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THE EFFECTS OF COOPERATIVE LEARNING STRUCTURES AND PRIOR KNOWLEDGE TOWARD THE LEARNING OUTCOMES OF UNDERSTANDING AND APPLICATION OF PHYSICS CONCEPTS FOR THE STUDENTS OF MATHEMATICS EDUCATION DEPARTMENT

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Abstract

The background of this research relates to a current problem faced by the teacher and students of Mathematics Education Depatment, in which the quality of learning process and the results were still not optimal. Learning basically has the social aspect, therefore it needs instructional design which can give the opportunity for the students to do the social, interpersonal interaction and increase the academic ability. The cooperative learning of Numbered Heads Together (NHT) and Think-Pair-Share (TPS) are cooperative learning structure that can be used to teach the academic content and social skills. The purpose of this research were to examine the main effects and interaction effects of cooperative learning structure and the level of prior knowledge on learning outcomes of understanding and application of physics concepts for the students of Mathematics Education UNIROW Tuban. Experimental design which was used was quasi experiment pretest-posttest nonequivalent control group design. The technique of data analysis which was used was 2 x 2 factorial MANOVA. The results of the research showed that: (1) learning outcomes of understanding and application of physics concepts Mathematics Education students between NHT and TPS cooperative groups did not differ significantly, (2) learning outcomes of understanding and application of physics concepts of Mathematics Education students between groups of students with high prior knowledge and low prior knowledge differed significantly, (3) there were interaction effects between the cooperative learning structure and the level of prior knowledge on learning outcomes of understanding and application of physics concepts for the Mathematics Education students.

Key words: cooperative learning, NHT, TPS, prior knowledge, learning outcomes, understanding of concepts, application of concepts, physics

INTRODUCTION

One of the many problems in education in Indonesia these days is the quality of learning process in results is still not optimal. In the teaching and learning processes nowadays, there are still some views placing students as the object, not the subject of the processes, who must be given chances to construct and develop their own knowledge and understanding.

Effective learning emphasizes the importance of learning as a personal process, in which each learner construct his/her own knowledge and personal experience (Slavin, 2005). Personal knowledge and experience is constructed through the interaction of learners and their environment. Learning must be seen as knowledge construction from real life experience, from collaborative, reflective, and interpretative activities (Degeng, 1997). To come to this point, teaching paradigm which has long been dominating our educational fields must be changed into learning paradigm, in which the new paradigm places emphasis on learners as to let learners to

be active in constructing their own knowledge while still taking into consideration the social substances of learning. This is in line with Piaget's and Vygotsky's idea—which emphasizes social substances in learning, as well as cognitive development in constructing knowledge (Slavin, 2005).

Based on the documentation, observation, and interviews with several Mathematics students taking Basic Physics Course I and the lecturers teaching the course, some conclusions could be drawn: (1) students' achievement in the course was still low; (2) students' understanding and ability to apply concepts was still low; (3) some students were simply memorizing Physics formulas without understanding the formulas, which caused them to face difficulties in applying those formulas to solve problems; and (5) many students knew concepts and formulas without knowing how to apply them in solving problems related to Physics.

Two of the factors affecting learning outcomes are the learning strategies applied in class and the characteristics of learners (Slavin, 2005; Degeng, 1997). Learning outcomes are also affected by learning condition and interaction between learning methods and learning condition (Dick, et al., 2001). Learning situation covers all variables which cannot be manipulated by teachers and have to be accepted as they are. These variables are learning aims, learning contents, availability of learning sources, and learners' characteristics (Degeng, 2007). One of learners' characteristics which can affect learning outcomes is prior knowledge (Dochi, 1992; Sudyana, et al., 2007; Prastiti, 2007; Hailikari, 2009; Beskeni, et al., 2011). Considering the hierarchical nature of Physics materials and the close relationship of Physics with Mathematics, one may expect that learners' prior knowledge will affect understanding and application of Physics concepts.

Considering the expected learning outcomes, learners' characteristics, learning environment, and learning materials, teachers need to choose appropriate learning strategies. Learning basically has social aspects (Degeng, 2007); this implies that learning activities must give chances to learners to work in groups and to cooperate with each other in such heterogeneous groups. Thus, the learning strategies not only must give chances for learners to improve their academic skills and to have social and interpersonal interaction, but also must help learners to develop good characters by learning good values such as tolerance, discipline, hard work, independence, cooperation, responsibility, etc. One of the learning strategies considered suitable for those purposes are cooperative learning strategies since these kinds of strategies will allow students to learn cooperating skills and develop the good characters.

The cooperative learning strategies, *Numbered Heads Together (NHT)* and *Think-Pair-Share (TPS)*, are two kinds of cooperative learning strategies under structural approaches. These two strategies can be done in daily teaching and learning processes since the strategies are simple, easy to conduct, and fun (Kagan, 1994), and have been empirically proven to help improving learners' academic and social skills.

