method, and the latter is a research method, although the latter can be integrated into former (Ito & Takeuchi, 2020). The case method is a learning method by raising real cases and then presenting them in the classroom. This case describes a real event or situation related to the material being studied. This method can provide simulation of real-world conditions into a controllable environment in the classroom. Case method instruction offered an opportunity to consider decisions involving equity in a low stake environment (Leggett & Smith, 2022).

The case method is one of the learning methods mandated in Permendikbud number 3 of 2020 to support higher education IKU. Case method as an andragogical approach connects theory and practice in numerous fields: law, medicine, business, and education (Leggett & Smith, 2022). The aim of this research is to analyze the improvement of students' scientific literacy skills by using case method learning.

Method

This research is a quasi-experimental research using a one group pretest-posttest design. The research population is the students of the Chemistry Education Study Program, Universitas Samudra in the odd semester of the 2022/2023 academic year. Sampling using purposive sampling technique. The experimental group is a class with case method learning. The research sample is first semester students consisting of 12 people.

This research consists of four stages, namely material analysis, development of learning tools and test instruments, implementation of case method learning, and data analysis. The data of this research are in the form of pretest and posttest scores of students' scientific literacy skills. Scientific literacy test instruments on electrolyte and nonelectrolyte solutions were used to measure students' scientific literacy skills at the pretest and posttest. . Students' scientific literacy abilities were analyzed into percentages of ability in aspects of content, scientific process, and context using Equation 1.

$$NP = (R/SM) \times 100\% \quad (1)$$

Where, NP = Percentage value; R = total score; and SM = Maximum score value.

The percentages are then grouped according to the category of scientific literacy ability in Table 1. The increase in scientific literacy skills is analyzed from the N-gain value using the following Equation 2.

Table 1. Category of scientific literacy ability

Interval (%)	Category
85<x≤100	Very High
75<x≤85	High
65<x≤75	Medium
55<x≤65	Low
x≤55	Very Low

$$g = (\text{posttest} - \text{pretest})/(\text{maximum score} - \text{pretest}) \quad (2)$$

With the gain score analysis criteria: g 0.7 is in the high category, 0.3 g <0.7 is in the medium category, and g < 0.3 is in the low category. Differences in scientific literacy skills between before and after case method learning were analyzed using the paired sample t test with SPSS from the pretest and posttest results.

Result and Discussion

Students' scientific literacy ability was measured using science literacy test questions at the pretest and posttest. The posttest was carried out after the application of the case method learning on electrolyte and non-electrolyte materials. The percentage of students based on the category of scientific literacy ability as shown in Figure 1.

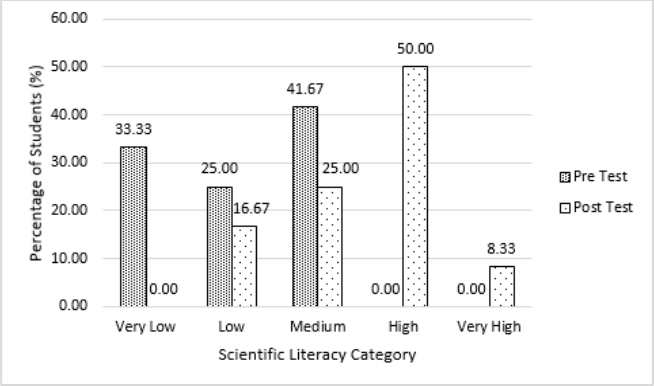

Figure 1. Percentage of students by category of scientific literacy ability

Based on Figure 1, in the pretest most of the students (41.67%) had scientific literacy skills in the medium category. Meanwhile, in the posttest, most of the students (50%) had scientific literacy skills in the high category. This is in line with Cigdemoglu (2020) who stated if science concepts are instructed effectively, there is the possibility to increase students' chemical literacy.

Chemical content in scientific literacy is grouped into properties of matter, composition of matter, chemical changes of matter, and energy that accompanies a change in matter. Students' scientific literacy ability according to content as shown in Figure 2. Based on Figure 2, the students' scientific literacy ability in the pretest was highest in the energy content that accompanies material changes (79.2%) in the high category, while in the posttest the material composition content (82.5%) was in the high category. The students' scientific literacy ability in the pretest was lowest on the content of material changes (37.5%) in the very low category, while in the posttest on the energy content that accompanies material changes (62.5%) in the low category. In all content, scientific literacy ability on posttest is higher than pretest except for energy content that accompanies material changes. Seprianto et al. (2017) also found that students' scientific literacy skills in Aceh were lowest in the energy content that accompanies material changes.

