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The Impact of Problem-Solving Model on Students' Concept Mastery and Motivation in Learning Heat Based on Gender

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ABSTRACT This study investigated the impact of the problem-solving model on students' concept mastery and motivation in learning heat based on gender. The method which was used in this research was quasi-experiment with pretest-posttest design in girls and boys class. Data are collected from girl class (N=16) and boys class (N=16) of a 7th grade in one of a Bilingual Boarding School in Bandung. The quantitative data of this research was obtained through the objective test, while the qualitative data was gained through a questionnaire. Students' motivation is measured by Attention, Relevance, Confidence, and Satisfaction (ARCS) Model. On the other hand, students' concept mastery is measured based on Bloom's taxonomy cognitive level through the objective test and being analyzed by using statistical software *Statistical Package for Social Science* (*SPSS)* version 20.0 for Windows 8. The results show that overall concept mastery of girls and boys students have improved. However, girls students are higher achiever than boys. Overall, the problem-solving model makes an improvement in students' concept mastery in both girls and boys. Thus, it indicates that the implementation of the problem-solving model in learning heat can improve students' motivation and students' conceptual understanding in secondary level.

Keywords Problem-solving model, students' concept mastery, students' motivation, heat, gender

1. INTRODUCTION

The basic goal of science education system is bringing in skills to get information instead of transferring to literal at the present day in the information age. One of the purposes of science education reformation is to train up students who are interested in science actively. As a result of these rapid changes, the education systems need to be modified that they can enable the students to learn the ways to reach the knowledge, improve the skills of decision-making and to solve problems (Lorsbach & Tobin, 1992). Much of the literature concerning the relative performance of girls and boys in science indicates that boys outperform girls in most areas of the science curriculum and that it is rare to identify areas of the science curriculum in which girls outperform boys (Hola, 2005).

Student's attitudes towards science have been found in some studies to be linked to performance in the subject and have been found to be influenced by different teaching approaches (Hola, 2005). Students process of acquiring knowledge and achieving the goal in the class activity commonly done by their own effort (Ajaja & Eravwoke, 2010). It is a common problem for middle school students that school is boring and that they cannot relate to nor understand the material that is presented to them each day in class (King, 2009). Students are neither passionate nor motivated to learn in class. This problem can be both challenge and opportunity for the teacher to deliver the material in an alternative way by engaging the students to learn in class. Students' engagement can be done by providing several activities which lead them to have experience and connect them immediately to the knowledge (Umam, 2014). In another hand, application of interaction among students will help to reshape and develop students reasoning, critical thinking, and some others students' ability. Cooperative learning is one of the ways in teaching learning process which gives chance to students to interact each other in order implementing their learning ability. This interaction will eventually lead students to shape their values and perspective that can be useful to be used either inside or outside of class (Ajaja & Eravwoke, 2010). One of the fundamental achievements of education is to enable students to use their knowledge

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in problem-solving. Therefore, many researchers find that their students do not solve problems at the wanted level of proficiency. To help improve the teaching and learning of physics problem solving, studies were started in the 1970's (Gok and Silay, 2010). Two primary goals in teaching introductory physics are to help students learn major concepts and principles and to help students learn how to apply them to solve the problems. In traditionally taught courses we assign many problems with the assumption that solving the problems will help develop students in the understanding of concepts and principles, as well as an appreciation of the role they play in solving problems. The research on student's concept has been being approved as a key concern for science learning especially after Ausuble has developed the idea about the importance of prior knowledge to the learning of scientific knowledge (Ausuble, 1963). Students nowadays are lack of critical thinking and they are only good at memorizing. Instead of giving readily prepared information, teaching students to learn how to learn, make comments, getting them to understand and apply the information is needed in science courses. Furthermore, making them gain skills of problem solving, behaviors and helping them to gain a habit of scientific thinking should be taught. Therefore, it is needed to improve students' skills of problem-solving (Altunçekiç, Yaman & Koray, 2005).

Motivation is the determining factor in learning since students who do not want to learn will not learn regardless of the caliber of the instructor, and students who do want to learn will. However, students' motivations may change, such that even those who do not want to learn will change their minds upon exposure to stimulating environments that capture their attention.

