Vol 13 (3), 2024, 84-103 DOI: 10.23960/jppk.v13i3.31848
Jurnal Pendidikan dan Pembelajaran Kimia
e-ISSN: 2714-9595| p-ISSN 2302-1772
http://jurnal.fkip.unila.ac.id/index.php/JPK/index

Sustainable Learning Through Problem Based Learning with Socioscientific Issue: An Analysis of Science Literacyand scientific attitudes of high school students

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Accepted: November 15th, 2024 Accepted: December 8th, 2024 Online Published:December 26th, 2024

Abstract : Sustainable Learning Through Problem Based Learning with Socioscientific Issue: An Analysis of Science Literacyand scientific attitudes of high school students. The research aimed to analyse the effect of Problem Based Learning model with Socioscientific Issue on science literacy and scientific attitude of high school students. This research was conducted in public high school in Kalianda. The research design used was Quasi-Experiment with Pretest- Posttest Control Group method. Cluster Random Sampling technique was used to get the sample of Class XI. The sample consisted of Class XI.10 totalling 35 students as the control class while Class XI. 5 class totalling 36 students as the experimental class. The type of data is quantitative. Tests and questionnaires were used to collect data. Based on the Pretest-Posttest results, the experimental class met the 'High' category with an N-gain score of 0.804, while the control class met the 'Medium' category with an N-Gain score of 0.650. Independent sample t-test was used to test the hypothesis, with a Sig (2-tailed) value of 0.000 <0.05. The conclusion of this study is that science literacy and scientific attitudes of high school students are influenced by the Problem Based Learning model with Socioscientific Issue. Therefore, it is expected that this research is useful in improving the scientific literacy and attitude of high school students.

Keywords: Problem Based Learning, Socioscientific Issue, Science Literacy, Scientific Attitude.

Abstrak : Pembelajaran Berkelanjutan Melalui Model Problem Based Learning Dengan Socioscientific Issue: Analisis Literasi Sains Dan Sikap Ilmiah Siswa SMA. *Tujuan penelitian untuk menganalisis pengaruh model Problem Based Learning dengan Socioscientific Issue terhadap literasi sains dan sikap ilmiah siswa SMA. Penelitian ini dilaksanakan di SMA Negeri di Kalianda. Desain penelitian yang digunakan adalah Quasi-Experiment dengan metode Pretest- Posttest Control Group. Teknik Cluster Random Sampling digunakan untuk mendapatkan sampel Kelas XI. Sampel terdiri dari Kelas XI.10 berjumlah 35 siswa sebagai kelas kontrol sedangkan kelas XI. 5 berjumlah 36 siswa sebagai kelas eksperimen. Jenis data berupa kuantitatif. Tes dan angket digunakan untuk mengumpulkan data. Berdasarkan hasil Pretest-Posttest, kelas eksperimen memenuhi kategori "Tinggi" dengan skor N-gain sebesar 0,804, sedangkan*

kelas kontrol memenuhi kategori "Sedang" dengan skor N-Gain sebesar 0,650. Uji t-sampel independen digunakan untuk menguji hipotesis, dengan nilai Sig (2-tailed) sebesar 0,000 < 0,05. Kesimpulan penelitian ini adalah bahwa literasi sains dan sikap ilmiah siswa SMA dipengaruhi oleh model Problem Based Learning dengan Socioscientific Issue. Oleh karena itu, diharapkan penelitian ini bermanfaat dalam meningkatkan literasi dan sikap ilmiah siswa SMA.

Kata Kunci: *Problem Based Learning, Socioscientific Issue, Literasi Sains, Sikap Ilmiah.*

▪ INTRODUCTION

The 21st century is signalled by significant technological advances in science education. The pattern of technological advances in education is used as an important step in welcoming sustainable learning according to Indonesia's 2045 development goals. Therefore, science education plays an important role in preparing students with science literacy. So that students are able to face the challenges that arise due to the development of science and technology (Utami & Setyaningsih, 2022). The demands of learning in this era according to (Wang et al., 2018) include the development of values, mindsets, and skills as well as cognitive abilities. Students are expected to master the knowledge, skills, attitudes and values that are at the core of 21st century competencies. The main goal of learning this century is to equip students with adaptive skills to deal with the changes that continue to occur in society (Sutrisna, 2021). Science literacy is key in facing the challenges of the 21st Century era (Syahidi et al., 2023).

Literacy comes from the word 'literacy' which refers to the ability to read and write, while the word science itself comes from the term 'science' which means knowledge. The skill of understanding scientific concepts and methods, and applying them to solve everyday problems, is known as science literacy. According to PISA, science literacy is the ability to apply scientific knowledge, recognise relevant problems, and formulate conclusions based on scientific data to understand and make decisions related to the environment and the impact of human activities (OECD, 2023). There are three components in science literacy: knowledge or content, competence or process, and context. Competencies include evaluating and designing scientific investigations, explaining scientific phenomena, and interpreting scientific data and evidence. Content, procedural and epistemic knowledge are all included in the content. Health, energy resources, environmental quality, risk, and the latest developments in science and technology are all included in the context (OECD, 2023).

One of the main goals of science learning today is to improve science literacy. Individuals who lack science literacy will have difficulty evaluating social, scientific, and global learning issues (Aliyana et al., 2021). For (Muliani et al., 2023) science literacy is very important because it expands students' understanding of the interrelationships between science, technology and society, while increasing knowledge and vocabulary. Science literacy also plays a crucial role in the world of work, where skills such as critical thinking, innovation and problem-solving are needed (Masithah et al., 2022). Therefore, science literacy is one of the important skills that need to be assessed to evaluate how well a programme can prepare students. PISA or Programme for International Student Assessment, is one of the instruments used to measure the science literacy of students in various countries (Hemamalini et al., 2022).

Every three years, the Organisation for Economic Cooperation and Development (OECD) conducts the PISA study to measure the science, reading and mathematics literacy of 15-year-old students. OECD is an international organisation that promotes economic cooperation. Indonesia has joined the PISA programme since 2000. However, the scores achieved by Indonesia tend to be low and still below the average PISA standard. This shows that Indonesian students' understanding of scientific concepts and methods is still uneven. In addition, students find it difficult to apply the knowledge they have learnt in their daily lives. In comparison, the PISA score in 2018 reached 371, while in 2022, the reading skill score dropped 12 points to 359. On the other hand, the target score for reading in the 2024 National Medium-Term Development Plan (RPJMN) is 392. This condition should be a serious concern, considering that science literacy, as one of the 21st century skills, is important to develop critical, creative thinking and scientific understanding so that students can contribute to a global society and understand environmental and social issues (Yusmar & Fadilah, 2023).

