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The Effectiveness of Student Worksheet Development Based on Problem-Based Learning in Respiratory System Material to Improve High School Students' Quantitative Literacy

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Abstract. This study aims to produce teaching materials in the form of student worksheet based on problem-based learning (PBL) in respiratory system material to improve quantitative literacy of eleventh grade students of senior high school using ADDIE development model method (Analysis-Design-Development-Implement-Evaluation). The instruments of this study were validation sheets for the teaching materials and pretest and posttest for quantitative literacy. The validation sheets were validated by an expert at teaching material, an expert at material, two biology teachers, four colleagues and fifteen students. Pretest and posttest to measure students' quantitative literacy were validated by two experts and were tested to 29 eleventh grade students of senior high school. The results revealed that the teaching materials were theoretically feasible to use in that the feasibility score of the materials was 3.50 (very good), the feasibility score of the teaching materials was 3.59 (very good), and the feasibility score of the biology teachers and colleagues was 3.52 (very good) and the students' response score was 3.48 (very good). Moreover, the results of quantitative literacy showed that there are nine students categorized to high criteria and twenty students categorized to moderate criteria. The results indicated that the PBL-based student worksheet as a teaching material is feasible and recommended to be implemented in the learning process.

1. Introduction

The implementation of 2013 curriculum is a process of "student-centered learning" in order to improve students' skill and proficiency and to encourage students to develop quantitative literacy. The 2013 curriculum directs the learning using the data related to the observation which has quantitative characteristics, namely suggesting hypothesis, processing data, calculating and presenting the data systematically and attractively, interpreting, drawing a conclusion based on a gained fact, and scientific communicating to the results of experiment in oral and written. Starting from 21th century, biology learning is expected to develop the learning that tends to science which is more quantitative because a quantitative literacy is an ability to analyze numbers and to criticize in solving the problem in daily life [1]. Improving students' quantitative literacy can be assisted with the development of learning material, namely student worksheet. Several students' literacy skills have not trained yet, and it is evidenced from the teachers' interview and the students' result score of the pretest on the



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respiratory system. Thus, teachers are able to prepare teaching materials that are made interesting so that the learning process can be interesting as well. The monotonous learning activity can give an impact on the students who are not accustomed to learning through discovery or experiment, as a result, teaching materials are needed. Majid [2] stated that the teaching materials are all forms of materials used to assist teachers or instructors in carrying out the learning activities. The teaching materials or learning media mostly used are modules, magazines, journals and student worksheet [3]. This study develops a teaching material namely student worksheet, which is a sheet containing the student's learning activities to be carried out in which the students learn the real objects and collect them to become a book. According to Prastowo [4] student worksheet as a teaching material helps the students direct and ease the learning activities because it contains materials, summaries and assignment's instructions for the students to work in the form of theory and practice that refer to the basic competencies. The student's understanding of the material to be delivered can be maximized according to the predetermined achievement indicators [5]. The teacher can develop the student worksheet independently by analyzing the curriculum, including core competencies, basic competencies, indicators and learning materials.

The development of student worksheet which is independently carried out by the teacher should have an innovation. The innovation is in the form of student worksheet that is based on problem-based learning (PBL) and is provided with the videos that can be accessed with a barcode. The problem-based learning is not intended to convey a large amount of knowledge for the students, but to focus on encouraging the ability to solve the problems and to actively build their own knowledge [6]. The use of PBL-based student worksheet in science learning, especially biology as an investigation and resolution of real-world problems requires a guidance for the activities in order to make the learning directed and systematic based on the scientific method. It is similar to the research conducted by Wulansari [7] that the implementation of problem-based learning on student worksheet can improve students' cognitive and psychomotor aspects. Problem-based learning has stages that encourage students to be active in the learning activities and to help students improve their quantitative literacy, such as interpretation, representation, calculation, assumption, application/ analysis, and communication. Besides, the learning using the student worksheet has videos that can be accessed with a barcode connected to the address site of the videos. The student worksheet provided with videos will help the students better understand the material being learned. Similar to Megahati's opinion [8] the students' understanding can be increased using the student worksheet during the learning process. The students who use the student worksheet during the learning activities will know the steps of how the students should learn because they will learn to be responsible for completing the work that they are learning [9]. The development of PBL-based student worksheet will give a benefit for the students because Sasmaz Oren [10] suggested that there are various objectives in the use of student worksheet and their effects impact on the student's success, information retention and motivation while participating the learning activities in the classroom. The use of PBL-based student worksheet in the classroom is expected to provide a positive effect on the student's learning outcomes.

