



## Problem based learning model using vee diagrams on students' scientific literacy of environmental pollution material



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### ABSTRACT

One of the factors of the low scientific literacy of students is influenced by the learning model used during the learning process. This study aims to determine the effect of the problem based learning (PBL) model using vee diagrams on environmental pollution material on students' scientific literacy skills. The sample consisted of 68 students, consisting of class VII 1 and VII 3 who were selected by purposive sampling technique. The research data were obtained from test questions and response questionnaires, the data were analyzed using the independent sample t-test. The results showed the average N-gain of science literacy abilities of students in the experimental class ( $0.48 \pm 0.16$ ) with "moderate" criteria and the control class ( $0.23 \pm 0.13$ ) with "low" criteria. This shows that learning using the PBL model using vee diagrams has a better effect on increasing students' scientific literacy skills. The results of the questionnaire response analysis had an average percentage was 88.8%.

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### INTRODUCTION

The development of science and technology in the 21st-century has increased rapidly, causing competition in the future, especially in the field of education that must be faced by students. Education is expected to be a solution to create a generation that is ready to face global competition in various fields so they will be able to meet the needs of human resources who have complete competence. This demand is known as the competence of the 21st-century. Based on the "21st-century partnership learning framework", there are several competencies and expertise that 21st-century human resources must possess, which are: 1) critical thinking and problem-solving skills, 2) communication and collaboration skills, 3) creation and renewal skills, 4) information and communication technology literacy, 5) contextual learning skills, 6) information and media literacy skills (BSNP, 2010).

The curriculum becomes an important part of the successful implementation of education. Currently, the education system in Indonesia has implemented the curriculum K13 (Kemendikbud, 2013). According to the Kemendikbud (2013), K13 is a competency-based curriculum designed to anticipate the competency needs of the 21st-century. The use of the 2013 curriculum is expected to produce a generation that is ready to face global competition in various fields, especially in facing the world of work. There are 4 points for the development was 2013 revised 2017 curriculum, which are: 1) strengthening character education; 2) creative, critical thinking, communicative, and collaborative (4C); 3) higher-order thinking skill (HOTS); 4) science literacy. Students through this learning can finally produce graduates with character, competence, and literacy who are ready to face the challenges of the 21st-century (Kunandar, 2015).

Students are required to have scientific literacy skills. Scientific literacy is defined by PISA (Program for International Students Assessment) as knowledge and its use to identify questions, acquire new knowledge, explain scientific phenomena and draw conclusions based on evidence. The importance of scientific literacy to be mastered by students in understanding the benefits and purposes of what has been learned, including the ability to use scientific knowledge, the ability to gain scientific understanding, and the ability to interpret and obey facts (Rusmiyati & Saptaningrum, 2017). In this case, PISA distinguishes scientific literacy in four dimensions, that are: content (knowledge), process (competence), context, and attitudes (OECD, 2015).

The fact of the low level of scientific literacy in Indonesia can be seen from the organization for economic cooperation and development (OECD), which shows that Indonesia's ranking on PISA in 2009 was 57th out of 65 with a score was 383. In 2012 Indonesia was ranked 64th out of a total of 65 countries with the current score was 382. Furthermore, in 2015 Indonesia was ranked 64th out of 72 participating countries, with a score was 403. Based on the results of the three surveys, the scores of Indonesian students on scientific literacy skills are still far behind the international standard score set by the OECD institution. The low ability of scientific literacy in Indonesia is influenced by several factors, including the curriculum and education system, the selection of models and methods in teaching by educators (Kurnia, Zulherman & Fathurohman, 2014).

The results of the previous study obtained data which shows that Way Jepara junior high school I has implemented the 2013 curriculum. During the learning process by the science teachers at Way Jepara junior high school I, they have not used various methods and models, especially models that direct students to carry out scientific skills. The method that is often used by the teachers is the lecture method, but certain materials are delivered using experimental and cooperative methods in the learning process.

It can be said that the scientific literacy skills of students at Way Jepara I junior high school have not been achieved. This can be seen from the answers of the teachers when conducting interviews, they already know about scientific literacy in school, but in its application, the teachers still find it difficult because students' reading interest in science material is still lacking. Besides, the teachers do not know the indicators in scientific literacy so that the science learning process has not been oriented towards achieving scientific literacy. The teachers also do not know how to measure scientific literacy skills in science learning so that the test questions used cannot be categorized as measuring students' scientific literacy abilities. Teachers stated that some of the students were able to use science knowledge at school and relate it to phenomena in everyday life even though they were not able to do it independently and still needed guidance.