In this study, three biology teachers in one of the high schools in South Lampung Regency were interviewed and supported by observations. The findings show that despite implementing student-orientated learning models, such as the Problem Based Learning model, the development of students' science literacy has not reached the expected standard. Students do not actively participate in the learning process due to the teacher's role which still dominates learning. Students have difficulty in answering questions related to the application of concepts in everyday life. Students' inability to answer issues that require analysis indicates an obstacle in connecting one concept that has been learned with other concepts. On the other hand, the evaluation carried out by teachers is more focused on assessing understanding of the material rather than developing students' science literacy. As a result, students are less trained in critical thinking and expressing opinions, which has an impact on low science literacy. Teachers' understanding of science literacy is limited to reading skills and content mastery, whereas science literacy includes the application of science and critical thinking skills in various contexts. According to research conducted by (Budiman et al., 2021), teachers' lack of understanding of science literacy is one of the factors contributing to the low level of science literacy among students.

It is important to improve students' science literacy and critical, analytical and scientific thinking skills using science-based learning strategies. By using the right model, the scientific approach that focuses on socioscientific issues can be implemented systematically in the learning process. One of the appropriate models for this scientific approach is Problem Based Learning. According to (Parwasih & Warouw, 2020) Problem Based Learning is an approach that focuses on real problems that require in-depth investigation. The Socioscientific Issues approach is an effective tool in deepening students' understanding of the relationship between science and society, while encouraging intellectual, moral, and ethical development. It helps students better understand the environment and respond to it in a scientific and organised manner. The main objective of this model, when coupled with socioscientific issues, is to enhance critical thinking as well as problem-solving skills through discussion of real issues related to society. When students are exposed to science-related social issues, their ability to provide scientific answers will improve as their science literacy progresses. Based on the theories discussed, the combination of the Problem Based Learning model with socioscientific issues can provide an authentic and meaningful learning experience. Thus, it is expected that students' ability in.

One of the main objectives of science learning is the development of positive scientific attitudes. As revealed by (Sari, K., & Nurwahyunani, 2016) a deep understanding of science is often accompanied by a scientific attitude towards science. According to research conducted by (Rusdi et al., 2017) also showed a positive relationship between scientific attitudes and student science literacy. Scientific attitude is an important character possessed by students who study science, it is expected that students become more sensitive to the environment and their surroundings. This attitude includes curiosity, scepticism or disbelief, a positive view of failure, prioritising evidence, accepting differences, and being able to work together. When students develop scientific attitudes, they tend to become more creative and innovative individuals. This is important because during the process of learning science, students will experience a variety of meaningful and diverse experiences, which will ultimately increase knowledge and skills. (Qonita et al., 2019).

Students' scientific attitudes in science learning are still lacking. During the learning process, students are often passive and contribute little, especially in question and answer sessions and group discussions. Many students seem to lack focus and only wait for directions from the teacher, without any initiative to learn or understand the material. The observation at SMA Negeri 2 Kalianda shows that although the laboratory facilities are adequate, some practicum materials are hampered due to limited tools and materials. In addition, the laboratory is also used as a classroom, so practicum is not carried out routinely and is replaced by working on LKPD. The low scientific attitude of students is influenced by the lack of intensity of practicum implementation. Students who are active in practicum usually show better science literacy. Practicum allows students to actively participate in learning, which ultimately contributes to improving science literacy competencies.

The results of interviews with twelve students showed that most respondents considered the importance of developing critical thinking, especially on the material of the excretory system, which is one of the topics in grade XI SMA that is closely related to aspects of science literacy. Although abstract in nature, the excretory system can be applied in everyday life and requires in-depth understanding as it covers invisible bodily functions. Science literacy in this material is very important, considering that learning often only focuses on memorisation. In addition to interviews, researchers also conducted written tests in the form of 10 Mulltiple Choice questions measuring science literacy and a 20-item Likert scale questionnaire for students' scientific attitudes. The results of the tests and questionnaires show that science literacy and scientific attitudes are still relatively low, as shown in Figures 1 and 2.

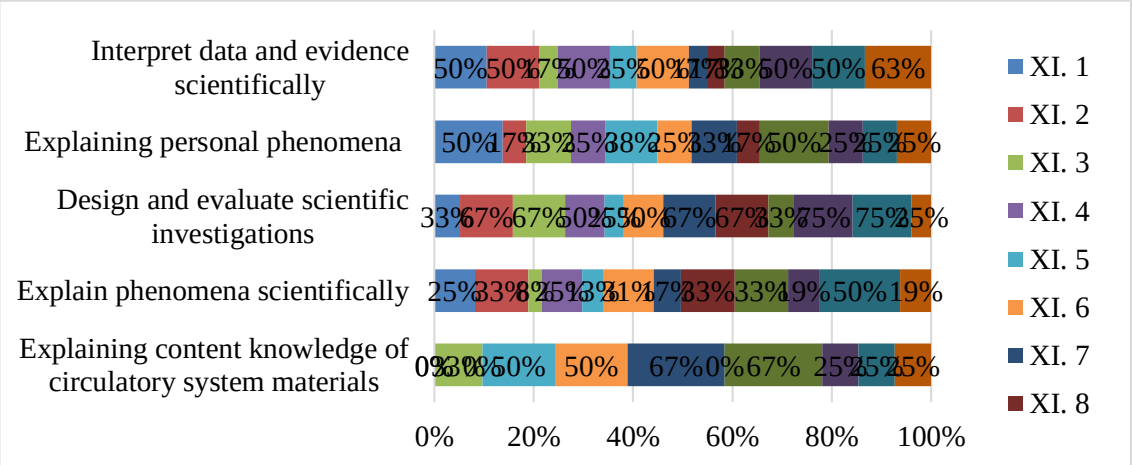

Figure 1. Data on Science Literacy of class XI

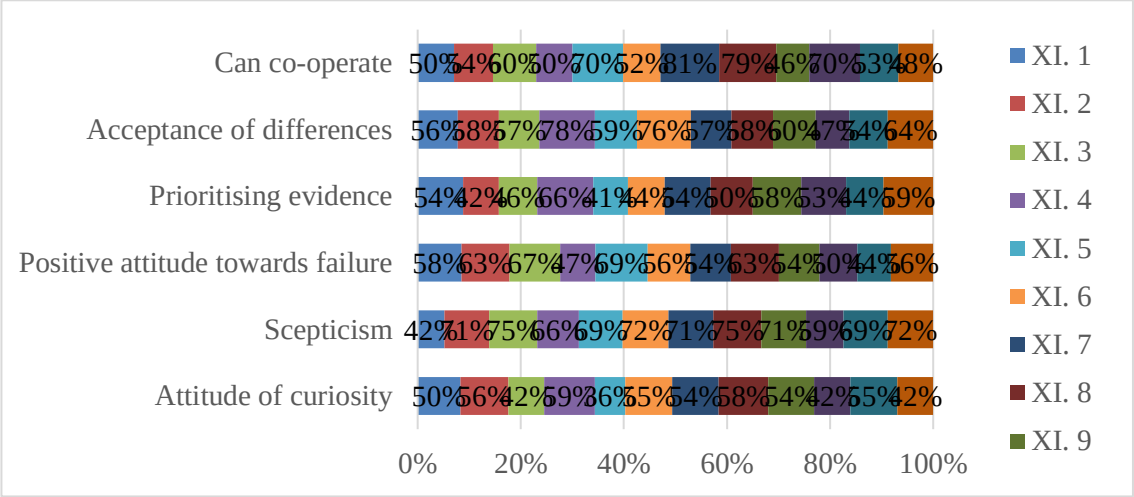

Figure 2. Data on Scientific Attitude of Class XI

Based on Figures 1 and 2, the data obtained shows that students' science literacy skills and scientific attitudes are still at a level that needs to be improved. This indicates that efforts to improve students‘ science literacy are still needed and students’ scientific attitudes also need to be improved. The low scores may be due to the lack of training in science literacy and scientific attitude development, both during the classroom learning process and during practicum activities.