2. METHOD

The quasi-experimental method is used in this research to collect and obtain data in the field. Researcher uses this experimental research to test the effect of the problem-solving model on students' concept mastery. In this method, research carried out on two experimental groups of 7th-grade students which are girl class and boy class. Pre-test and post-test design definition from Cresswell (2012) provides a measure on some attribute or characteristic that is assessed for participants in an experiment before they receive a treatment. Post-test can be used to assess participant in experiment after a treatment. The experiment design is shown in Table 1.

Table 1 Experiment design

Class	Test	Stage I	Test	Action
Girl	Pre-test	Problem-Solving Model	Post-test	Questionnaire
Boy	Pre-test	Problem-Solving Model	Post-test	Questionnaire

The location of this research is taken in one of Bilingual School in Bandung. This school is one of the Pasiad partner school which uses Kurikulum 2013 along with Zambak modular system. This school named as a bilingual school because it uses Bahasa and English as its instructions language. This school is appropriate for this research because it has a different system of class division. The class of girl and boy students are separated.

The population in this research is 7th-grade students at Bilingual Junior High School in Bandung. The sample is taken from two classes of the 7th grades. There are 7 A and 7 B as different based on gender classes. 7 A is boys' class and 7 B is girls' class, both of classes are given the same treatment.

A sampling is selected by purposive sampling technique according to Fraenkel et.al., (2011). The sampling consideration is based on the specific purpose which compares the cognitive achievement of the girl and boy students, therefore researcher chooses a sample from based gender classes (Fraenkel et.al., 2011). The total samplings are 32 students of a 7th grader, with 16 girl students and 16 boy students.

In this research, the concept of heat topic is limited based on Indonesian Curricula 2013 by core competence No. 3, basic competence No 3.7 as attached in *Badan Standar Nasional Pendidikan (2013).* The analysis of curriculum about core competence and basic competence indicates the subtopics that will be investigated by students such as (1) temperature (2) heat and expansion (3) heat transfer (4) its application in the body to maintain the stability of body temperature in humans and animals in everyday life.

The terms of heat in this research refer to a form of energy associated with the motion of atoms or molecules of a body and the subject encompasses temperature, thermometry, heat transfer, such as conduction, convection, and radiation.

There are three types of instrument used in this research. There are an objective test, observational sheet, and questionnaire. **First,** the objective test is conducted to describe the cognitive ability of students in mastering the concept. The objective test consists of two sections which are pre-test and post-test. Multiple choice questions consist of cognitive domain C1 (remembering), C2 (understanding), C3 (applying), C4 (analyzing) and C5 (evaluating) (Anderson et al., 2001). The objective test consists of twenty-seven questions before passing judgment by experts. It is used to look students' comprehension. After judging by the expert the objective is only twenty-five questions as a representative for each learning indicators. Then, the test was distributed to students in grade 7 as a limited test. The next step after conducting a limited test to 7th-grade students, this objective test is analyzed using ANATES to measure the validity, reliability, difficulty level, discriminating power and

distractor. **Second,** Observational sheets have been created so that teaching staff can take the opportunity to observe and reflect on the particular positive teaching and behavior management strategies employed. **Third,** Questionnaire is an instrument, which is distributed to the students to investigate students' motivation towards this learning model which is consist of 15 questions that assess attention, relevance, confidence, and satisfaction towards this learning model.

3. RESULT AND DISCUSSION

The results show quantitative and qualitative data. The pre-test and the post-test are conducted to determine the students' concept mastery before and after treatment. Qualitative analysis will describe the students' motivation during this learning model.

3.1 Students' Understanding

The pretest was conducted at the beginning of the learning to investigate the students' prior knowledge. A pretest with the same question was given to both girl and boy class. Statistic result shows that the data of Normality test with significance 0.520 for girl class' pre-test with criteria Sign. ≥ 0.05. It can be categorized as a normal distribution. It is the same with boy class, 0.772 for the pre-test. Meanwhile, for homogeneity test, the result of pre-test (both girl and boy class) is 0.585 with criteria and for post-test is 0.004. Both of them can be categorized as homogeny. For pre-test, girl class shows 80 for the highest score with standard deviation 17.220 and 92 is the highest score in the girl class for post-test with the standard deviation 7.711. Meanwhile, in boy class, it reaches 72 for pre-test with standard deviation 17.435 and 92 for post-test with standard deviation 16.360.