The efforts to improve students' scientific literacy skills are by choosing the right learning model so that each learning process can build students' scientific literacy. The learning model chosen must be by the learning environment so that the objectives of learning are achieved. The learning model that can overcome these problems is the problem-based learning (PBL) model. PBL

or problem-based learning is a learning approach that presents contextual problems that stimulate students to learn, in this case, students work in teams (groups) to solve real-world problems (Kurniasih & Berlin, 2014). The results of research from Mundzir, Sujana & Julia (2017) shown that the increase in scientific literacy with problem-based learning (PBL) is not more by the activities of students who are active in ongoing learning, because in problem-based learning students are trained to think critically to solve existing problems. In other research, it has also been revealed that the application of the PBL model can help familiarize students with understanding concepts and be able to apply known concepts to solve daily life problems and students' scientific literacy can increase (Imaningtyas, Karyanto, Nurmiyati & Asriani, 2016). So, it can be concluded that the implementation of the PBL model can improve scientific literacy skills in the attitude aspect significantly.

Not only using the problem-based learning (PBL) model but in the learning process, it will be assisted by vee diagrams. Novak & Gowin (1984) suggest that the vee diagram concept can be used as a strategy or instructional structure to develop students' metacognitive abilities. So far, teachers are not familiar with Vee Diagrams, their function, and their use in learning. Vee diagrams can be a tool to help to form the concept of knowledge of students. Research conducted by Alvarez & Rizko (2007) and Dewi, Saefudin, Supriatno & Anggraeni (2016) regarding the effectiveness of using Vee Diagrams to help students in the concept of science and meaningful learning shows that Vee Diagrams are a viable tool for studying knowledge structures and the process of gaining knowledge including participant metacognitive students. Based on the results of research conducted by Dewi et al. (2016) the application of vee diagrams in problem-based learning (PBL) has a significant effect in increasing the quantitative literacy skills of students. Whereas in this study, the authors examined scientific literacy in terms of content aspects including the ability of students to define scientific terms, classify, understand natural phenomena, and illustrate problem-solving related to learning materials and aspects of the process which include the ability to identify scientific questions, explain scientific phenomena, and use scientific evidence.

The material regarding environmental pollution is one of the topics contained in KD 3.8 class VII, where the students are required to analyze the occurrence of environmental pollution and its impact on the ecosystem. This material is important to be understood by students and its application in everyday life. In environmental pollution material, students will understand the concept better if it is presented in an environmental problem that occurs around them. The choice of the PBL model in learning helps to achieve learning competencies because PBL directs students to find problem solvers and is assisted by vee diagrams as a tool to build students' knowledge concepts.

Based on the problems that have been described, the researchers are interested in studying and analyzing the application of the vee diagram structure in learning with the PBL model to find out how much influence the vee diagram strategy can develop students' literacy skills. This is what motivates researchers to research to determine the effect of the problem-based learning (PBL) model using vee diagrams on students' scientific literacy skills in environmental pollution material for class VII in Way Jepara junior high school I.

## RESEARCH METHODS

### Research Design

The research design used was a quasi-experiment with a pretest-posttest technique non-equivalent control group design. This design is in the placement of subjects in groups that are compared not randomly. Individual subjects are already in the group that will be compared before the study. The pretest-posttest non-equivalent control group design technique involved two groups

(the experimental group and the control group). The two groups will be treated with different learning models (Sugiyono, 2013).

### Population and Samples

The population in this study were all VII grade students in the even semester of Way Jepara junior high school I in the 2019/2020 academic year which consisted of 8 classes, namely VII 1 to VII 8. The sample used was class VII 1 as an experimental class which has 34 people students and class VII 3 as a control class group which has 34 students. The sample is drawn from the population by using the purposive sampling technique, which shows the research sample based on certain criteria.

