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Using problem-based worksheet on human reproductive system for improving student thinking skills

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Abstract. The aims of this study were to determine (1) the effect of Problem-based Student Worksheet on Human Reproductive Systems upon students' Higher Order Thinking Skills (HOTS) and (2) to analyse the contribution of Problem-based Student Worksheet on students' HOTS. This classroom research used non-equivalent control group design. Population of students involved in this study was approximately 252 grade XI Math and Science students (MIA) from the public senior highschool at Pati, Sekolah Menengah Atas Negeri 2 Pati in the second semester of the academic year 2016/2017. Students as research sample were collected by purposive sampling technique, by which MIA 4 students were chosen either as the treated group or the control one. Score of students' HOTS as dependent variables were collected by written tests consisting of 10 free-response questions. The other dependent variable, namely the scores of problem-solving skills, were measured by questionnaires provided by the Problem-based Student Worksheet, administered only for the treated class. Data obtained were analyzed using t-test and correlation test. The findings showed that the Problem-based Student Worksheet affected the students' HOTS (coefficient value of 0.809). In sum the higher score of problem-solving skills was the higher score of students' HOTS.

1. Introduction

Thinking skills in biology has been seen as one of the prime teaching objectives in schools, but some Indonesian students were lack of proper thinking classroom culture. Preliminary observation (January, 2017) on biology classrooms at Sekolah Menengah Atas Negeri (SMAN) Pati underlined that many students did not show their the higher level of their thinking (HOTS), they were more likely to be passive in a biology class, and almost no question was identified during one hour class meeting. Students had difficulties in solving biology problems when they were presented with problems requiring them to use their HOTS, proven by their low scores (interview with biology teacher, January, 2017). Moreover, significant facts about the low level of students' HOT in Indonesia was also reported by International Survey, Program for International Student Assessment (PISA), indicating that Indonesia were put in the position 64 of 65 countries due to a series of tests involving problem-solving skills [1]. The low level of students' HOTS can be triggered by several factors, including the implementation of inappropriate teaching models, the use of question/problems with lower cognitive level (C1-C3), and the unavailability of teaching materials that can support students to develop their knowledge [2].

Encouraging students to think, not to remember, has been the emphasis of any educational reform [2]. Thinking can be improved by (1) becoming aware of thinking, (2) examining its process and (3)



practising it [3]. In his book Johnson (2010) put emphasis that thinking skills can be taught in schools [4]. Problem-solving and thinking skills do not operate in isolation from each other, they need support and tools. Frangeheimbelieved that learners are empowered when they understand the level of questions and appropriate tools to employ [5]. He shared his understanding of how to encourage thinking skills by developing some necessary tools. Canas et. al. underlined that concept mapping could be used to promote students' thinking [6]. Worksheet can be used as tools to promote thinking because students are challenged by tasks that promote thinking.

Student worksheet is one of the teaching tools commonly used for teaching and learning process. Student worksheet is supposed to be able to optimize the student learning outcomes. The student worksheet-based discussion process can build students' knowledge individually, and in groups it can facilitate students in collaborating, exchanging ideas, in the process of problem solving [7]. Problem solving is the way students do to achieve their desired goals, through a process that uses high-level thinking skills [8]. In this case, students cannot automatically recognize the right way to achieve the desired goal. To overcome this, the teacher can help students by providing worksheets to students. A worksheet or learning guide useful to help students master the ability of the science process skill. Students who have science process skills will display various abilities, including designing investigations, carrying out investigations, also gathering, analyzing and interpreting data, and drawing conclusions from data [9]. Improving science skills can also be done through inquiry-based learning. Training science skills can also be done through inquiry-based learning [10, 11].

There are several strategies for improving high-level thinking skills, including problem-based learning (PBL) and inquiry learning [12, 13]. Results of Bell's research prove that PBL is a very interesting and motivating approach to students, increasing student involvement and interest in learning. PBL also increases student self-esteem. In PBL the teacher must help a students to understand the meaning of high-level thinking skills [14]. This can be done by showing students how to ask good questions. Bell (2010) explains that PBL is an innovative learning approach that encourages students to learn through inquiry, to do research by working collaboratively. Collaboration is done by students when collecting data, also in preparing and presenting their research findings. In conducting this research / investigation, students can use teacher-provided study guides, in the form of inquiry-based, problem-based or project-based study guides.

In this study, problem-based student worksheet used contained a series of problems that should be solved by students when learning human reproduction system. Many problems presented in this student worksheet were ill-structured, open, and integrated. They need more than one way of solution and involved more than one subject to be applied by student in order to solve the problem. Problems encouraged the students to understand information and to arrange their own questions, not the problems than can be solved directly after the student read the article. This study aimed to determine the effect and contribution of problem-based student worksheet on students' HOTS.