The analysis of pre-test resulted that there is a difference between boy and girl class' result. Although the difference is not really significant, this result indicates that prior knowledge between girl and boy are quite similar but girls have a more comprehensive understanding. The average score of pre-test in girl class is 54 men meanwhile in boy class is 45. These results are categorized as a low result because this is the first time for the students to learn heat concept in a comprehensive way. Chances are primary school have taught them the heated topic but it probably only the basic knowledge as it can be seen from the result that they have been already good in the basic theory of heat concept.

Post-test is given at the end of the learning process to know students' concept mastery after receiving the treatment. Post-test are also given to both girl and boy class. Statistic result shows that the data of Normality test with significance 0.591 for girl class and 0.397 for boy class. It is categorized as normal with criteria Sign. ≥ 0.05. Homogeneity test with significance 0.711 can be categorized as homogeny. Girl class shows the highest score 92 and the lowest score 60 with the average score 84.5 and standard deviation 7.711. For boy class, the highest score is the same as the girl class, 92 but for the lowest score is 40 with the average score 71.7 and the standard deviation 16.360.

Table 2 Result analysis of n-gain

Component	Girl Class		Boy Class	
	Pre-test	Post-test	Pre-test	Post-test
N	16	16	16	16
Average	54	84,5	45	71,7
Standard Deviation	17.220	7.711	17.435	16.360
Highest Score	80	92	72	92
Lowest Score	16	60	16	40
Gain Score	30.50		26.75	
N-Gain Score	0.83		0.62	
N-gain				
N-Gain Interpretation	**Result**			
<g> ≥ 0.7 : high	15		6	
0.7 < <g> ≥ 0.3 : medium	1		9	
<g> < 0.3 : low	0		1	
Homogeneity Test (Levene Statistics)				
	Pre-test		**Post-test**	
Sig.	0.585		0.004	
Conclusion	Homogeny			
Normality Test (Kolmogorov-Smirnov)				
Sig.	0.520	0.591	0.772	0.397
Conclusion	Normal			
T-Test				
Sig.	0,007			
Conclusion	H_o rejected			

The analysis of post-test showed that there is also a difference between girl and boy class post-test result. According to the students' average score (84.5 for girl class and 71.7 for boy class), problem-solving model contributes to students' concept mastery improvement. This result indicates that problem-solving model can improve students' concept mastery supporting previous research conducted by Aka, Aydogdu, and Guven (2010). It showed that problem-solving model was able to make students have a more comprehensive understanding.

Another analysis is performed to investigate students' concept mastery improvement using problem-solving model. Analysis of N-gain is conducted to investigate the statistically significant differences in students' understanding improvement between pre and post-treatment. The average of N-gain result is tabulated in Table 2. The result of the girl class is higher than resulted in the average. It achieved 0.83 N-gain for girl class and 0.62 for boy class.

Conceptual mastery in this study is also analyzed from the cognitive domain refer to Bloom Taxonomy revised of cognitive domain (Anderson, 2001). The cognitive domain

Table 3 Students' concept mastery result based on gender

Class	Subcategory Concepts	Questions	Number of Students	Max Score	Pre-test Score	Post Test Score
Boys	General heat concept	2, 4, 6, 9, 11, 15, 18, 19, 21, 24	16	160	70	150
	Heat Transfer	1, 3, 5, 12, 22, 25		96	30	90
	Temperature	8, 14, 16		48	12	40
	Heat Concept on Daily Life	7, 10, 13, 17, 20, 23		96	24	72
Girls	General heat concept	2, 4, 6, 9, 11, 15, 18, 19, 21, 24	16	160	50	100
	Heat Transfer	1, 3, 5, 12, 22, 25		96	18	72
	Temperature	8, 14, 16		48	15	27
	Heat Concept on Daily Life	7, 10, 13, 17, 20, 23		96	30	60

which involves in this research is remembering (C1), understanding (C2), applying (C3), analyzing (C4) and evaluating (C5). The improvement in each cognitive domain also categorizes as a medium until high improvement for both girl and boy classes. But most of the high improvements are categorized in C3 and C4 cognitive domain.