### Instruments

The instrument used in this study is to use learning tools including syllabus, lesson plan (RPP), student worksheets (LKPD), instruments in the form of tests (pretest-posttest) scientific literacy abilities in the form of 20 points reasoned multiple-choice and vee diagram worksheets. Besides, there are other supporting instruments, such as student response questionnaires. Before the test instrument is used, there will be a test first regarding the validity, reliability, difference power, and difficulty level of the items. The results of the validity value test showed that 20 of the 50 questions tested were valid. Reliability test results obtained a correlation coefficient was 0.87 with very strong criteria. The results of the different power tests obtained more than 15 questions with good criteria and others with very good, moderate, and bad criteria. Meanwhile, for the difficulty level test, it was found that the criteria were easy, medium, and difficult. The assessment of scientific literacy skills is based on the aspects of PISA provisions which consist of content and process aspects. Aspects of the PISA provisions can be seen in [Table I](#).

**Table I.** PISA science literacy aspects

No	Aspects	
	Content	Process
1	Defining the terms contained in the material	Identifying scientific questions
2	Classify the things contained in the material	Explain scientific phenomena
3	Understand certain natural phenomena based on several key concepts	Using scientific evidence
4	Illustrates problem-solving contained in the material	

### Procedures

The research procedure consisted of 3 stages, which are pre-research, research, and final research. In the pre-research stage, the researcher made observations to the school that would be used for research, made research instruments such as test questions and student worksheets, and then tested the test instruments. At the research stage, the researcher collected quantitative data obtained from the pretest and posttest scores and the vee diagram scores. The pretest is done before the learning material is given, and the posttest is carried out after the material is delivered. Learning activities are carried out by using the discussion method for the control class and the PBL model for the experimental class. During learning, students are given LKPD to help the learning process. The experimental class was given the task of making a vee diagram at the end of the meeting. The learning process was carried out in the even semester on 11 February 2020 - 28 February 2020 with 6 meetings on environmental pollution material. At the end of the research, the researcher processed the data and analyzed all the research results.

### Data Analysis

Quantitative data in the form of pretest-posttest values are calculated by finding the average value of each class, then the prerequisite test is carried out, which are the normality and homogeneity test. Hypothesis testing is done by calculating the N-gain score and performing the Independent Sample T-test. All data analysis used the SPSS version 17 program. Vee diagram values were calculated by giving scores on each vee diagram component and assisted by Microsoft Excel. Qualitative data in the form of student questionnaire responses were analyzed descriptively to support quantitative research data.

### RESULTS

Pretest and posttest are given to students at the beginning and end of the meeting using test questions that have been tested for validity, reliability, power differences, and difficulty levels. The results of the research conducted in the experimental and control classes obtained statistical test data from the pretest, posttest, and N-Gain values presented in Table 2.

**Table 2.** Statistical test results of students' pretest, posttest, and N-gain data

Value	Class	$\bar{X} \pm Sd$	Normality Test	Homogeneity Test	Independent Test <i>Sample t-test</i>
<i>Pretest</i>	E	58.05 ± 6.54	Sig. 0.24 > 0.05	Sig. 0.41 > 0.05	0.003 < 0.05 (BS)
	K	53.34 ± 6.23	Sig. 0.70 > 0.05		
<i>Posttest</i>	E	78.90 ± 5.70	Sig. 0.56 > 0.05	Sig. 0.55 > 0.05	0.000 < 0.05 (BS)
	K	64.56 ± 5.09	Sig. 0.88 > 0.05		
<i>N-gain</i>	E	0.48 ± 0.16	Sig. 0.67 > 0.05	Sig. 0.33 > 0.05	0.000 < 0.05 (BS)
	K	0.23 ± 0.13	Sig. 0.34 > 0.05		

The average pretest and posttest scores of the experimental class and the control class increased after the learning process. In the experimental class, the increase in post-test scores is higher. Besides, the pretest, posttest, and N-Gain data proved to be normal with a Sig > 0.05 and proved to be homogeneous with a Sig > 0.05 value. Sig value. (2-tailed) 0.00 < 0.05, which means that the average N-gain of students' scientific literacy abilities between the experimental class and the control class is significantly different. It is also known that the N-gain average of students' scientific literacy abilities in the experimental class (0.48 ± 0.16) with the "moderate" criteria is higher than the control class (0.23 ± 0.13) with the "low" criteria. So the decision to accept H1 means that there is a significant influence in the application of the problem-based learning (PBL) model with Vee Diagrams on the scientific literacy skills of grade VII students on the subject matter of environmental pollution. The average N-Gain score for scientific literacy is calculated on two aspects, namely the content and process aspects. The comparison of the average N-Gain content aspect in the experimental and control classes can be seen in Table 3.