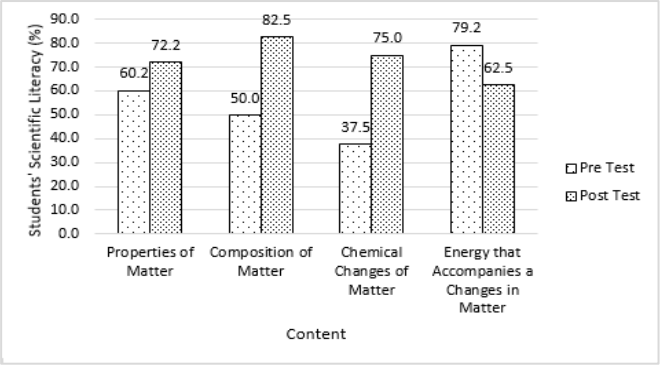

Figure 2. Scientific literacy ability by content

The scientific process in scientific literacy is grouped into identifying scientific issues, using scientific evidence, and explaining phenomena scientifically. The scientific literacy ability of students according to the scientific process is as shown in Figure 3.

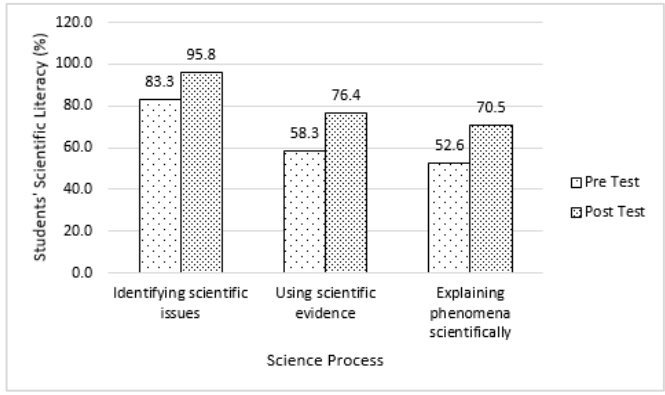

Figure 3. Scientific literacy ability according to the scientific process

Based on Figure 3, the students' scientific literacy ability in the pretest was highest in the process of identifying scientific issues (83.3%) in the high category and in the posttest also in the process of identifying scientific issues (95.8%) in the very high category. Meanwhile, the students' scientific literacy ability in the pretest was the lowest in the process of explaining phenomena scientifically (52.6%) with a very low category and in the posttest also in the process of explaining phenomena scientifically (70.5%) in the medium category. In all science processes, scientific literacy ability at posttest is higher than pretest. Research by Nurkhin et al. (2022) stated that the increase in student learning activities can be seen in the increased ability of students to ask questions, provide responses or answers, and express opinions or ideas during lectures.

The context in scientific literacy is grouped into natural resources, the frontiers of science and technology, health, hazard, and environment. Students' scientific literacy ability according to context as shown in Figure 4.

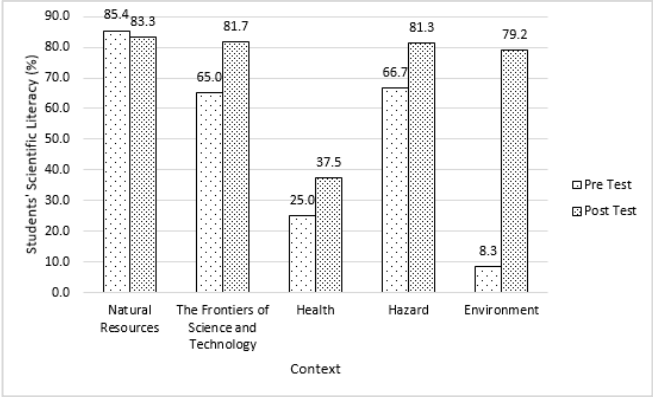

Figure 4. Scientific literacy skills according to context

Based on Figure 4, the students' scientific literacy ability in the pretest was highest in the context of natural resources (85.4%) in the very high category and the posttest was also the highest in the context of natural resources (83.3%) in the high category. The students' scientific literacy ability at the pretest was lowest in the environmental context (8.3%) with a very low category and in the posttest in the health context (37.5%) with a very low category. In all contexts, the scientific literacy ability on the posttest was higher than the pretest except for the context of natural resources. Seprianto et al. (2017) also found that students' scientific literacy skills in Aceh were lowest in the health context. This is in line with study by Fadly et al. (2021) showed that the innovative strategy significantly improves students' chemical literacy, and it greatly affected all aspects of chemical literacy measured (e.g. content, epistemic, and procedural knowledge). Case method brings a piece of the real world into the classroom to facilitate elevated thinking skills among students, develop a deeper understanding of problems, and arrive a better solution (Puri, 2020). Science, technology, and society content knowledge in earth science, life science, and health science were positively associated with science teachers' self-efficacy in chemistry (Walag et al., 2022).