This result establishes that problem-solving model works well in higher order thinking level, especially C4 (Analyzing), correlate the problem-solving model to cognitive taxonomy. Constructing and learning by using this model factually improve the conceptual mastery in each cognitive domain, and better in the C3-C4 cognitive domain. C3 deals with applying concept meanwhile C4 deals with analyzing. This is in line with the hypothesis that the ability of information analysis & processing. Thus, this learning model better improves the higher level of the cognitive domain. It proves that the problem-solving model support student to higher thinking ability as analyzing and applying.

Those phenomena show that problem-solving model works in helping the student to improve their conceptual mastery. Besides that, the problem-solving model also facilitates student to involve most of all their senses, improve their critical thinking and stimulate their curiosity. Another factor which is involved in the role of the problem-solving model in improving students' level of cognitive is the involvement of critical thinking when students are learning. The problem-solving model here facilitates students' imagination in the process of learning. Learning physics, especially on the topic of heat transfer is not that easy for some students because there are a lot of things that could be leading into misconception.

An objective test of students' understanding is given to the students. The test includes four sub-indicators concepts. Table 3 shows the comparison of the result of the objective test. Based on N-gain, the problem-solving model is resulting good in students' concept mastery in general knowledge heat concept. It has the highest score of both boys and girls classes. It also makes an improvement in several indicators such as temperature, heat transfer and heat concept application in daily life. It can be seen from the result that the students either boys and girl can differentiate easily the way of heat transfer at the end of the learning without misconception.

According to the curricula 2013 minimum standard, both girls and boys classes' result have achieved 5 indicators accomplished by students during the learning activity. The improvement in indicator about the application of heat concept on daily basis is not significant, but fortunately, overall result can make students pass this concept. Students' critical thinking might be needed to improve this understanding so that students can fulfill this indicator to the maximum score. Problem-solving model is also suggested to improve students' critical thinking and how a student can evaluate their own work. It is suitable to be used for heat concept because this concept of heat needs actual explanation or contextual explanation so they can imagine by themselves what it is like and what it relates to their life and they can easily understand the concept.

3.2 Students' Motivation

Students' motivation toward this learning model is obtained by questionnaire. This questionnaire consists of 15 questions that have positive and negative statements which represent the point of Attention, Relevance, Confidence, and Satisfaction. This questionnaire also consisted of three different indicators of the student's response toward instructions using the problem-solving model in learning heat.

Those statements in questionnaire also indicate interested in learning leisure in using problem-solving model, response toward the usefulness of the problem-solving model, and indicate students' preference of learning method. This questionnaire is distributed to determine

Table 4 Students' response toward problem-solving model on their motivation in percentage

Score	Category	Numbers		Percentage	
		Boys	Girls	Boys	Girls
1.00–1.49	Very Unmotivated	0	0	-	-
1.50–2.49	Unmotivated	0	0	-	-
2.50–3.49	Sufficiently Motivated	3	1	18.75	6.25
3.50–4.49	Motivated	10	3	62.5	18.75
4.50–5.00	Highly Motivated	3	12	18.75	75

students' motivation and interests toward this learning model. Summary of the result of students' motivation towards this model represents in Table 4. It is shown that girls have higher motivation about the instructions than boys. It can be seen from the value of the percentage. It is 75% of students in girl class are highly motivated toward this learning. Meanwhile, it is only 62.5% of students in boys class are only motivated. However, students' motivation toward this learning was appeared to be alright. It can be concluded that they have resulted in the motivated rate of learning heat using problem-solving model. Even so, due to the needs of a deeper analysis of the ARCS motivational categories which are Attention, Relevance, Confidence, and Satisfaction, which has negative and positive statements,

The implementation of the problem-solving model is expected to gain the motivation of students to learn and understand the heat chapter. The ARCS motivational questionnaire consisting of 15 statements resulted in various response and different rates of each category of Attention, Relevance, Confidence, and Satisfaction. From 32 students participated in this research that is consisted of 16 girl students and 16 boy students, there is 10 boy students are classified as motivated students. While other 3 students are sufficiently motivated and the other 3 student is highly motivated.

