UNIVERSITAS SEBELAS MARET
BIOEDUKASI: JURNAL PENDIDIKAN BIOLOGI
https://jurnal.uns.ac.id/bioedukasi
1693-265X (Print) | 2549-0605 (Online)

The Effect of Problem-Based Learning on Students' Science Literacy Skills on the Topic of Human Excretory System

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Submission : 12/06/2023
Revision : 04/10/2023
Accepted : 02/02/2024

ABSTRACT

Science literacy is one of the 21st-century skills that students need to have. One of the things that affects students' science literacy skills is the learning model used. This study aims to determine the effect of the Problem-Based Learning (PBL) learning model on students' science literacy skills in human excretory system material in the class XI MIPA SMA Negeri 1 Tasikmalaya, Academic Year 2022/2023. The research method used was a quasi-experiment with a static-group comparison design. The population in this study were all XI MIPA classes of SMA Negeri 1 Tasikmalaya as many as 8 classes with a total of 283 students. The sampling technique was done by cluster random sampling method. The sample used in this study consisted of 2 classes, namely class XI MIPA 2 as an experimental class with a total of 33 students and class XI MIPA 3 as a control class with a total of 39 students. Data collection techniques in the form of giving instruments of science literacy skills with multiple choice questions as many as 37 questions related to the topic of human excretory system. Hypothesis testing using an independent t-test with a Sig value. (2-tailed) of 0.000 <0.05, therefore that H0 is rejected means that there is an effect of Problem-Based Learning (PBL) on students' science literacy skills on the subject of human excretory system in class XI MIPA SMA Negeri 1 Tasikmalaya Academic Year 2022/2023.

Keywords: Learning model, Problem-Based Learning, Science literacy skills

Introduction

Today the world has entered the 21st century which certainly brings its own challenges. Humans are required to have 21st-century skills in order to compete in everyday life. World Economic Forum (2015) states that there are 16 skills needed in the 21st century and are grouped into three broad categories, namely basic literacy, competence, and character quality. Based on the World Economic Forum, the basic literacy includes numeracy literacy, science literacy, digital literacy, financial literacy, and cultural literacy. Competencies include critical thinking and problem solving, creative thinking, communication and collaboration. Character qualities include curiosity, initiative, perseverance, adaptability, leadership, and social sensitivity.

Science literacy as one of the skills that must be possessed in the 21st century, needs to be considered for its development so that educational activities should aim to create a society that has science literacy. Science literacy by PISA is defined as the ability to engage with issues related to science and science ideas as a reflective citizen that includes the ability to explain phenomena scientifically, evaluate and design scientific investigations, and interpret data and evidence scientifically (OECD, 2017). Science literacy is considered important for learners to have because understanding related to science is an understanding of oneself or personal. However, can be shared with anyone because all individuals must experience scientific phenomena, the whole world is faced with life questions that require information and scientific thinking in order to determine and make decisions that are useful for the common good (Pratiwi et al., 2019). In addition, science literacy is also the core of science knowledge, because someone who has good science literacy is someone who can apply the knowledge, they have to be able to contribute to solving problems related to science in everyday life.

The ability assessment of students at the international level is known as the Program for International Student Assessment (PISA) which is held every three years by the Organization for Economic Cooperation and Development (OECD). One of the abilities of students assessed in PISA is science literacy. Indonesia is one of the countries assessed by PISA. In the 2015 assessment, Indonesia ranked 62nd out of 70 participating countries with an average score of 403 (OECD, 2016). Then in the assessment conducted by PISA in 2018, it was reported that Indonesia experienced a decrease in scores and ranked 70th out of 78 participating countries with a science ability score of 396 (OECD, 2019). The report from PISA shows that Indonesia is a country with a low level of science literacy skills (Sutrisna, 2021). Factors that cause the low science literacy skills of students in Indonesia include the curriculum and education system applied, the selection of teaching methods and models used by teachers, available facilities, teaching resources and teaching materials used in learning, and so on (Kurnia et al., 2014). In addition, science learning in Indonesia has not been contextualized, teachers prefer to transfer more knowledge without giving students the opportunity to explore their own abilities, which of course makes students unlikely to have progressed including their science literacy skills. Science literacy requires more attention from all parties. Science literacy can be improved in several ways, including paying attention to the quality of teachers, improving the teaching and learning process carried out by teachers including the use of appropriate learning models, preparing teaching materials and learning administration needed (Palines & Cruz, 2021).