Based on the above problems, the researcher plans to apply the Problem Based Learning model with Socioscientific Issue to improve students' science literacy and scientific attitude. This model allows students to explore knowledge independently while working in groups, as well as facing situations that encourage students to find solutions, so that critical thinking skills develop. Socioscientific issue-based learning provides space for students to actively apply their knowledge of scientific concepts and processes. This process helps them to make decisions based on real facts and evidence from everyday life, especially related to actual issues in society (Alfionita et al., 2019). Social issues related to science were chosen because they are relevant in improving science literacy (Merghli et al., 2009). Social issues are often complex and require science literacy skills to make informed decisions (Sadler, 2004). This model also provides space for students to interact and learn collaboratively through real challenges (Merritt et al., 2017).

This research has an important value in the world of education because it aims to analyse the impact of applying the Problem Based Learning model combined with the Socioscientific Issues approach on the science literacy and scientific attitudes of high school students. In the midst of globalisation and rapid technological advances, scientific literacy is one of the main abilities that must be possessed by the younger generation in order to understand and face various scientific challenges related to social issues in the student environment. In addition, scientific attitudes, such as curiosity, scepticism, positive attitude towards failure, prioritising evidence, accepting differences, and working together, are important foundations in shaping the character of students who are responsible for society's problems. Problem Based Learning model with Socioscientific Issues is designed to integrate active learning with real issues, so that students not only understand science concepts, but also able to apply them in the context of relevant daily life. Therefore, this research becomes very important to present a more innovative,

contextualised and relevant learning strategy. This approach is expected to contribute to improving the quality of education and supporting the development of 21st century skills. In addition, the results of this research can be a reference for educators, schools and policy makers in designing a curriculum that is more responsive to the needs of the times.

▪ METHOD

This research is a quantitative type with Pretest-Posttest Control Group design with Quasi-Experiment technique. The research was conducted at SMA Negara 2 Kalianda, in the even semester of the academic year 2023/2024, precisely in May 2024. The research subjects were students of grade XI, and the population of all students of grade XI totalled twelve classes. The research sample was selected using the Cluster Random Sampling technique, consisting of 36 students of class XI.5 as the experimental class and 35 students of class XI.10 as the control class. The research procedure was conducted through three main stages: (1) pre-research includes field observations, interviews with teachers and students, and preparation of tests and questionnaires; (2) research implementation includes Pretest, Treatment, and Posttest; and (3) post-research includes data analysis. This study lasted for four weeks and was structured based on the method proposed by (Fraenkel et al., 2007).

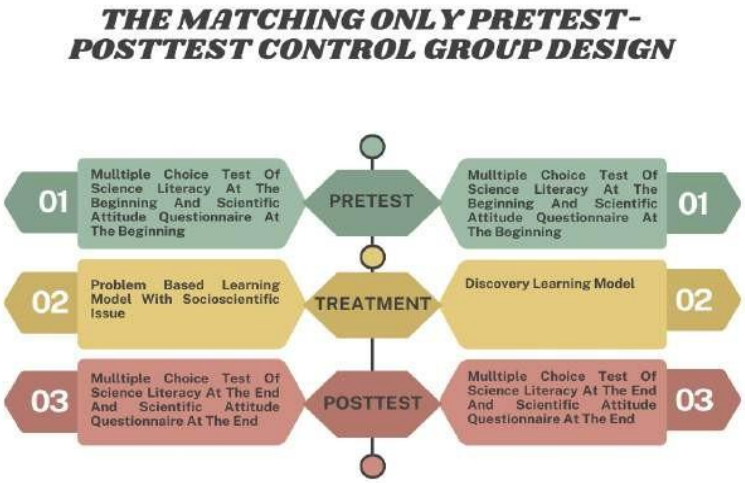

Figure 3. Research Design

The research instruments consisted of a Likert scale questionnaire to measure scientific attitudes, as well as a Mulltiple Choice test designed to measure science literacy on excretory system material. The science literacy test consists of 20 items covering content, process, and context, arranged according to the dimensions of science literacy according to the OECD (OECD, 2023). Meanwhile, the student scientific attitude questionnaire contains 20 items grouped based on indicators developed by Arthur A. Carin. These indicators include curiosity, scepticism, positive attitude towards failure, prioritising evidence, accepting differences, and working together. The grids of the science literacy and scientific attitude instruments are presented in Figure 4.

Data analysis using SPSS version 26 involved several steps. First, the N-Gain value was calculated to measure the effectiveness of the Problem Based Learning with Socioscientific Issue model on students' scientific literacy and attitude before and after learning. To determine whether the test and questionnaire data were normally distributed,

the normality test was conducted using the Kolmogorov-Smirnov method with a significance level > 0.05. If the data distribution is normal, the next step is to conduct a homogeneity test (using the Fisher test) to ensure that the sample variance matches the population (significance > 0.05), so that the data is declared homogeneous. Finally, the parametric Independent Sample t-Test was conducted with a significance level of < 0.05 to determine whether the learning treatment had a significant impact on students' scientific literacy and attitude.

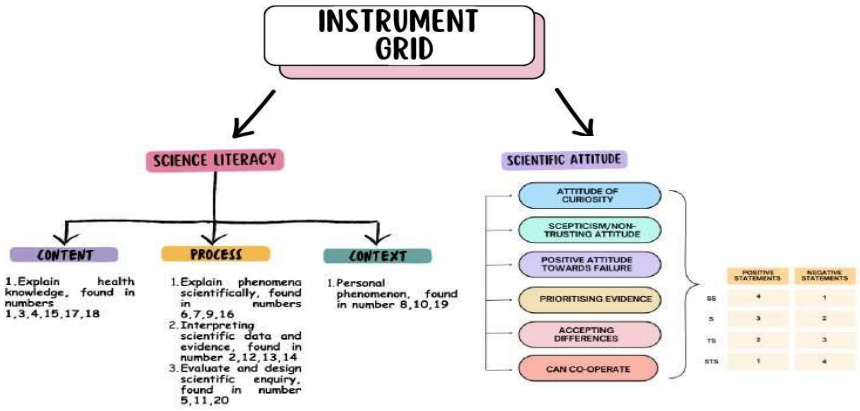

Figure 4. Instrument Grid

▪ RESULTS AND DISCUSSION

This study aims to analyse the effect of Problem Based Learning model associated with socioscientific issues on science literacy and scientific attitudes of high school students. The research data were obtained through science literacy and scientific attitude tests of students before and after learning. The pretest and posttest results for the control and experimental classes are summarised and explained in the following sections.