2. Research Methodology

To determine the quality of a teaching material developed from the aspects of validity, practicality and effectiveness, the Research and Development (R & D) method was used. This research method aims to produce a certain product by analyzing the results of the lack of the previous products and examining the effectiveness of the new product [11]. Through the various developments toward the product improvement (development), the product development in this study used the ADDIE development model which consists of five stages, namely Analysis, Design, Development, Implementation and Evaluation [12]. This study was conducted in February 2019 and the place of the study was at State Senior High School 6 Yogyakarta.

The instruments used in this study were the validity sheets of student worksheet development by a lecturer who is expert at teaching material, a lecturer who is expert at material, two biology teachers, and four colleagues, and the response sheet by fifteen students. The validation results were calculated using Likert scale with the lowest

scale 1 and the highest scale 4 and were analyzed using quantitative and qualitative method. The quantitative data given by the validators were converted into qualitative data through descriptive analysis. The conversion of quantitative data to qualitative data is presented in Table 1 below [13].

Table 1. The conversion of quantitative data to qualitative

Interval	Interval	Criteria
$M_i + 1.5 SD_i \leq M \leq M_i + 3 SD_i$	$3,25 \leq M \leq 4$	Very good
$M_i + 0 SD_i \leq M \leq M_i + 1.5 SD_i$	$2,5 \leq M \leq 3,25$	Good
$M_i - 1.5 SD_i \leq M \leq M_i + 0 SD_i$	$1,75 \leq M \leq 2,5$	Fair
$M_i - 0 SD_i \leq M \leq M_i - 1.5 SD_i$	$1 \leq M \leq 1,75$	Poor

In addition, the instruments used to examine students' quantitative literacy skill are pre-test and post-test sheets. The data analysis of quantitative literacy was through descriptive quantitative analysis. The improvement skill of students' quantitative literacy was calculated using the n-gain formula [14]:

$$g \geq = \frac{\langle Spost \rangle - \langle Spre \rangle}{Smax - \langle Spre \rangle}$$

Then, the n-gain was interpreted as follows:

Tabel 2. Criteria conversion of quantitative data to qualitative

Range	Criteria
$g > 0,7$	High
$0,3 \leq g \leq 0,7$	Moderate
$g < 0,3$	Low

3. Results and Discussion

Student worksheet should be developed as creatively as possible in order to meet the criteria for implementing the learning activities effectively because the main function of the student worksheet is to encourage active students to participate in the learning activities through a designed series of activities based on the student worksheet and the applied learning models, such as discussions, observations and experiments. According to Suyanto, Paidi and Wilujeng [16] the student worksheet has a function as a guide for the students to conduct an investigation, an experiment and a guideline in the discussions for the conceptualization. A good student worksheet helps the students find, apply and integrate a concept that has been found. The previous research conducted by Dyah [17] found out three aspects that must be fulfilled in the development of PBL-based student worksheet, namely didactic aspect, constructive aspect and technical aspect. The research on the development of PBL-based student worksheet involves an expert at materials, an expert at teaching materials, biology teachers, colleagues and students' responses to provide an evaluation of the developed teaching materials. The research conducted by Firdaus and Wilujeng [18] also involved material expert, teaching material expert, biology teachers, colleagues and students' responses. Based on the function of student worksheet, therefore, the use of PBL-based student worksheet is able to give an impact on students in improving their quantitative literacy. The quantitative literacy is a knowledge, a skill to solve a problem, a thinking method, a communication and a capability in the education field [19].

3.1 Validation Results of Material Expert

The PBL-based student worksheet was validated by an expert at material, namely Dr.drh. Heru Nurcahyo, M.S, a lecturer in Biology Education of Postgraduate Programs, Yogyakarta State University. The feasibility evaluation of PBL-based student worksheet includes didactic aspects and

language aspects with fifteen statement items. The results of the feasibility validation of PBL-based student worksheet from the material expert can be seen in Table 3 below.

Table 3. Validation Result of Material Expert

No	Evaluation Aspects		Score
	Didactic Aspects		
1	The presented material concept is suitable with core competencies, basic competencies, indicators, and the learning objectives about respiratory system which are complete and easy to understand.		3
2	The materials presented thoroughly represent the scope of the respiratory system materials which are complete and suitable with the education level of eleventh grade of senior high school.		4
3	The learning activities in the PBL-based student worksheet aim to improve quantitative literacy.		4
4	The accuracy of the materials or the accuracy of the presented discourses is appropriate and easy to understand.		3
5	The depth of the materials is suitable with the student's competencies in the 2013 curriculum.		4
6	The development of the concepts is related to daily life.		4
7	The concept of the respiratory system is complete.		3
8	The materials are suitable with the learning indicators.		3
9	The respiratory system materials are up-to-date, following the development of science.		4
10	The presented respiratory system materials and problems are relevant between the presented fact and concept.		4
Total			36
Average			3.60
Criteria			Very good
Language Aspects			
11	The language use is adjusted to the intellectual level of the students.		3
12	The accuracy of the sentence use is simple and easy to understand by the students.		3
13	The accuracy of the language use in the instructions of the learning activities can be clearly understood.		3
14	The use of communicative language is accurate.		4
15	The accuracy of the language use does not give a dual meaning (ambiguous).		4
Total			17
Average			3.40
Criteria			Very good