Based on observations and interviews conducted by the author at SMA Negeri 1 Tasikmalaya in September 2022, the biology learning that was carried out still lacks varied learning, one of which was in the application of learning models. Learning that occurs is in the form of one-way learning and does not involve student activeness. Learners are still passive and have not displayed the abilities needed in the 21st century, such as conveying valid scientific arguments and scientific knowledge related to quantitative data, which are part of the science literacy indicator. In addition, the assessment instrument used did not contain questions with indicators of science literacy skills. Therefore, it is necessary to conduct research by applying a learning model that is able to train and improve science literacy skills in students at SMA Negeri 1 Tasikmalaya. The indicators of science literacy skills used in this study refer to the indicators of science literacy skills proposed by Gormally *et al*. (2012) which consisted of 9 indicators, including (1) identifying valid scientific arguments; (2) evaluating the validity of sources; (3) evaluating the use and misuse of scientific information; (4) understanding the elements of research design and how they impact scientific findings; (5) creating graphical representations of data; (6) reading and interpreting graphical representations of data; (7) solving problems using quantitative skills, including probability and statistics; (8) understanding and interpreting basic statistics; and (9) justifying inferences, predictions, and conclusions based on quantitative data. The selection of the human excretory system as topic of this study is based on the reason that the excretory system involves the interrelationship between many systems, such as the respiratory system and the sensory system so it is quite complicated for students. Based on the results of interviews with students in SMA Negeri 1 Tasikmalaya, it is known that students still have a poor grasp of the concepts in the excretory system because there are terms that are difficult to understand, which affects learning activities.

One solution that can be applied to train and improve science literacy, as part of the 21st-century skills that students must have, is to apply a learning model that is integrated with a scientific approach, one of which is the Problem-Based Learning (PBL) learning model (Kurniawati & Hidayah, 2021). This is in line with the explanation stated by Rizkita *et al*. (2016) that improving science literacy skills can be done by training problem-solving skills through the use of the Problem-Based Learning learning model. The Problem-Based Learning learning model is a learning model that is oriented towards real problems that occur and involves students to carry out activities to summarize information and use their logic to solve these problems and create a better understanding of the learning topic (Alatas & Fauziah, 2020). Problem-based learning is a model that uses problems as a learning context that requires deep thinking from learners to identify and evaluate several solutions and apply strategic thinking for problem-solving, thus presenting targeted and meaningful learning for learners (Smith et al., 2022).

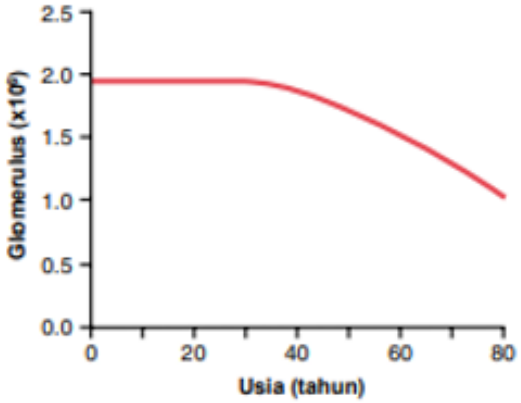
Based on the analysis of the problem, the purpose of this study is to determine the effect of Problem-Based Learning on students' science literacy skills on the topic of human excretory system in the class XI MIPA SMA Negeri 1 Tasikmalaya in the 2022/2023 academic year.