**Table 3.** Average N-gain value of science literacy on content aspects

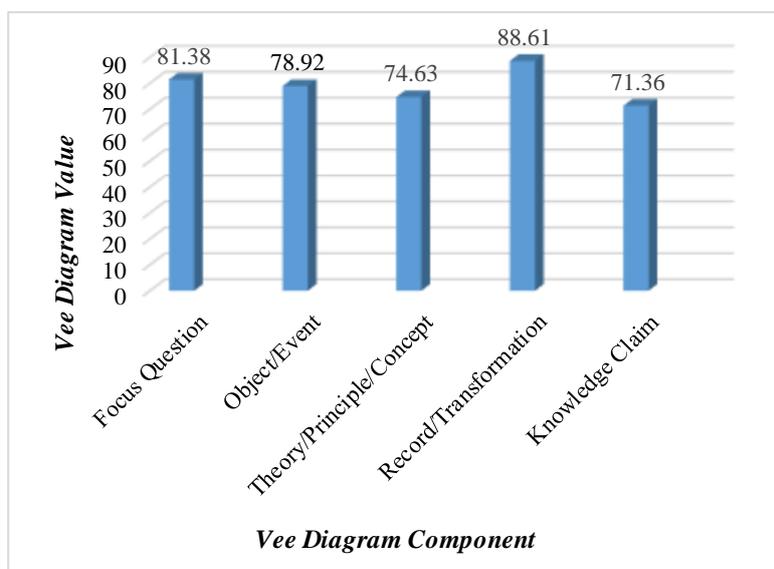
No	Indicator	Experimental Class		Control Class	
		Value	Interpretation	Value	Interpretation
1	K1	0.46	Medium	0.24	Low
2	K2	0.38	Medium	0.26	Low
3	K3	0.56	Medium	0.22	Low
4	K4	0.50	Medium	0.25	Low
Average		0.48	Medium	0.24	Low

Based on Table 3 shows the average N-Gain value for each indicator of scientific literacy in the content aspect. The average value of the experimental class N-gain on the content aspect was "0.48" with the "medium" category while the control class was "0.24" with the "low" category. The comparison of the average N-Gain aspect of the process in the experimental and control classes can be seen in Table 4.

**Table 4.** Average N-gain value of science literacy on process aspects

No	Indicator	Experimental Class		Control Class	
		Value	Interpretation	Value	Interpretation
1	P1	0.45	Medium	0.14	Low
2	P2	0.50	Medium	0.27	Low
3	P3	0.52	Medium	0.25	Low
Average		0.49	Medium	0.22	Low

Based on Table 4 shows the average N-Gain value for each indicator of scientific literacy in the process aspect. The average value of the experimental class N-gain in the process aspect is "0.49" with the "medium" category and the control class is "0.22" with the "low" category. Not only the pretest and posttest values are used in analyzing scientific literacy skills, but the use of Vee Diagrams also helps students in the learning process, so the vee diagram data analysis is carried out. The average value of the vee diagram components is presented in Figure 1.



**Figure 1.** Vee diagram component value graph

Based on Figure 1 shows that the average value of each vee diagram component is the highest in record or transformation with a value was 88.61 and the lowest value on knowledge claim was 71.33.

## DISCUSSION

Hypothesis testing shows that the problem-based learning (PBL) model with the vee diagram shows a significant effect on the scientific literacy skills of grade VII students at Way Jepara junior high school I on environmental pollution material. The results of this study are reinforced by the results of Wulandari, Nisa, Sholihin & Hayat (2015) research that the application of a problem-based learning model can significantly improve students' scientific literacy skills. Besides, research

by Mustofa, Kuswanti & Hidayati (2017) suggests that in the aspects of content and process, scientific literacy has increased.