Corresponding to Borphy (2011) at "Motivating Students to Learn" stated that establishing the class with learning communication through emphasizing that learning goals are more important than performance goals so students are paying attention to self-improvement rather than comparison with classmates. This is what happening insufficiently motivated category students who are more importantly keep themselves motivated without worrying.

Girl class has a higher percentage of highly motivated students than boy class. It means that girl class tends to have a positive response in each indicator. In the first indicator which is attention, the girl's class averagely have score 4.7 from the scale of 1-5. This can be interpreted that girl's class is in highly motivated to have the leisure when they learn using problem-solving model. Meanwhile, boy's class tend to have a positive response but the score of boy class for this indicator is diverse and mostly in the motivated categorized which is 3,5 – 4,49. It can be interpreted that their response is not really good for the learning leisure when they learn using problem-solving model.

A second indicator, both of girl and boy class also have the diverse contribution of frequency but girl's class still in the lead in the motivated and highly motivated category. It can be interpreted that they tend to have positive response toward the relevance category. Although mostly boy and girl students are categorized as motivated and highly motivated students, there are still some few people who are sufficiently motivated during this instruction.

Table 5 Recapitulation of ARCS categorization of students' motivation

Score	Number of Students (f)							
	Attention		Relevance		Confidence		Satisfaction	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
1.00-1.49	-	-	-	-	-	-	-	-
1.50-2.49	1	-	2	-	1	-	1	-
2.50-3.49	1	1	1	-	3	3	3	-
3.50-4.49	9	4	7	6	7	1	7	4
4.50-5.00	5	11	6	10	5	12	5	12

Approximately 3 students in total both of classes according to Table 5 are just only sufficiently motivated during the instructions, but still, boy students seem like not really motivated toward this leaning. This might happen because of the different style of different gender student, as it is stated in the previous explanation based on theory of Kolb (1984) women tend to prefer concrete learning styles, and boy prefers to an abstract one. Problem-Solving model facilitates student to learn in a concrete way. Thus, girl class is mostly like and feeling helpful and motivated when they learn using problem-solving model.

Hence from all of the discussion above it can be interpreted, generally most of girl student response positive toward this learning strategy, which means they all are generally feel satisfy, relatable and prefer this learning strategy than the conventional one. Only around half of boy students give the positive response toward this learning strategy.

This preference also gives any impact on the learning outcomes. Girl students which show more positive attitudes toward this learning model result a higher improvement than the boy who less interested in this learning model. The preference and feeling of joy might increase the learning motivation. So that it gives any big impact on learning outcomes, this is in line with what Ormrod (2008) stated in his book about the girl motivation in learning.

It can be concluded from all of the discussion above that the girl class has a higher motivation than boy class. Girl class gives more positive response than boy students in all of the category. There is learning leisure during the instructions using problem-solving model, feeling helpful while learning using problem-solving model, and the preference of student to learning using problem-solving model compare to conventional learning strategy. This positive response of girl class is given a positive impact on the achievement of girl class. Girl's class who give more positive response toward problem-solving learning model gain more achievement than boy students who do not really respond positively toward this learning model.

4. CONCLUSION

Research about the impact of the problem-solving model on students' concept mastery and motivation has been conducted systematically. According to the research

results, it is obtained some conclusions as follows. The implementation of the problem-solving model in learning heat chapter can improve students' conceptual mastery. It is noticed and proven by the results of average N-Gain of both boys' and girls' class. The average N-Gain result obtained by girl's class is 0.83 which is categorized as high, while boy's class got 0.62 for an average N-Gain result which can be categorized as a medium. The result indicates that the concept of heat can be understood better by the students after having instruction using problem-solving model. The improvement of students' conceptual mastery is also supported by the acceptance of H_1 which means that there is a significant effect of the problem-solving model towards students' conceptual mastery. The implementation of the problem-solving model in learning heat chapter can improve students' motivation. It is noticed and proven by processing data of boy students' response percentage. The percentage of girl students' motivation class is higher than the percentage of boy students' motivation. The response of students' motivation towards the implementation of the problem-solving model in learning heat chapter shows positive response in two indicators; leisure and usefulness. The highest score is obtained by the indicator of usefulness which means that the students agree that problem-solving learning is stimulating students' curiosity.

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