Science Literacy

The ability to understand, communicate and use scientific information in solving problems is referred to as science literacy. Science literacy includes scientific knowledge (content), scientific competence (process) and relevant application of science (context) (OECD, 2023). Science literacy has an important role in learning, which can be seen from a number of key aspects that are the focus of attention, such as mastery of concepts, ability to analyse, make conclusions, and apply knowledge gained through critical thinking. Figure 5 below shows the average N-Gain, Pretest and Posttest scores of science literacy

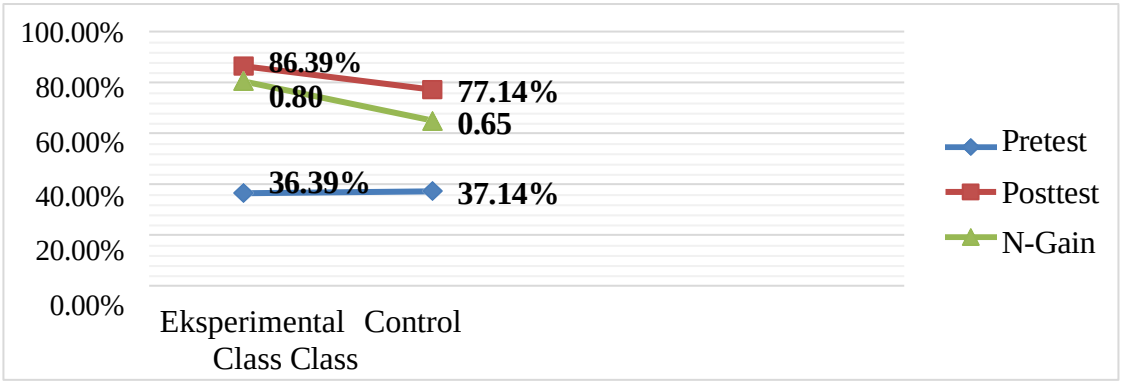

Figure 5. Average Science Literacy Pretest and Posttest Scores

Based on Figure 5, science literacy in the experimental class increased from 36.39% Pretest, to 86.39% Posttest, with an N-Gain of 0.804 in the 'high' category. In the control class, Pretest results reached 37.14%, while Posttest results were 77.14%, with an N-Gain of 0.650 in the 'medium' category. Both classes showed an increase in science literacy. However, the increase in science literacy in the experimental class was more significant than the control class. The Problem Based Learning model encourages students to learn actively, find solutions, and develop critical thinking and problem solving skills by placing problems as the main focus of the learning process (Lismiyani et al., 2017). Research (Giriyanti et al., 2019) concluded that the application of the Problem Based Learning model produced an N-gain of 0.69 in the 'high' category and had a significant impact on science literacy with an Effect Size of 1.94.

In both classes, both experimental and control, the proportion of students based on N-Gain achievement in the science literacy test showed similar results, namely no students were classified in the low category. The experimental class consisted of 83.33% or 30 students in the high category, and 16.67% or 6 students in the medium category, with the dominance of the high category. Meanwhile, the control class had 28.57% or 10 students in the high category, and 71.43% or 25 students in the medium category, with the dominance of the medium category. The percentage of N-Gain can be seen in Figure 6.

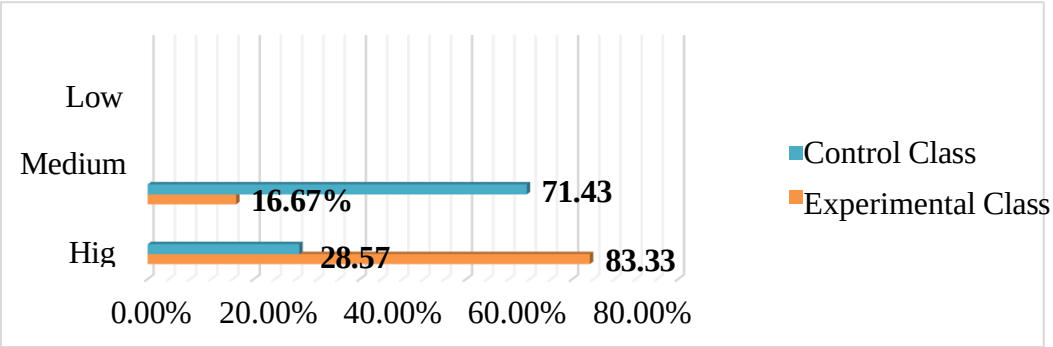

Figure 6. Percentage of Number of Students by N-Gain Achievement

Based on Figure 6, students with high science literacy are able to utilise scientific knowledge to solve everyday problems with the support of data and facts. This shows that the Problem Based Learning model with Socioscientific Issue has a significant impact in improving science literacy. Students with medium science literacy are able to apply scientific knowledge well, although they still rely on data and facts. Meanwhile, the low category shows an opportunity for improvement in the utilisation of scientific knowledge. Based on these results, the Problem Based Learning model with Socioscientific Issue proved effective in improving science literacy, which includes five main components: understanding health, explaining scientific phenomena, interpreting data, designing scientific investigations, and understanding personal phenomena. Figure 7 shows the percentage of science literacy in each component.