The increase in students' scientific literacy skills was analyzed from the N-gain value. The average pretest, posttest, and N-gain scores can be seen in Table 2. The calculated N-gain value is 0.40, which means the increase in students' scientific literacy skills in the experimental class is classified as moderate because 0.3 g <0.7. The N-gain value indicates an increase in scientific literacy skills by learning the case method on electrolyte and nonelectrolyte solutions. Even though the students have good chemical literacy in implementing the context-based learning, they need to improve their abilities to reach the goals of the science/chemistry curriculum (Wiyarsi et al., 2020).

Table 2. Average scores of pretest, posttest, and N-gain

Value	Average
Pretest	57.08
Posttest	74.33
N-gain	0.40

The normality test was carried out to meet the test requirements for the paired sample t test. Normality test using Kolmogorov-Smirnov and Shapiro-Wilk methods. The results of the data normality test are presented in Table 3 and Table 4.

Table 3. The results of the normality test of pretest and posttest scores with the *Kolmogorov-Smirnov* test

Test	Statistic	df	Sig.	Interpretation
Pretest	0.218	12	0.120	Normal
Posttest	0.238	12	0.058	Normal

Table 4. The results of the normality test of pretest and posttest scores with the *Shapiro-Wilk* test

Test	Statistic	df	Sig.	Interpretation
Pretest	0.890	12	0.117	Normal
Posttest	0.918	12	0.271	Normal

From Table 3 and Table 4 it can be seen that the significance of the pretest and posttest on both normality tests > 0.05, so it can be concluded that the pretest and posttest data are normally distributed. The paired sample t test was used to determine the difference in scientific literacy skills between before and after learning the case method. The results of the paired sample t test are presented in Table 5. Table 5 shows sig. (2-tailed) < 0.05. These results indicate that there is a significant difference in students' scientific literacy skills between before and after learning the case method on electrolyte and non-electrolyte solution materials.

Table 5. The results of the paired sample t test

	t	df	Sig. (2-tailed)	Interpretation
Pretest-Posttest	-6.928	11	0.000	Significantly different

Thus, based on the average pretest, posttest, N-gain, and paired sample t test results, it can be stated that case method learning can improve students' scientific literacy skills in the three domains of scientific literacy, namely content, scientific process, and context. This is in line with the study by Chumak et al. (2022) showed the high efficiency of the case method in the educational environment of higher educational institutions. The case method leads students to explore information in solving cases scientifically, this of course directly shapes students' scientific literacy skills (Rahayu, 2020). The case study method was beneficial for improving student's learning, engagement, and critical thinking (Almuqayteeb, 2021). Improving the long-term memory, enhancing the quality of decision making and understanding the individual differences of individuals are the advantages of case method teaching (Afsouran et al., 2018).

Study by Mu and Hatch (2019) stated each student entering a case method course as having an underlying mental set which is the sum of their existing knowledge, cognitive and affective abilities, technical and behavioral skills, and value systems. Students' emotional engagement was a significant factor in enriching outcomes (Nkhoma et al., 2017). The case method approach is necessary for education to expose students to real scenarios that challenge them to develop the appropriate skills to deal with practical problems by providing solutions for different activities (Chkoniya, 2021). The meanings and essences of the learning experience can inform the provision of more appropriate and effective science teaching (Yee, 2019).

Conclusion

Most of the students (41.67%) at the pretest had scientific literacy skills in the medium category. Meanwhile, during the posttest, most of the students (50%) had scientific literacy skills in the high category. In all content, scientific processes, and contexts, the students' scientific literacy ability at the posttest was higher than the pretest except for the energy content that accompanies changes in material and the context of natural resources. The average scientific literacy ability of students in the posttest (74.33) was higher than the pretest (57.08). Based on the N-gain value of 0.40, the increase in students' scientific literacy skills by applying the case method learning is in the medium category. Analysis with paired sample t test obtained sig. (2-tailed) <0.05, which is 0.000 which indicates a significant difference in the pretest and posttest scores. Based on the average pretest, posttest, N-gain, and paired sample t test results, it can be stated that case method learning can improve students' scientific literacy skills in the three domains of scientific literacy, namely content, scientific process, and context.

Acknowledgments

We would like to thank to the LPPM and PM of Universitas Samudra for funding this research.

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