2. Methods

To identify the effect of the use of worksheet on thinking, quasi-experiments with non-equivalent control group design was used. Population of students in this study was 252 XI MIA students of SMA Negeri 2 Pati in the 2016/2017 academic year. Students as unit of study was determined by purposive sampling technique, in which XI MIA 4 was chosen as the treatment class and XI MIA 2 was the control class. The dependent variables was scores of students' HOTS gained from the pre-test and post-test. The instrument used was 10 free-response questions. The independent variable was the score of students' problem-solving skills collected from the completion of questions/problems on Problem-based Student Worksheet. Both normality and homogeneity tests were implemented to identify normality and homogeneity of the data collected. Data analysis techniques are the one sample mean difference test (t-test) and correlation test. The one sample t-test was used to determine whether there were differences in learning achievements from the experimental and control class, while the correlation test was used to find out how high Problem-based Student Worksheet affects the students' HOTS.

3. Results and Discussion

3.1. Higher Order Thinking Skills (HOTS)

The pre-test was given to measure the students' initial HOTS in both control and treatment class. While the post-test was used to measure students' HOTS after the treatment/learning process. The results of students' pre-test and post-test are presented in Table 1.

Table 1 showed the low level of students' HOTS. The difference mean score of pre-test between the treatment and control class was not too large (2.22). This indicated the low level of students' HOTS in both treatment and control class. The results of the Kolmogorov-Smirnov normality test using SPSS version 21 indicated that the pre-test data of the experimental class and control class are normally distributed with a significance value of $0.200 > 0.05$. The homogeneity test results also showed that the experimental and control class had the same variance with the significance value of $0.321 > 0.05$ in the Levene Statistic test using SPSS version 21.

Table 1. The Results of Students' Pre-test and Post-test in both Control and Treatment Class

Statistic data	Treatment		Control	
	Pretest	Posttest	Pretest	Posttest
The number of students	36.00	36.00	36.00	36.00
Mean score	32.72	76.72	30.50	60.72
Highest score	45.00	95.00	45.00	78.00
Lowest score	20.00	60.00	20.00	50.00
Median	33.00	78.00	30.00	61.60
Standard deviation	7.32	8.72	6.34	7.09

After the determination of the level of students' HOTS, the treatment using Problem-based Student Worksheet was then conducted. The Problem-based Student Worksheet was given only to the treatment class, while the regular student worksheet were given to the control class. The result of post-test showed that there was a significant difference of mean score of students' HOTS between treatment and control class. The mean score of the treatment and control class are 76.72 and 60.72 respectively. The post-test score was then tested by the one sample t test to prove that the learning process conducted has an effect on the students' HOTS. Kolmogorov-Smirnov normality test was performed on post-test data using SPSS version 21 program with significance result in the treatment class was $0.200 > 0.05$ and in control class was $0.160 > 0.05$. This means that the data in both treatment and control class are normally distributed. Once it was known that the data is normally distributed, then the t test requirements was satisfied.

One Sample t Test on SPSS version 21 indicated that the significance value (sig. 2-tailed) was $0.000 < 0.05$. This means that the learning process affected the students' HOTS. The improvement of this students' HOTS occurs on every indicator measured in this study: analysis, evaluation, and creation, as presented in figure 1.

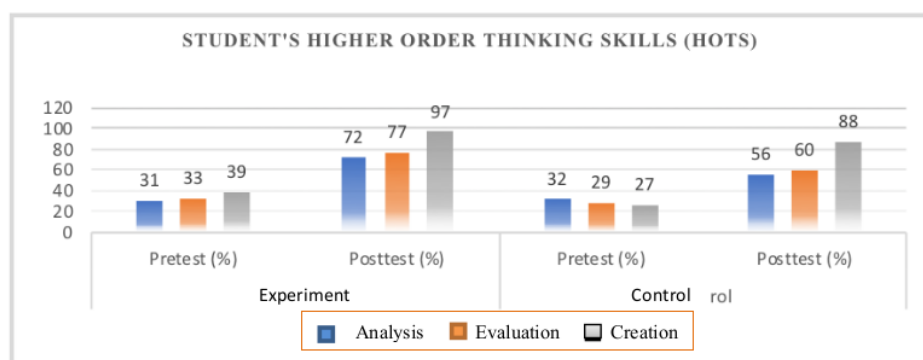


Figure 1. Graph of the Higher Order Thinking Skills' Indicator Achievement in both Treatment and Control Class

Figure 1 showed the increase of student's HOTS in both treatment and control class. However, the increase was higher in treatment class than in the control class. The increase of students' HOTS could be seen from the value of N-gain as presented in Table 2.

Based on the data in Table 2, it could be seen that students in the treatment class had a higher level of HOTS than in the control class. This was supported by the statement of Chidozie et al., [15] showing that PBL could improve students' HOTS. High-level thinking skills include critical, logical, reflective, metacognitive, and creative thinking [16]. These skills will be activated when students are faced with problems, uncertainties, questions, or dilemmas that are not yet known.