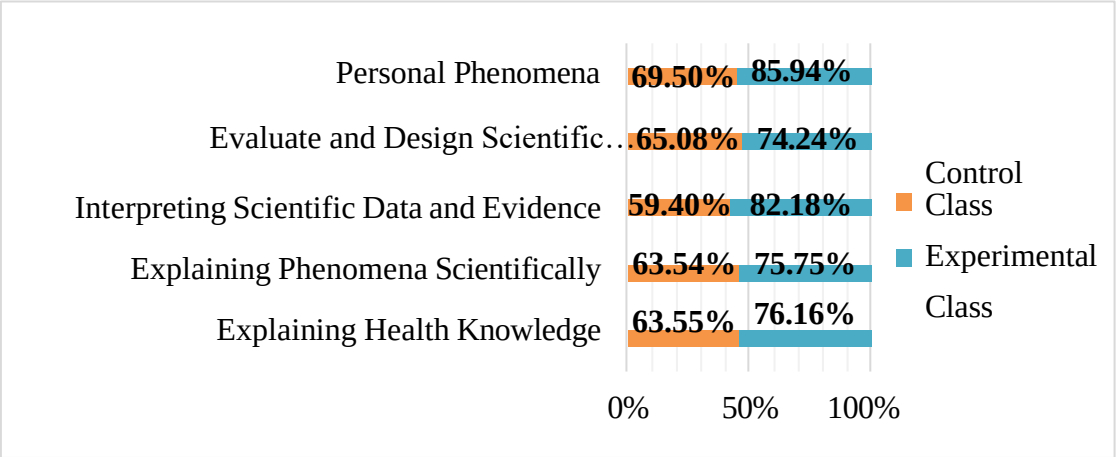

Figure 7. Comparison of The Percentage of Science Literacy Components

Based on Figure 7, students' science literacy in the experimental class improved more significantly than the control class. The N-Gain shows a clear difference between the two classes for each aspect of science literacy. In the experimental class, all aspects improved, with personal phenomena recording the highest increase of 85.94% (high category). Whereas in the control class, personal phenomena reached 69.5% (medium category), and the ability to interpret data and scientific evidence was the lowest with 59.45%. In contrast, in the experimental class, the lowest score on designing and evaluating scientific investigations reached 74.24%. The experimental class using Problem Based Learning with Socioscientific Issue showed more significant results than the control class with Discovery Learning. This shows that the Problem Based Learning model is more effective in improving science literacy. This finding is supported by research (Zulfa et al., 2022) and (Lendeon & Poluakan, 2022) which show that the application of the Problem-Based Learning model has a positive impact on students' science literacy skills at the secondary school level. This model encourages active participation and critical thinking of students in dealing with problems. Other research by (Juleha et al., 2019) and (Qomariyah et al., 2019), which states that Problem Based Learning significantly improves higher-order science literacy in various components.

Problem-Based Learning Model With Socioscientific Issues In Improving Explaining Health Knowledge

The first component of science literacy is content, covering the basic ideas of science needed to understand changes due to human activities and natural phenomena (OECD, 2023). The ability to explain health knowledge is included in this component. In the experimental class, there was a more significant increase in the average pretest and posttest scores compared to the control class. Figure 8 shows the average score of the component of explaining health knowledge on the Pretest and Posttest.

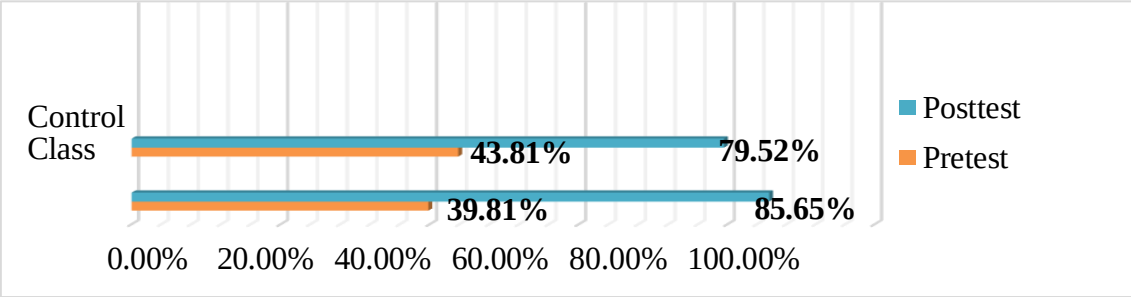

Figure 8. Mean Score of Science Literacy Component of Explaining Health Knowledge

Based on Figure 8, it can be seen that students' science literacy skills in the experimental class experienced a significant increase, with an average value of 39.81% in the Pretest and reached 85.65% in the Posttest in the excellent category. Meanwhile, the control class only obtained an increase from the Pretest of 43.81% to 79.52% on the Posttest. This improvement is due to the application of the Problem Based Learning model with Socioscientific Issue, which helps students maximise student knowledge. This model supports the content dimension with stages of organising students to learn, where students review science concepts and collaborate to solve problems based on scientific evidence. The Problem Based Learning model is designed to create a deep and meaningful learning experience. It actively involves students at every stage, encouraging them to collaborate, think critically and find solutions to problems, making learning more relevant and applicable (Pasaribu & Suyanti, 2024). This model is proven effective in improving students' science literacy because it involves students actively in problem solving (Sari et al., 2024). Research (Utami & Setyaningsih, 2022) also supports these findings, showing that the application of the Problem Based Learning model significantly improved students' understanding of science content.

Problem-Based Learning Model With Socioscientific Issues In Improving The Ability To Explain Phenomena Scientifically

The second component of science literacy is competence/process, which includes the ability to answer questions and solve problems (OECD, 2023). One of the main components in this category is the ability to explain scientific phenomena. Students must recall relevant knowledge in a specific context to analyse and explain the phenomenon at hand, including the capacity to explain or characterise changes that may occur. The mean scores of the Pretest and Posttest of the experimental class showed a more significant increase than the control class on this component. Figure 9 displays the average score of the component of explaining scientific phenomena in the Pretest and Posttest.

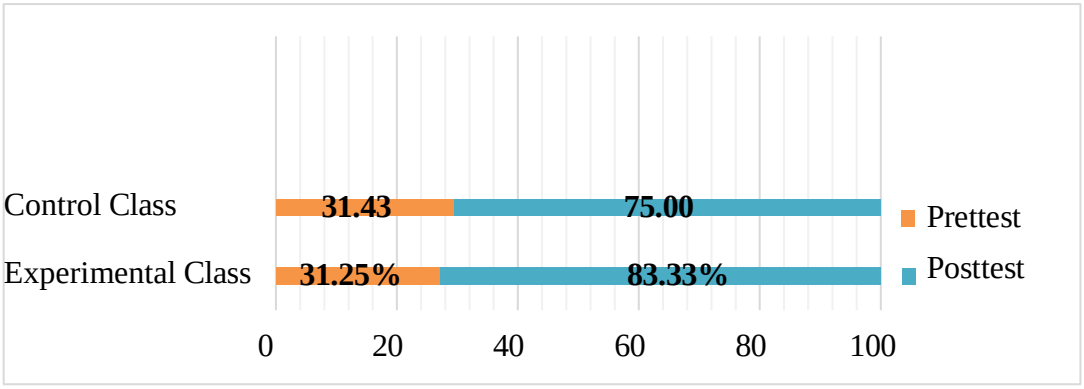

Figure 9. Average Score of Science Literacy Component of Explaining Scientific Phenomena

Based on Figure 9, students' ability to explain scientific phenomena in the experimental class increased to 83.33%, while in the control class to 75.00%. This increase shows that students in the experimental class can remember and use scientific data in everyday situations. This finding is supported by (Gunawan et al., 2021), which states that a high N-Gain value reflects an increase in students' ability to explain scientific phenomena through contextual learning. Students find it easier to understand questions related to scientific phenomena than other aspects. Students are able to evaluate material, identify scientific issues, and use relevant data to answer questions appropriately.

This aspect of science literacy is strengthened through the application of the Problem Based Learning model with Socioscientific Issues which focuses on guiding individual or group investigations. Students are expected to gather information from trusted sources, conduct investigations, and have active discussions to resolve issues. Students also practice urine examination, discuss, and prepare a report and E-Poster on the prevention of excretory system disorders. This model helps students develop scientific attitudes and improve science literacy. Research (Permatasari et al., 2019) shows that investigative activities that are adapted to everyday situations make learning more innovative, fun, and challenging, allowing students to build their own knowledge.

