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Global Conferences Series:
Sciences and Technology (GCSST), Volume 2, 2019
The 1st International Conference on Education, Sciences and Technology
DOI: https://doi.org/10.32698//tech1315145

Minimizing Misconceptions on Temperature and Heat Topic by Jigsaw Cooperative Learning

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Abstract. This experiment research pretest-postest control group design was aimed to improve the student's understanding of the concept and minimize misconceptions on the Temperature and Heat topic. The subjects of this research were selected`using cluster random sampling from High School students in Gorontalo. The instruments used to collected the data included pretest, posttest and questionnaires. The data were analyzed using t-test and the students' conception profiles were carried out using CRI, Certainty of Response Index technique. The results of research show the significant difference in the posttest average and normalized gain average between the experimental class (81.976 and 0.679) and control class (68.267 and 0.437) and tcount = 12.575 greater than ttable = 2.000 on the confidence level 0.05. This results of research are supported by the fact that misconceptions in the experimental class are smaller than those in the control class. The implementation of Jigsaw Cooperative Learning is effective to improve the understanding of the concepts and minimize the misconceptions on the Temperature and Heat topic.

Keywords: Jigsaw Learning, Concept Understanding, Misconception, Temperature and Heat

1. Introduction

The researchers were agree that improper understanding of concepts is called misconception (Novak & Gowin, 1984; Van den Berg, 1991; Dahar, 1996; Indrawati, 1997; Prasetyo, 2001; Suparno, 2005). Some of researchers describe that students' difficulties in understanding the concept of kinematics (Sutopo, et al., 2012; Trowbridge & McDermott, 1980; McDermott, et al., 1987; Halloun & Hestenes, 1985). The students' difficulties in understanding the concept of physics is causing misconceptions. The students' misconceptions in physics will occur if their conception is contrary to the experts conception. Some physics education researchers such as Van den Berg (1991) and Dahar (1996) define concepts as grouping a number of objects, phenomena, events, or processes in terms of their distinctive characteristics.

The understanding of concepts is the most urgent aspect in the physics learning process. The proper understanding of facts, concepts, principles, and law or theory of physics can be realized through constructivism learning theory, namely students must actively construct their knowledge continuously to a more complete understanding, while the teacher facilitates students by providing means, learning resources and a conducive environment for constructing his knowledge, stimulating student curiosity and helping students communicate their ideas, as well as monitoring and evaluating student activities (Suparno, 1997).

The Jigsaw cooperative learning is a form of learning process based on constructivism learning theory. The Jigsaw cooperative learning model is requires each student to active in the material understanding when discussing in experts group and explaining it when returning to the original heterogeneous group so that eventually each group member gains a comprehensive understanding (Aronson, 2002; Lai & Wu, 2006). In other words, the application of the Jigsaw cooperative learning allows students to construct their knowledge, improve understanding of concepts and minimize misconceptions on the temperature and heat topic. It is said that because the each member group in Jigsaw cooperative learning is required to cooperate work and help each other to understand the subject matter.

The based on the description above, this research is describes the efforts to improve understanding of concepts and minimize students' misconceptions on the temperature and heat topic through the Jigsaw cooperative learning model.

2. Method

The subject of this experiment research were selected from X classes by using cluster random sampling technique on the high school in Gorontalo. The number of respondents was 30 students in the experimental class and 30 students in the control class. This experiment research used the Pretest-Posttest Control Group Design (Sugiyono, 2006; Cohen & Manion, 1994). In answering the multiple choice test, the students were also asked to give the score of confidence level about the accuracy of the answers with using the scale of 0 to 5 (Hasan et al. 1999). The score 0 states that totally guessed answer, score 1 states almost guess, score 2 states not sure, score 3 states sure, score 4 states almost very confident, and score 5 states very confident (certain). The combination of the accuracy of the answers and the level of confidence of students in answering the test is used to express the level of student understanding of the concepts of temperature and heat tested as presented in Table 1. Potgieter et al. (2010) have used this method to reveal students' conceptual understanding.