The average score given by the material expert in the didactic and language aspects was 3.60 and 3.40, and the average score of the two aspects was 3.5. These aspects are categorized to very good criteria. These results indicated that the teaching materials in the form of PBL-based student worksheet are feasible to be implemented and used as a teaching material that supports the student's learning activities although there are several language uses used in the student worksheet that must be improved.

3.2 Validation Results of Teaching Material Expert

The teaching materials were validated by Dr. Paidi, M.Sc, a lecturer in Biology Education of Postgraduate Program, Yogyakarta State University. The feasibility evaluation of PBL-based student worksheet includes technical, language and constructive aspects with thirty statement items. The

validation results of the feasibility of PBL-based student worksheet from a teaching material expert can be seen in Table 4 below.

Table 4. Validation Result of Teaching Material

No	Evaluation Aspects	Score
Technical Aspects		
1	Interesting cover design of PBL-based student worksheet	4
2	The use of font and text arrangement	4
3	Attractive PBL-based student worksheet display	3
4	Well-matched writing layout and picture	3
5	Effectiveness of images that can convey messages related to the materials	3
6	Interesting design of each page and the layout of PBL-based student worksheets attracting readers' interest	4
7	Typography of the content	4
Total		25
Average		3.57
Criteria		Very good
Language Aspects		
8	The language use is adjusted to the intellectual level of the students.	3
9	The accuracy of the sentence use is simple and easy to understand by the students.	4
10	The accuracy of the language use in the instructions of the learning activities can be clearly understood.	3
11	The use of communicative language is accurate.	4
12	The accuracy of the language use does not give a dual meaning (ambiguous).	4
Total		18
Average		3.6
Criteria		Very good
Constructive Aspects		
13	Respiratory system material in student worksheet has clear syntax.	4
14	Compilation of the materials in each chapter in PBL-based student worksheet is correct.	3
15	The questions in PBL-based student worksheet can be answered by processing the information.	3
16	Provided space for writing or drawing is enough to give a freedom to the students.	3
17	Clear and useful goals for students are listed.	4
18	Student worksheet contains the student's identity column.	4
19	The presence of images or video barcodes can convey messages related to the materials.	4
20	Various ways of presenting the information in the form of discourse news or video are developed.	4
Total		29
Average		3.62
Criteria		Very good

The average score given by the experts on the technical aspects of the media was 3.57, the average score of the language aspects was 3.6 and the average score of the constructive aspects was 3.62. From these results, the average total score of the three aspects was 3.59 and it is categorized to very good criteria. The results of this evaluation indicated that PBL-based teaching material is feasible to be implemented and used as a learning material in the school. However, there is a feedback from teaching

material expert about selecting the more appropriate videos so that they can support the learning material.

3.3 Validation Results of External Validators

The feasibility of PBL-based student worksheet was also validated by external validators, namely biology teachers and colleagues. The external validators evaluated didactic aspects, language aspects, technical aspects and constructive aspects. Table 5 below shows the validation results from two biology teachers of State Senior High School 6 Yogyakarta and four colleagues who have conducted or are conducting a research about learning development, media or learning material.

Table 5. Validation Results by External Validators

No	Aspects	Biology Teachers		Colleagues				Average	Category
		V1	V2	V3	V4	V5	V6		
1	Didactic	35	33	35	34	37	37	3.51	Very good
2	Language	18	18	19	18	16	18	3.56	Very good
3	Technical	23	23	25	25	26	26	3.52	Very good
4	Constructive	27	25	28	29	30	28	3.52	Very good
Total score		103	99	107	106	109	109	3.52	Very good

Table 4 shows the feasibility evaluation by biology teachers and colleagues. The average score of the didactic aspects was 3.51, the average score of the language aspects was 3.56, the average score of the technical aspects was 3.52 and the average score of the constructive aspects was 3.52. Then, the average total score of the four aspects was 3.52, which means that the four aspects are categorized to very good criteria. Thus, the PBL-based student worksheet is feasible to be implemented and used as a biology teaching material.