The quality of thinking skills was also changed by the particular cycle of teaching, as reported by Colley (2006) [9]. Frangeheim (2005) also mentioned that thinking skills could be changed by the higher questions posed by teachers. PBL already provided students with higher questions, not merely low order thinking. Students understood the concept of reproduction system, analyse problems, evaluated the results of problem-solving, and created an idea/opinion to solve the problem. While, students with a low level of HOTS understood the concept correctly but they were not involved in the process of analysis, evaluation, and creation.

Table 2. The N-gain of Pre-test and Post-test in both Treatment and Control Class

Statistic data	Treatment	Control
The number of students	36	36
Highest N-gain	0.92	0.71
Lowest N-gain	0.37	0.15
Median	0.66	0.45
Standard deviation	0.12	0.13
Average	0.66	0.43

3.2. Problem-solving skills

Problem-solving skills were measured through the problems on Problem-based Student Worksheet. The ability of students in solving those problems was used as a means to train the HOTS of students in treatment class. The results of students' problem-solving skills score were presented in Table 3.

Based on the data in Table 3, it could be seen that the achievement of student scores on each worksheet has increased. Increased achievement score in the worksheet also did not occur suddenly, but it took a series of exercises continuously. In the material of this human reproduction system, there were 12 lesson periods that must be fulfilled in learning, so that during the learning hours the students were directed to practice solving problems contained in the worksheet continuously. This was

supported by the results of the Colley's study (2006), show that learning instruction (project-based / PBSI) are useful for equipping students with science process skills. Science processes skills are important skills for solving problems [14]. Various activities such as obtaining data, analyzing, and interpreting data is inquiry-based activity, which is useful for developing critical thinking and problem solving skills in students [17]. Problem solving skills characterize the presence of high-level thinking skills. Thus it can be stated that the use of worksheets in this study can improve high-level thinking skills.

The mean worksheet score data was then analyzed by correlation test (Pearson Correlation) with the data of post-test score to determine the effect of students' worksheets on students' HOTS. The result of Pearson Correlation analysis obtained correlation coefficient equal to 0.809. In this study, students carry out active learning activities. What students do in active learning among others, planning investigations, reviewing things that have been known as evidence / results of experiments, using equipment to collect data [18]. Students also conduct data analysis, interpret data, express statements, predictions, and answer problems, and communicate the results of investigations.

Problem-based Student Worksheet had a significant effect on improving students' HOTS. This is in accordance with the results of Lee's research [19], which states that worksheets are useful for adding information, and can attract students to find out various useful things to construct their minds. Other similar findings also supported this claim, such as (1) the demand for students to use high-level thinking skills could improve their motivation, (2) confronting students to problem drove student to solve the problem, so they can optimize their skills of thinking to think critically and creatively in order to solve the problem, (3) assessing high-level thinking of students could be done by exposing students to something to think, (4) assessment and learning are two things that are inseparable [8, 14, 20]. Thus, exposing students to a problem was useful for training students' thinking skills, especially high-order thinking skills, and finally PBL could help train student's HOTS [15, 21].

Table 3. The Mean Score of Problem-Based Student Worksheet

Group	Mean Score of each Group						Mean score of worksheet
	Worksheet 1	Worksheet 2	Worksheet 3	Worksheet 4	Worksheet 5	Worksheet 6	
1	51	59	67	76	73	76	67
2	57	66	71	78	74	76	70
3	59	65	74	77	77	79	72
4	62	65	73	72	88	88	75
5	54	68	69	72	73	76	69
6	51	74	80	81	77	78	74
7	51	60	83	78	82	83	73
8	50	79	83	86	78	80	76
Average	54	67	75	78	78	80	72

Basically, students with good / high problem-solving skills are students who have the ability to recognize and understand the problems from different points of view, solve problems in various ways that produce good quality of problem-solving and are able to solve problems over time that has been determined. Problem-based Student Worksheet significantly affected the students' HOTS. Students were encouraged to be more interested in reviewing and recognizing the problems that exist in the community other than the problems already presented in the worksheet. Students often asked questions about events that have been experienced by them or events that they have been observed before. This shows that students have skilled communication, critical thinking which means having high-level thinking skills. Communication, critical thinking, collaboration, and problem solving skills are also part of 21st century skills that need to master by student [22, 23, 24].

Based on the description in the above, it is confirmed that problem-based student worksheets are **10**ful for increasing higher-order thinking skills. Higher-order thinking skills are based on low-level skills such as discrimination, simple application and analysis, and cognitive strategies related to prior knowledge of subject matter content [16]. In this study, student do learning activities assisted by worksheets, and they succeed in achieving lower-level thinking skills. Mastery of low-level thinking skills is a strong basis for improving high-level thinking skills in students, indicated by their ability to solve problems. In such conditions, students have the skills to think logically, objectively, systematically, and creatively.

4. Conclusion

Problem-based Student Worksheet significantly effects on XI MIA students' HOTS of SMA Negeri 2 Pati. The higher score of problem-solving skill is in line with the higher score of students' HOTS. Further research on the similar topics are suggested to improve the findings by a bigger number students involved and true experiment research design. Biology teachers are expected to maximize the use of problem-based worksheet as one of tools to support thinking, however it is not always easy to implement.

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