Table 1. Rubric of understanding level according to accuracy of answers and level of confidence

Answer	Understanding Level According to Score Confidence Level					
	5	4	3	2	1	0
True	Very Good	Good	Enough		Weak	
False		Misconception			Weak	

(adapted from Hasan et al. (1999)).

The data in Table 1 is categorized as understanding of concepts, misconceptions, and not understanding of concepts. The pretest was aimed to determine the homogeneity level of students 'understanding of concepts, while the posttest was aimed to determine the differences in the students' understanding of concepts between the experimental class and the control class on the temperature and heat topic. The normalized gain average <g> of the experiment class and control class was calculated from the results of the pretest and posttest by using the Hake equation (1998). The normalized gain average is classified as presented in Table 2.

Table 2. Classification of the Normalized Gain Average

Hake Equation	Number	Normalized Gain Average <g>	Klasifikasi
$< g >= \frac{< X_f > - < X_i >}{100 - < X_i >}$	1.	$< g > \geq 0.7$	High
	2.	$0.3 \leq < g > < 0.7$	Medium
	3.	$< g > < 0.3$	Low

The value of normalized gain average for experiment class and control class are determine the success of the experiment, while differences in students' understanding on temperature and heat topic were analyzed by using the t-test at the convidence level 0.05.

3. Results and Discussion

Data pretest, posttest, and normalized gain averages for the experiment class and control class as presented in Table 3.

Table 3. Pretest, Posttest and Normalized Gain Averages

Pretest Average		Posttest Average		Gain Average	
Exsperiment	Control	Experiment	Control	Experiment	Control
43,8	43,6	81,967	68,267	0,679	0,437

The data pretest average in Table 3 show that there is no difference in the students' understanding initial between the experiment class and the control class or homogeneous. But the data posttest average shows the difference in understanding of the concept between the experiment class and the control class, which occurs in the normalized gain average <g> in the medium category.

The results of the t-test was obtained t_{count} = 12.575 greater than t_{table} = 2.000 on the confidence level 0.05 and degrees of freedom is 58. This result indicates the differences of the students' understanding on the temperature and heat topic between the experiment class and control class after the application of the Jigsaw cooperative learning model. Thus the application of the Jigsaw cooperative learning model is effective in increasing students' conceptual understanding on the temperature and heat topic. This result is similar to the research result of Mursalin's (2014) that the application of the Predict-Observe Explain (POE) learning model effectively improves understanding of concepts and minimize misconceptions on the electrical circuits topic; Santoso et al. (2007) that the application of the POE learning model was able to improve the mastery of students' concepts and generic skills on the dynamic fluid topic.

The difference in the students' understanding between the experiment class and the control class is due to the application of constructivism learning theory on the experimental class, which is the each group member has responsibility, cooperate with each other, and helps each other in understanding the subject matter, and empowers of the peer tutors from the expert group. The experiment class is also a democratic class where each student has the opportunity to express his opinion freely, and the application of scaffolding technique for data analysis and conclusions.

The application of CRI and interviews techniques can be described as causes of the students' misconceptions on the temperature and heat topic . **First**, 87% of 30 students of the experiment class and 83% of the 30 students of the control class were stated that water in the glasses A and B (same temperature) are mixed in glass C, the mixed of temperature was twice the temperature of water in glass A or glass B. Next, the water in the glass A is poured as much into glasses B and C, the temperature of water in the glasses B and C becomes half of the original temperature. They reasoned that the mass of the water was increased to twice the original mass or reduced by half of the original mass. Even though if the measured by using a thermometer will get the temperature of water in glasses A, B, and C are the same.

Second, 77% of 30 students of the experiment class and 80% of 30 students of the control class were stated that if two objects with same the mass and different of temperatures, it touch each other there will be a flow of temperature from high-temperature objects to low-temperature objects. They reason that the temperature can flow as it does with water flowing from high place to low place. They cannot

distinguish between the temperature and heat concepts. Even though if asked to heat one end of the metal rod and the other end is held it will get the end of the metal rod held is hot.