3.4 Evaluation Results of Students' Responses

The evaluation of the responses to PBL-based student worksheet in a small-scale feasibility test carried out by fifteen students. The evaluation includes learning aspects, language aspects and constructive aspects. The evaluation results of the responses to the PBL-based student worksheet by twelfth grade of science students of State Senior High School 6 Yogyakarta are presented in the following table.

Table 6. Evaluation Results of Students' Responses

NO	Total Score			Average	Category
	Learning Aspects	Language Aspects	Constructive Aspects		
1	25	10	15	3.57	Very good
2	21	10	12	3.07	Good
3	20	9	13	3.00	Good
4	21	11	13	3.21	Good
5	24	11	14	3.50	Very good
6	28	12	16	4.00	Very good
7	25	1	16	3.79	Very good
8	25	10	14	3.50	Very good
9	26	12	14	3.71	Very good

NO	Total Score			Average	Category
	Learning Aspects	Language Aspects	Constructive Aspects		
10	27	11	16	3.86	Very good
11	23	10	14	3.36	Very good
12	20	10	11	2.93	Good
13	24	12	16	3.71	Very good
14	25	11	14	3.57	Very good
15	21	10	13	3.14	Good
Total Score	355	161	211	51.92	Very good
Average	3.38	3.57	3.51	3.46	Very good

The results presented in Table 5 were obtained from the evaluation by fifteen students' giving the responses that showed the average score of 3.38 for the learning aspects. The average score of the language aspects was 3.57 and the average score of the constructive aspects was 3.51. As a result, the average total score of the three aspects was 3.48 and the three aspects are categorized to very good criteria. From these results, it can be declared that the PBL-based student worksheet is feasible to be implemented and used by the students as biology teaching materials that support more meaningful learning. This is in line with a research conducted by Chandra [20] and scientific approach [21] that the activities designed using the PBL-based student worksheet are able to make the learning activities interesting and fun for the students.

3.5 N-gain Value of Students' Quantitative Literacy

To measure students' quantitative literacy, pre-test and post-test regarding respiratory system material were given to 29 science students of eleventh grade of State Senior High School 6 Yogyakarta. The illustration of n-gain value is seen in Figure 1 below.

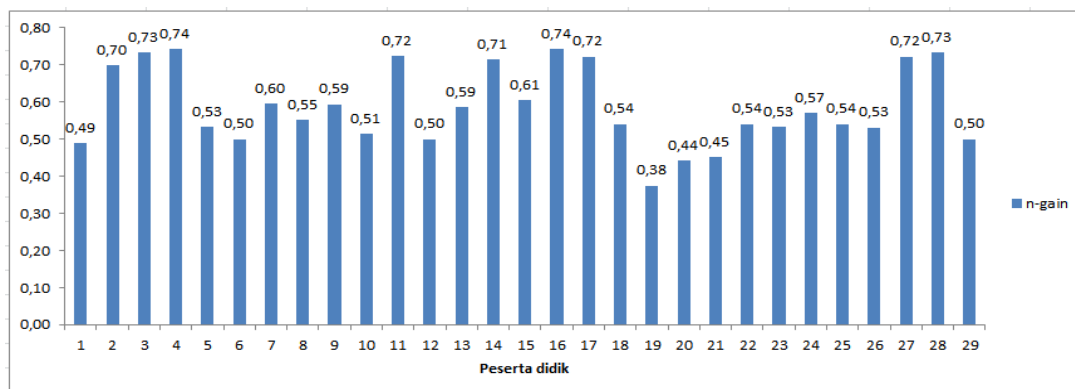


Figure 1. N-gain Value of Students' Quantitative Literacy

Figure 1 presented the n-gain value from 29 students. Based on the n-gain value, there are nine students who have the n-gain higher than 0.70, so that it is categorized to high criteria. In other words, the PBL-based student worksheet gives an impact on students in improving their quantitative literacy. In addition, there are twenty students in the n-gain range between 0.38 and 0.61, and these are categorized to moderate criteria.

4. Conclusion

The PBL-based student worksheet in the respiratory system material of eleventh grade science students of State Senior High School 6 Yogyakarta is feasible to be used as a teaching material for the students as an effort in assisting the students to improve their quantitative literacy. This is evidenced by the results of the validation scores from the validators and the students. The total score of the material expert was 3.50 (very good), the total score of the teaching material expert was 3.59 (very good), the total score of the external experts was 3.52 (very good) and the total score of the students' responses was 3.48 (very good). Moreover, the calculation results of students' quantitative literacy skill were found out that there are nine students with high n-gain value and twenty students with moderate n-gain value. Thus, the PBL-based student worksheet as a teaching material can be implemented in biology learning.

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