Problem Based Learning Model with Socioscientific Issue in Improving the Ability to Interpret Scientific Data and Evidence

The next competency component is interpreting scientific data and evidence, where students are expected to convey the meaning of scientific facts and their impact on certain groups using their own words, diagrams, or other relevant presentations (OECD, 2023). The average of the Pretest and Posttest in the experimental class showed a more significant improvement compared to the control class in this aspect. Figure 10 displays the average results of the Pretest and Posttest for the component of interpreting scientific data and evidence.

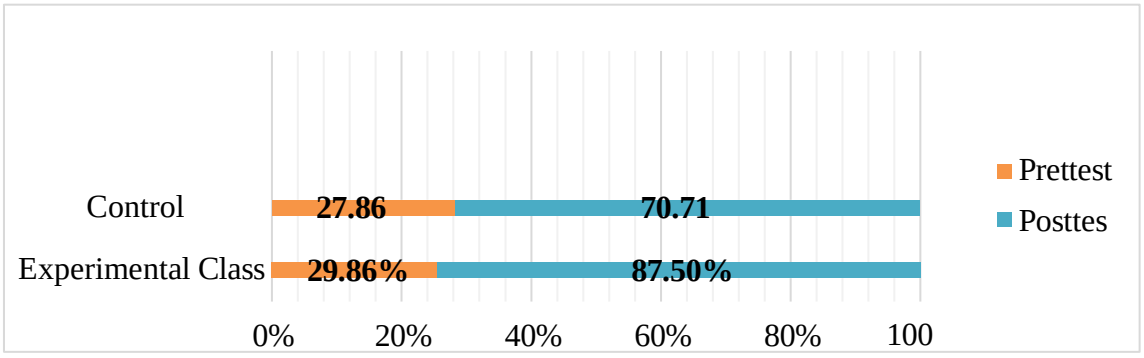

Figure 10. Results of The Average Score of The Science Literacy Component of Interpreting Data And Scientific Evidence

Based on Figure 10, the average Posttest score of students' ability to interpret data and scientific evidence in the experimental class increased to 87.50%, while in the control class it only reached 70.71%. This shows that students who work together in investigations understand the topic better. This component of science literacy is strengthened by the Problem Based Learning with Socioscientific Issue model, where students develop and present tasks and compile lab reports supported by facts collected during learning. Students' analytical, evaluative and creative skills are evident when students are asked to formulate hypotheses related to the problem at hand, especially in the early stages of organising learning. These skills become stronger when students complete advanced tasks, producing works such as lab reports and E-Posters. After completing the task, students presented their findings in class to continue the discussion. This research shows that the application of the Problem Based Learning model with Socioscientific Issues makes students more involved and responsible in exploring ideas and problem solutions (Wulansari et al., 2019).

Problem-Based Learning Model With Socioscientific Issues In Improving The Ability To Evaluate And Design Scientific Investigations

The ability to evaluate and design scientific investigations is the last component of science literacy competence, relating to students' skills in critically analysing scientific information and findings (OECD, 2023). The average Pretest and Posttest scores in the experimental class showed a more significant improvement than the control class in this component. Figure 11 displays the average results of the Pretest and Posttest for the component of evaluating and designing scientific enquiry.

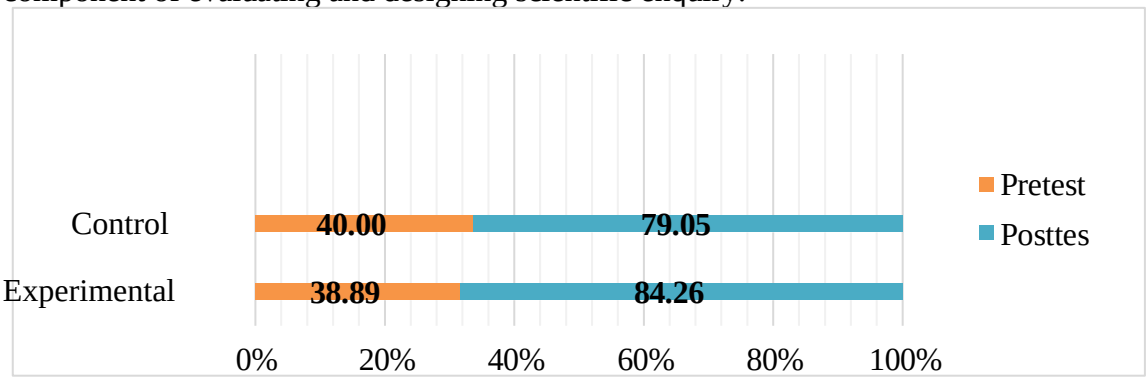

Figure 11. Results of The Average Score of The Science Literacy Component of Evaluating And Designing Scientific Investigations

Based on Figure 11, in the experimental class, the average Posttest score of students' ability to evaluate and design scientific investigations increased to 84.26%, while in the control class it was 79.01%. This increase can be seen in the analysis and evaluation stage of Problem Based Learning with Socioscientific Issues, where students analyse learning experiences, including investigative skills. Students evaluate the initial learning issues and search for answers related to the health of the excretory system. The teacher provides constructive feedback and supports reflection on ideas and tasks completed. This addresses the need for critical and analytical thinking in the evaluation of scientific projects. However, science learning still tends to focus more on theory rather than application of ideas to the real world (Pratiwi et al., 2019). And students need to practice these analytical skills further.

Problem-Based Learning Model With Socioscientific Issues In Improving The Ability Of Personal Phenomena (Context)

The context dimension is the last dimension in science literacy, which shows the application of science in everyday life (OECD, 2023). This dimension helps students understand science concepts through scientific processes in the real world. One of the components in this dimension is personal phenomena. Based on these components, it can be seen that the increase in Pretest and Posttest scores is more significant in the experimental class compared to the control class. The average Pretest and Posttest scores of the personal phenomena component are shown in Figure 12.