Increasing students' scientific literacy skills can occur due to several factors, one of which is by using the problem based learning (PBL) model. Through the PBL model, students get the right way of dealing with realistic problems, the ability to work together and explore existing sources to formulate ideas (Nafiah & Yunin, 2014). This is in line with research conducted by Hartanti (2015) that the PBL model makes a good contribution to improving aspects of students' scientific literacy attitudes. Another research result from Wulandari et al. (2015) states that the increase in aspects of scientific literacy cannot be separated from the effect of the treatment given in the form of applying the PBL model to the experimental class. The application of the PBL model syntax encourages students to be more active in building their knowledge through the group work they do.

The scientific literacy abilities of students are also measured from the aspects of scientific literacy in the form of content and processes. The scope of science content is not only knowledge that is the material for the school science curriculum but includes knowledge that can be obtained through other sources such as encyclopedias, newspapers, magazines, news, articles, journals, and information that can be accessed freely on the internet (Nofiana, Mufida, Julianto & Teguh, 2018). During the learning process with the PBL model, students are required to solve a problem related to everyday life. This problem is packaged in a form of content in the form of images, as well as news texts contained in the LKPD. The increase in scientific literacy in the aspect of the process occurs because classes that use this learning model at each meeting are always carried out in the learning stages. Students are asked to orient problems in the form of images and videos into phenomena in everyday life, then identify scientific questions related to the material, and organize previously owned learning experiences to be used as material for group discussions. Students must also collect information as a source to solve problems and make conclusions from solving these problems. The stages that these students go through help in the thinking process and train scientific literacy skills.

During the learning process, students are facilitated with student worksheets (LKPD). The LKPD in the experimental class adjusts to the PBL syntax. It was found that the average score of the experimental class LKPD was quite high. This shows that students in the experimental class can take part in learning with the PBL model. With this learning model, students are trained to be able to understand the real problems presented, formulate problem solutions, identify what they already know before, what they need to know next, and what needs to be done to solve the problems presented in the LKPD. Therefore, filling the student worksheet is proof that students' scientific literacy skills can be improved by applying the PBL model combined with the vee diagram in teaching and learning activities in schools. The PBL syntax can lead students to solve real problems through the process of finding, learning, and thinking independently.

The learning process does not only utilize the PBL model but is also assisted by vee diagrams. Vee diagrams are tools to help form an understanding framework that is based on certain concepts that have been learned. Through the vee diagram, students will find it easier to build the structure and construction of knowledge through interactions between the unknown and the familiar ones in a scientific investigation. This is in line with the opinion (Takes, Hanife & Selahattin, 2012) The use of vee diagrams can help students to properly build their knowledge structures. Five components are assessed in the vee diagram, namely focus questions, objects, theories/principles/concepts, records/transformations, and Knowledge claims. From the average of the five components in Figure 1, the record/transformation shows the highest average value of the vee diagram component, which is 88.61. Meanwhile, knowledge claim has the lowest average value for the vee diagram component, which was 71.36. Vee diagrams have an important role in improving the scientific literacy skills of students in the experimental class. This is by the research

conducted by Hapsari, Sudarisman & Marjono (2012) where it shows that vee diagrams can be utilized to make students' learning process to become more meaningful. Meaningful science learning cannot be separated from problem-solving. Learning is emphasized for problem-solving and thinking habits that encourage students to explore, find meaningful concepts, and develop scientific attitudes.

Other factors are assessed in increasing students' scientific literacy skills, namely the response of students in participating in learning which is shown by a positive response in the form of students' enthusiasm for learning. The results of the questionnaire recap in the form of students' responses showed that learning with the PBL model on environmental pollution material applied by researchers was proven effective and received positive responses from students. The result of the average percentage response was 88.8% which shows very good criteria in the experimental class. Based on the results of the percentage response was 92.6%, students showed a very good interest in science learning with the problem-based learning model. Based on the results of the percentage response was 86.3%, students showed very good use in the following science learning with the problem-based learning model. Based on the results of the percentage response was 88.2%, indicating a very good ability in following science learning with the problem-based learning model.

## CONCLUSION

The conclusion in this study is that the problem-based learning (PBL) model with the vee diagram has a significant effect on the scientific literacy skills of students of grade VII even semester Way Jepara junior high school I in science learning environmental pollution material. The results analysis of the questionnaire showed that students gave positive responses regarding learning using the problem-based learning (PBL) model with vee diagrams seen from the answers to the questionnaire and the enthusiasm of students during learning.

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