Methods

The research method used in this research is a quasi-experiment with the static-group comparison design. The population in this study were all XI MIPA classes of SMA

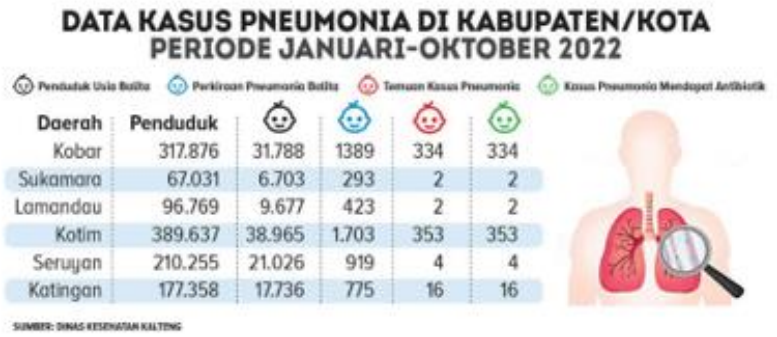
Negeri 1 Tasikmalaya, totalling 8 classes with a total of 283 students. The sampling technique used a cluster random sampling method consisting of 2 classes, which XI MIPA 2 class consisting of 33 students as the experimental class that uses problem-based learning and XI MIPA 3 class totalling 39 students as the control class uses discovery learning. The variables in this study are the Problem-Based Learning learning model as the independent variable and science literacy skills as the dependent variable.

The data collection technique used a research instrument of science literacy skills in the form of multiple-choice questions as many as 37 questions containing 9 indicators of science literacy skills proposed by Gormally. The research instrument was given to experimental and control class students after the learning material was delivered. Before the instrument is given, an instrument test is first carried out including a validity and reliability test using Anates software V.4 for Windows. The validity test results show that there are 37 valid questions and the reliability test results obtained a reliability coefficient (r) of 0.91 which can be interpreted as having a very high level of reliability. Data processing techniques include the normality test using the Kolmogorov-Smirnov test and homogeneity test using Levene test. Data analysis techniques include hypothesis testing using the independent t-test. All data processing and analysis used the help of SPSS software version 26 for *Windows*. A sample of science literacy skills questions is shown in Figure 1.



Berdasarkan grafik tersebut, pernyataan yang benar berikut adalah…

a. Semakin meningkat usia, maka tidak akan berpengaruh terhadap jumlah glomerulus
b. Semakin meningkat usia, akan menyebabkan peningkatan jumlah glomerulus
c. Semakin meningkat usia, akan menyebabkan penurunan jumlah glomerulus
d. Semakin meningkat usia, akan menyebabkan glomelurus semakin fungsional
e. Usia dan jumlah glomerulus tidak saling mempengaruhi



DATA KASUS PNEUMONIA DI KABUPATEN/KOTA
PERIODE JANUARI-OKTOBER 2022

Daerah	Penduduk				
Kobar	317.876	31.788	1389	334	334
Sukamara	67.031	6.703	293	2	2
Lamandau	96.769	9.677	423	2	2
Kotim	389.637	38.965	1.703	353	353
Seruyan	210.255	21.026	919	4	4
Katingan	177.358	17.736	775	16	16

Berdasarkan data yang disajikan pada gambar di atas, maka persentase temuan kasus pneumonia pada penduduk usia balita di daerah Kotim adalah…

a. 4,37 %
b. 20,73%
c. 0,91%
d. 1 %
e. 0,02 %

Figure 1. Sample of Science Literacy Skills Question

Results and Discussion

The data obtained in this study is in the form of posttest results of students' science literacy skills in experimental and control classes which can be seen in Table 1.

Table 1. Posttest Statistical Data of Science Literacy Skills of Experimental Class and Control Class Students

Statistic	Experimental Class	Control Class
Maximum Score	35	29
Minimum Score	20	13
Range	15	16
Mean	28.97	19.21
Standard Deviation	4.32	4.03
Variance	18.64	16.27

Table 1 shows that the average posttest score of science literacy skills of experimental class students is higher at 28.97 compared to the control class which is only 19.21.

Based on the results of the study and the prerequisite analysis tests that have been carried out including the normality test using the Kolmogorov -Smirnov test and the homogeneity test using the Levene test, the data population has a normal distribution and homogeneous variance. The entire prerequisite test analysis is shown in Table 2 and Table 3.

Table 2. Data Normality Test (*Kolmogorov – Smirnov* Test)

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Experimental Class	0.122	33	0.200*	0.941	33	0.075
Control Class	0.144	33	0.079	0.938	33	0.059

The results of the normality test in the experimental and control classes using the Kolmogorov - Smirnov test in Table 2 show a significance value of 0.200 (experimental class) and 0.079 (control class). The value is greater than 0.05 (> 0.05) so it can be concluded that H_0 is accepted which means that the posttest data of students' science literacy skills have been taken from a normally distributed population.