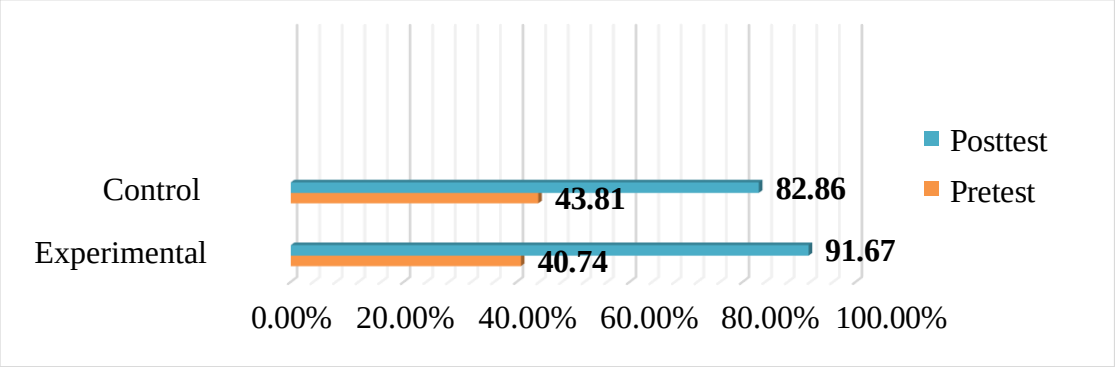

Figure 12. Results of the Average Value of Science Literacy Component of Personal Phenomena

Based on Figure 12, the average increase in Posttest understanding of personal phenomena of students in the experimental class reached 91.67%, while the control class recorded 82.86%. This component is present in the Problem Based Learning with Socioscientific Issue model at the problem orientation stage. At this stage, students are encouraged to analyse real-world problems more systematically with the help of visual media depicting personal issues. This phase is designed to train critical thinking skills and keep students engaged in learning. The main goal is to improve students' exploration and understanding of science, especially related to excretory system health issues.

In this study, researchers implemented the Problem Based Learning model with Socioscientific Issue, where students conduct practicum that focuses on problem solving, starting from identifying social issues, analysing their impact, to formulating relevant

problems. According to (Sutarno et al., 2017), practicum can improve students' critical and analytical thinking skills. The Problem Based Learning with Socioscientific Issue model also involves real-world issues as a learning context to train critical thinking and problem solving skills, as well as understanding knowledge concepts (Cahyani & Setyawati, 2017). Therefore, this model is considered effective in improving students' science literacy because it is contextualised and stimulates higher-order thinking.

The Socioscientific Issue approach during learning influenced the difference in improvement between the experimental and control classes. The observation results showed that students conducted discussion and observation as the main activities, both with and without the Problem Based Learning with Socioscientific Issue model. Students' understanding improved through the application of the Problem Based Learning with Socioscientific Issue model, with worksheets appropriate to the topic and its application in real life as a guide. Students conduct investigations and discussions to solve problems, and afterwards the teacher provides more relevant explanations. According to (Iordanou & Constantinou, 2015) students can build arguments through debate, receive criticism, and make improvements. This process helps students refine arguments and draw more appropriate conclusions, as well as improve understanding of the evaluation of socio-scientific issues. The Socioscientific Issue approach encourages students to learn science independently, practice argumentation skills, and hone moral reasoning (Friedrichsen et al., 2021). Because the topics discussed are relevant to everyday life, students find it easier to convey arguments when facing controversial social issues related to science (Friedrichsen et al., 2021). Research conducted by (Hestiana & Rosana, 2020) showed that the Problem Based Learning model with Socioscientific Issue proved effective in improving students' problem solving skills and science literacy.

The application of Problem Based Learning model with Socioscientific Issue can improve students' critical thinking skills and participation. Students are invited to work together to solve problems seriously. In dealing with relevant socioscientific issues, students are trained to think critically, openly, and reflectively in solving problems. According to research conducted by (Habibah & Asma Amaniatul 'Ulya, 2024) this model is effective in improving science literacy. The results showed that the experimental class had higher science literacy than the control class, proving the superiority of this model over Discovery Learning. This approach gives students the freedom to think more broadly, considering social, moral, and ethical aspects, so that students' problem-solving skills become more critical.

Scientific attitude

During learning, students' scientific attitudes are reflected in their responses to problems, helping students develop and complete tasks better. This scientific attitude makes students more sensitive to scientific issues and more prepared for complex tasks (Henrliniar, 2023). Students with good scientific attitudes tend to think clearly and are committed to higher achievement. The benefits are seen in the ability to solve problems effectively, deep understanding of the material, and good learning outcomes. Developing a scientific attitude is essential as it helps students appreciate their own and others' points of view, as well as being more analytical and open to new knowledge. The six scientific attitude indicators used in this study; curiosity, scepticism, positive attitude towards failure, prioritising evidence, and acceptance of differences were adapted from Arthur Carin. The N-Gain, Pretest and Posttest values for scientific attitude are shown in Figure 13.

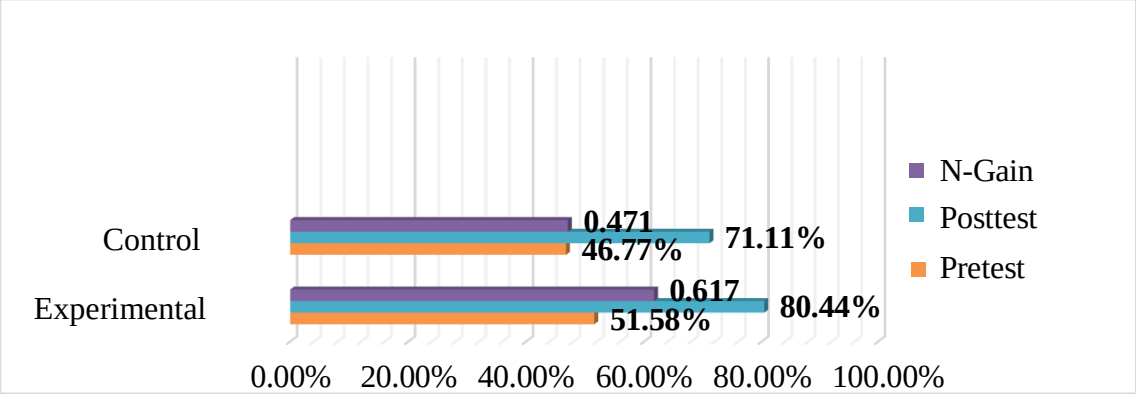

Figure 13. Average Pretest and Posttest Scores for Scientific Attitude

Based on Figure 13, the average value of scientific attitudes in the experimental class increased from 51.58% Pretest to 80.44% Posttest, with an N-Gain of 0.617 in the 'medium' category. In the control class, the N-Gain was only 0.471 with a category of 'low,' where the Pretest was 46.77% and the Posttest was 71.11%. Both classes experienced an increase, but the experimental class showed a more significant increase in scientific attitudes. This is because students in the experimental class followed the Problem Based Learning with Socioscientific Issue model, which encourages students to find solutions to real-world problems. Students are also invited to collect relevant information and work in small groups (5-6 people) to solve problems collaboratively.

There was a significant difference in the distribution of students based on the N-Gain achievement of scientific attitudes between the experimental and control classes. In the experimental class, 12 students (33.33%) were in the high category, 25 students (63.89%) in the medium category, and 1 student (2.78%) in the low category. Meanwhile, in the control class, only 3 students (8.57%) were in the high category, 26 students (74.29%) in the medium category, and 6 students (17.14%) in the low category. Figure 14 displays this N-Gain achievement.