Third, 90% of 30 students of the experimental class and 93% of 30 students of the control class were stated that if two objects with the mass and the temperature are the same but different heat capacity, it touch each other, then heat capacity is flow from objects that have a high heat capacity to objects that have a low heat capacity. They also state that if two objects with the mass and temperature are the same but different specific heat, it touch each other, then specific heat flow from object that has a high specific heat to object that has a low specific heat. Even though the heat capacity indicate the characteristics of objects and specific heat indicate the characteristics of substances that cannot move from one object to another.

Fourth, 93% of 30 students of the experiment class and 90% of students of the control class stated that if two objects (same the mass) are different of specific heat and its heated together, then both objects have the same of heat. They also state that if two objects (same the mass) are different of heat capacity and its heated together, then both objects have the same of heat. Even though the object that have the large of heat capacity or specific heat, it is faster to heat than the object have the small of heat capacity or specific heat.

Fifth, 80% of 30 students of the experiment class and 90% of 30 students of the control class stated that if 100 grams of ice at -10o C were heated to become vapor, then the temperature of the ice always increase and was never constant. Even though the relationship graph between the increase of temperature and the amount of absorbed the heat by ice, are be obtained: Ice temperature is increase from -10oC ice to 0oC ice, the ice temperature is constant from 0oC ice to 0oC water, the water temperature is increase from 0oC water to 100oC water, the water temperature is constant from 100oC water to 100oC vapor, then increase again.

The findings of the misconception as described above are verification of some of the results of research in Indonesia as mentioned by van den Berg (1991), Suparno (2005), and Tiberghien (1985) in France. The findings of their research the mention that the occurrence of misconceptions on the temperature and heat topic was caused by the students' initial concept or preconception. They mention a lot of the number and types of students' misconceptions on the temperature and heat topic. For example: temperature, specific heat and heat capacity are considered as something that can flow, the difference of concept between temperature and heat, heat as a form of energy that can flow, thermal equilibrium, and essence of form change .

After the treatment, profiles of students who understood the concept, did not understand the concept, and misconceptions on the temperature and heat topic for the experiment class and the control class are presented in Table 4.

Table 4. Percentage of understanding concepts, not understanding concepts, and misconceptions

Understanding (%)		Not Understanding (%)		Misconception (%)	
A	B	A	B	A	B
90	77	7	10	3	13

Data in Table 5 show that the profile percentage average of students who the understanding of concept on the temperature and heat topic for the experiment class is higher than the control class. The application Jigsaw cooperative learning and conventional learning are be able to improve the classically of the students' understanding of concepts on the temperature and heat topic on the above the minimum completeness criteria, 75%. Conventional learning are be able to contribute to increasing

students' understanding through learning methods and scenarios according to the student characteristics and subject matter. Furthermore, the application of the Jigsaw cooperative learning is superior in minimizing the occurrence of misconceptions on the temperature and heat topic than conventional learning. This is indicated by the profile of the students percentage average who experienced the misconceptions for the experiment class smaller than the control class. This finding reinforces of the theory which states that misconceptions can be reduced but cannot be erased with certain learning models (Suparno, 200%). The result of research from Mursalin (2013) that the PhET simulation model assisted by worksheets can be used to remediate and minimize the misconception of prospective physics teacher on the electrical circuits topic; and Sutopo (2016) stated that students' failure in solving conceptual problems on the mechanical waves topic is due to misconceptions.

4. Conclusion

There are differences in the students' understanding on the temperature and heat topic between students who were learned with the Jigsaw cooperative learning and students who were learned with conventional learning. The students who were learned with the Jigsaw cooperative learning are superior in improving understanding of concepts and minimize misconceptions than those the students who were learned with conventional learning. The Jigsaw cooperative learning is recommended to be applied to science learning in an effort to enrich the results of misconception research. In addition, the Jigsaw cooperative learning is also recommended for further research to test the consistency level of the previous findings in an effort to improve the quality of learning processes and outcomes in schools.

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