Table 3. Data Homogeneity Test (*Levene* Test)

Test of Homogeneity of Variances

			Levene Statistic	**df1**	**df2**	**Sig.**
Science Literacy Skills		Based on Mean	0.002	1	70	0.962
		Based on Median	0.003	1	70	0.958
		Based on Median and with adjusted df	0.003	1	67.493	0.958
		Based on trimmed mean	0.002	1	70	0.963

The results of the homogeneity test in the experimental and control classes using the Levene test in Table 3 show a significance value of 0.962. This value is greater than 0.05 (> 0.05) so it can be concluded that H_0 is accepted which means that the posttest data of students' science literacy skills have a homogeneous variance.

After the prerequisite analysis test is carried out and it is found that the data is normally distributed and homogeneous, then the hypothesis test is carried out using the independent t-test shown in Table 4.

Table 4. Hypothesis Test (*Independent T*-Test)

Independent Samples Test

		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**
Science Literacy	Equal variances assumed	0.002	0.962	9.770	70	0.000
	Equal variances not assumed			9.716	66.374	0.000

The hypothesis test results using the independent t-test in Table 4 show a Sig (2-tailed) value of 0.000. This value is smaller than 0.05 (<0.05) so it can be concluded that H_0 is rejected, which means that there is an effect of Problem-Based Learning on the

science literacy skills of students on the topic of the human excretory system in class XI MIPA SMA Negeri 1 Tasikmalaya in the 2022/2023 academic year.

The existence of this influence is because students have adapted to the use of the Problem-Based Learning model, which can increase students' learning activities from what was originally only an activity of listening to the teacher's explanation to activities that further improve the quality of students' thinking skills such as investigation and analysis activities. The stages of investigation and problem analysis in the Problem-Based Learning model can train students' science literacy skills because students are required to read, then search and find solutions to the problems presented so that students are trained to become problem solvers (Fauziah et al., 2019). Problem-Based Learning facilitates students in developing discussion skills among students in order to find and develop a solution to authentic problems related to the daily lives of students. A comparison of the average posttest scores of students' science literacy skills in experimental and control classes is shown in Figure 1.

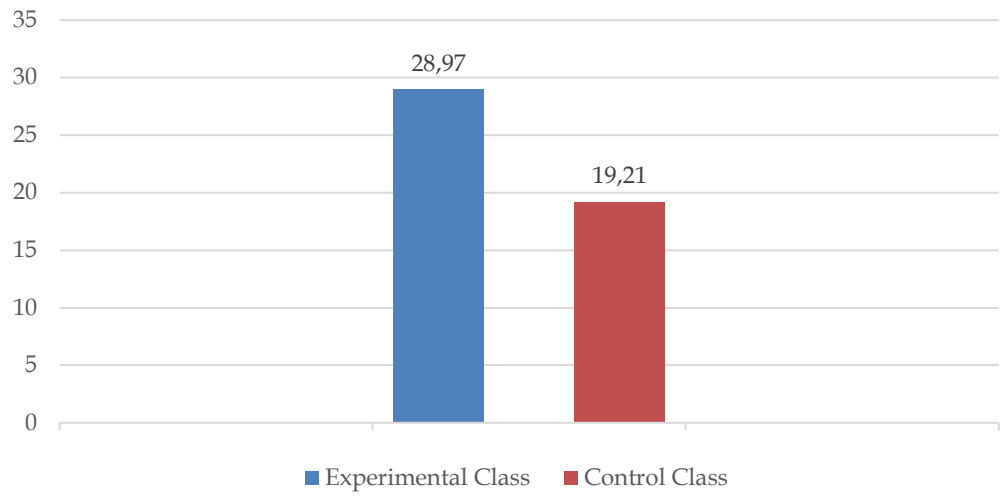


Figure 2. Comparison of Mean Posttest Score of Science Literacy Skills of Experimental and Control Classes

Figure 1 shows that the average posttest score of experimental class students using the Problem-Based Learning model is 28.97 and the control class using the Discovery Learning model is 19.21. From these results, it can be concluded that the average posttest score of science literacy skills of experimental class students is higher than the control class with a difference of 9.76.