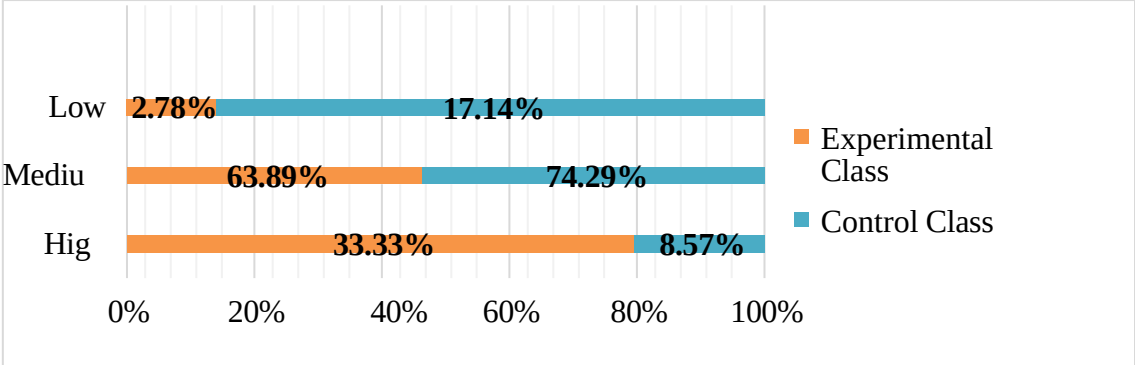

Figure 14. Percentage of Number of Students by N-Gain Achievement

The comparison between the experimental class with the Problem Based Learning and Socioscientific Issue model and the control class with the Discovery Learning model showed an increase in each scientific attitude indicator. The Problem Based Learning model is proven to have a positive impact on students' scientific attitudes because it involves real-life issues, gives freedom of thought, and encourages the preparation of reports as an

evaluation tool. This model also helps students develop self-discipline and scientific skills, so that students' scientific attitudes develop and become an important part of learning.

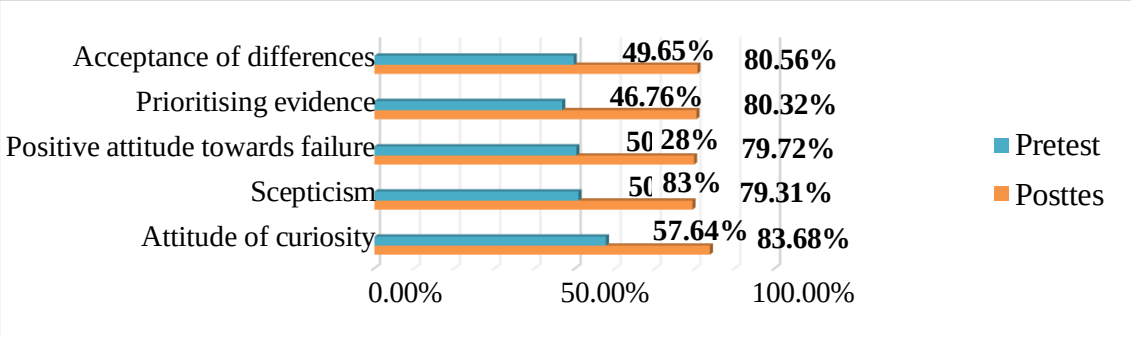

Figure 15. Comparison of Scientific Attitude Percentage

Based on Figure 15, the results of the scientific attitude questionnaire show that the Pretest score for each indicator is lower than the Posttest score, both in the experimental and control classes. In the experimental class, curiosity has the highest score with a Posttest of 83.68% and an N-Gain of 61.47% (moderate category). In contrast, skepticism has the lowest score with a Posttest of 79.31% (very good category) and an N- Gain of 57.92% (moderate category). In the control class, curiosity also recorded the highest score on the Posttest of 81.25% and an N-Gain of 57.32% (moderate category), while the indicator prioritizing evidence has the lowest score with a Posttest of 66.14% and an N-Gain of 39.22% (moderate category).

In the early stages, students are introduced to new challenges that trigger curiosity through the Problem Based Learning model with Socioscientific Issue. Students are given an introduction to problems relevant to learning objectives, using news articles or videos as stimuli to attract interest. At this stage, students in the experimental class showed higher curiosity than the control class. This finding is in line with research (Amalia & Pujiastuti, 2016), which states that Problem Based Learning provides interesting challenges that trigger students' interest in learning new information.

The second stage in the Problem Based Learning model with Socioscientific Issue is organizing students, where the teacher forms study groups and guides the learning process. Students work together to find solutions, with the help of LDPD or LKPD used to convey issues. In this stage, several scientific attitudes begin to appear, such as: (a) Strong curiosity about the issues presented, which encourages students to seek additional evidence to support their answers. Students in the experimental class were more actively involved and showed higher curiosity than the control class. (b) Cooperation, where students discuss and share ideas in groups to understand the concepts given.

In the third stage of the Problem Based Learning model with Socioscientific Issue, students conduct investigations individually or in groups, with teacher guidance. Students conduct experiments, such as urine tests for glucose, albumin, and chloride analysis. The practicum process includes preparation, implementation, collection, and data analysis. The teacher encourages students to seek information from credible sources and share views on the issues being discussed. At this stage, several scientific attitudes that emerge include: (a) curiosity, which encourages students to explore problems; (b) focus on evidence, where students conduct experiments to collect data and distinguish facts from opinions; (c) cooperation and respect for differences through collaboration in experiments; (d) a positive attitude towards failure, with students learning to analyze data carefully and correct

mistakes; and (e) a skeptical attitude, where students seek evidence to support the conclusions made.

In the fourth stage of Problem Based Learning with Socioscientific Issue, students are asked to present the results of experiments and group discussions in front of the class. In this process, students begin to develop a scientific mindset by learning to tolerate differences and appreciate other points of view. In addition, students also evaluate and analyze problem solving when drawing conclusions, which are then assessed by the teacher. When answering questions and conveying conclusions, students demonstrate deep understanding without manipulating facts, which indicates a skeptical mindset.

Students' scientific attitudes towards science need to be continuously developed so that students can act responsibly and understand the importance of science in everyday life. Science learning will be more effective if students are enthusiastic about understanding the concept, especially when the lesson begins with an interesting issue. A positive learning environment ensures that each student fully understands the material. A strong scientific attitude makes students more able to overcome obstacles because their curiosity drives their enthusiasm for learning more. One effective strategy to improve this scientific attitude is the application of the Problem Based Learning model with Socioscientific Issue. This is also reinforced by the findings (Wijaya et al., 2018) which state that student-centered learning models contribute to improving scientific attitudes in experimental classes.

▪ CONCLUSION

The implementation of the Problem Based Learning model based on Socioscientific Issue can be concluded to have an effect on students' scientific literacy and scientific attitudes in the excretory system material and supports continuous biology learning. For further research, it is important for researchers to have good time management so that the learning process can run efficiently and effectively. To provide more comprehensive and relevant results, future research is recommended to further explore the relationship between scientific literacy skills and scientific attitudes and see how much contribution the Problem Based Learning model based on Socioscientific Issue has to students' scientific literacy and scientific attitudes.

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