The indicators of science literacy skills used in this study refer to the indicators of science literacy skills proposed by Gormally *et al*. (2012) which amounted to 9 indicators, including: (1) identifying valid scientific arguments; (2) evaluating the validity of sources; (3) evaluating the use and misuse of scientific information; (4) understanding the elements of research design and how they impact scientific findings; (5) creating graphical representations of data; (6) reading and interpreting graphical representations of data; (7) solving problems using quantitative skills, including probability and statistics; (8) understanding and interpreting basic statistics; and (9) justifying inferences, predictions, and conclusions based on quantitative data. The average posttest score per question indicator from the experimental and control classes can be seen in Figure 2.

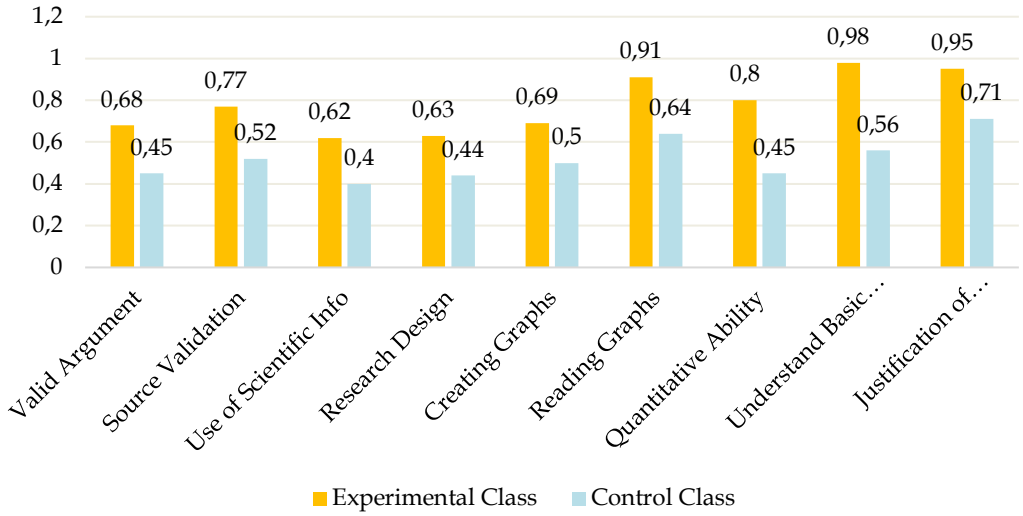


Figure 3. Average Acquisition of Posttest Score per Indicator of Science Literacy Skills of Experimental and Control Classes

Figure 2 shows that there are differences in the average posttest scores per indicator of science literacy skills from the experimental and control classes. The order of the average posttest score per indicator in the experimental class from highest to lowest is the indicator of understanding and interpreting basic statistics (0.98), justifying inferences, predictions, and conclusions based on quantitative data (0.95), reading and interpreting graphical representations of data (0.91), solving problems using quantitative abilities, including probability and statistics (0.80), evaluate the validity of sources (0.77), create graphical representations of data (0.69), identify valid scientific arguments (0.68), understand the elements of research design and how they impact scientific findings (0.63), and evaluate the use and misuse of scientific information (0.62). As for the control class, the highest to lowest average posttest scores started from the indicators of justifying inferences, predictions, and conclusions based on quantitative data (0.71), reading and interpreting graphical representations of data (0.64), understanding and interpreting basic statistics (0.56), evaluating the validity of sources (0.52), create graphical representations of data (0.50), solve problems using quantitative skills, including probability and statistics (0.45), identify valid scientific arguments (0.45), understand elements of research design and how they impact scientific findings (0.44), and evaluate the use and misuse of scientific information (0.40).

The indicator of science literacy ability with the highest average post-test score in the experimental class was the indicator of understanding and interpreting basic statistics with a score of 0.98. This result is in line with research conducted by Utami and Sari (2020) which states that the indicator of understanding and interpreting basic statistics is an indicator of science literacy with the highest percentage score in the research conducted, which is 60.22%. Meanwhile, the average posttest score on the same indicator in the control class only obtained a score of 0.56. The results obtained by the experimental class were higher than the control class because the learning process had been carried out according to the syntax of the Problem-Based Learning model in the experimental class, which is at the stage of guiding the investigation to the stage of analysis and evaluation of students.

In the third stage, guiding the investigation, students carry out investigative activities in the form of searching for as much information as possible from various sources and finding various scientific evidence that can help students formulate a solution to the problem. Information and scientific evidence found by learners can be in the form of statistical data, thus requiring learners to be able to understand statistical data as scientific evidence. Then, it is interpreted and becomes a discussion material that will be analyzed by learners in order to create the right solution to overcome the problems presented. This investigation stage will trigger the level of students' reading skills in processing various information, making a conclusion, analyzing various scientific evidence, and interpreting the evidence into a conclusion that can be understood by many people (Zulfa et al., 2022).

In the next stage, after students collect information and various scientific evidence, which can be in the form of statistical data, students will interpret statistical data into a solution that will be presented and conveyed to other students. Other learners then analyze and evaluate the solutions presented using possibly different interpretations. Therefore, from the stages or syntax of guiding investigation, presenting results, to analysis and evaluation, learners have been trained to understand and interpret basic statistics as scientific evidence to support the creation of a solution to the problem. Learners can improve their ability to examine data through scientific inquiry which can be trained in Problem-Based Learning activities at the problem investigation stage which includes the third, fourth, and fifth stages of guiding inquiry, presenting results, as well as analysis and evaluation (Hafizah & Nurhaliza, 2021).

The lowest average posttest score per indicator in the experimental class was in the indicator evaluating the use and misuse of scientific information with a score of 0.62 and 0.40 in the control class. Students have been able to find scientific evidence and information obtained from various sources, but have yet to be able to understand the use of scientific information and evidence in the right situation. Learners need to be able to apply the knowledge that has been obtained to be applied to the problems raised. Generally, the difficulty faced by learners in this indicator is still giving equal weight to all types of controversy or misuse without paying attention to the level of validity (Prabowo & Fidiastuti, 2017).

In all indicators of science literacy skills, the experimental class gets a higher average post-test score so it can be concluded that the use of the Problem-Based Learning model affects the science literacy skills of students. The Problem-Based Learning model is a learning model that makes authentic problems that have not been identified or are not well structured. So that it has the potential to bring up diverse or open-ended solutions as the core of learning that requires students to maximize all their thinking and analysis skills in order to solve these problems to find solutions.

Another advantage of the Problem-Based Learning model is that it requires a problem-solving process which is a good strategy to understand learning better., able to improve the ability and activeness of students, provide satisfaction for new knowledge and information obtained, provide opportunities for students to apply their knowledge to real life, and make students as problem solvers (Lestaringsih & Wijayatiningsih, 2017). This is in accordance with the definition of science literacy, which is the ability to explain scientific phenomena that occur in everyday life and use this scientific knowledge to make decisions in the form of solutions and solve real problems.

Hartati (2016) states that the Problem-Based Learning model makes students independent learners so it is oriented towards students (students-centred learning). Moreover, the learning stages in Problem-Based Learning facilitate students to be trained and develop their abilities in accordance with the indicators of science literacy skills that have been learned.

The use of the Problem-Based Learning model supported by the stages of problem orientation, organizing activities, guiding investigations, presenting results, as well as analysis and evaluation requires students to be more active in learning activities in order to solve problems that have not been identified, and also create diverse solutions. So that they were able to train students' higher-level thinking skills such as the ability to identify, evaluate, and use scientific information and evidence, which is part of the indicators of science literacy skills.

Conclusion

Based on the results of research and data analysis that has been conducted, it can be concluded that there is an effect of Problem-Based Learning on students' science literacy skills on the topic of human excretory system in the class XI MIPA SMA Negeri 1 Tasikmalaya academic year 2022/2023. This is proved by the results of hypothesis testing using an independent t-test which states that H_0 is rejected with a value of 0.000 < 0.05. From this study, it can be proposed that other studies could be conducted using different learning topics and different research instruments, such as using essay questions.

Acknowledgement

The author would like to thank the principal, biology teacher, students of class XI MIPA, all staff of SMA Negeri 1 Tasikmalaya, and all parties who have helped the completion of this research.

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