Based on the afore-presented explanation on common problems in our education and especially on problems in teaching and learning processe which cause the low quality of our education, and also the low Physics understanding and scores for Mathematics Department students, not to mention the high variety of students' prior knowledge which has not really been paid attention on, and the strengths of NHT and TPS learning strategies, thus a study on how NHT and TPS affect learning outcomes (understanding and application of Physics concepts) on Mathematics Department students at Unirow, Tuban. The results of the study is expected to be an alternative problem solving for teachers and educators who want to improve the quality of both the processes and the outcomes of teaching and learning.

The research problems were then formulated as follows: (1) Was there any significant

difference in the understanding of Physics concepts between students learning through NHT strategy and students learning through TPS strategy?; (2) Was there any significant difference in the application of Physics concepts between students learning through NHT strategy and students learning through TPS strategy?; (3) Was there any significant difference in the understanding of Physics concepts between students having high prior knowledge and students having low prior knowledge?; (4) Was there any significant difference in the application of Physics concepts between students having high prior knowledge and students having low prior knowledge?; (5) Was there any significant interaction effect of the implementation of cooperative learning strategies and prior knowledge on students' understanding of Physics concepts?; and (6) Was there any significant interaction effect of the implementation of cooperative learning strategies and prior knowledge on students' abilities to apply Physics concepts?

RESEARCH METHOD

Quasi-experimental pretest-posttest research design with a non-equivalent control group factorial 2 x 2 by employing intact groups was chosen for this present study. The research subjects were Mathematics Department students of Unirow, Tuban, who were taking Basic Physics Course I in the academic year of 2011/2012. Two classes, out of the total six classes, were chosen through cluster random sampling to be given the treatment. Those two classes were class 2011 A (as many as 35 students) which would be taught using NHT learning strategy, and class 2011 B (as many as 36 students) which would be taught using TPS learning strategy.

The learning aids developed throughout the study consisted of a syllabus, SAP, students' worksheet, and items for quizzes—five experts on the field of Mathematics and of teaching validated all instruments. The research instruments consisted of observation sheet on the application of the strategies (NHT and TPS) in classes and tests. The tests consisted of a test on prior knowledge (a prior knowledge test stage 1, a pretest on understanding of Physics concepts, and a pretest on application of Physics concepts), a posttest on understanding of Physics concepts, and a posttest on application of Physics concepts. The prior knowledge test stage 1 (consisted of 55 multiple choices items), test on understanding of Physics concepts (35 multiple choices items accompanied with written justification), and test on application of Physics concepts (10 open-ended items/essay) were all validated by four experts in Mathematics, and had all been proven to be valid and reliable through the try out stage.

Data were analyzed using MANOVA factorial 2 x 2, in which the data had first been tested for normality and homogeneity of variances. All hypothesis testing was done on the level of significance of 5% using SPPS version 19.0 for Windows.

RESEARCH RESULT

The result of *t*-test to compare the significant difference of the mean scores for the pretest on concept understanding between the NHT and TPS group showed that the scores did not differ significantly. The result of *t*-test to compare the significant difference of the mean scores for the pretest on concept application between the NHT and TPS group showed that the scores did not differ significantly.

The result of the test on normality on posttest scores on concept understanding and application from both the NHT and TPS strategies and also from both high and low prior knowledge based on the *Kolmogorov-Smirnov* test and *Shapiro-Wilk* test showed that all the scores were sig > 0.05, which means that all the scores were normally distributed. The homogeneity test of matrix covariance was done using the *Box's M Test* method and the

homogeneity test of variance was done using the *Levene's Test*.The result of the *Box's M Test* was 8.938 with a level of significance (sig.) = 0.498 (> 0.05), which means that the variance-covariance matrices on the variable of concept understanding and concept application were the same for both the groups of cooperative learning strategies and the groups of prior knowledge. From the *Levene's Test* on concept understanding sig. = 0.684 and concept application sig. = 0.318 (> 0.05), which means that variance-covariance matrices on the variable of individual concept understanding and individual concept application were the same for both the groups of cooperative learning strategies and the groups of prior knowledge. Since the assumption on same variance-covariance matrices could be fulfilled, the MANOVA could proceed.

TABLE 1. MULTIVARIATE TESTS[B]

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	,986	2405,207[a]	2,000	66,000	,000
	Wilks' Lambda	,014	2405,207[a]	2,000	66,000	,000
	Hotelling's Trace	72,885	2405,207[a]	2,000	66,000	,000
	Roy's Largest Root	72,885	2405,207[a]	2,000	66,000	,000
Strategy	Pillai's Trace	,007	,217[a]	2,000	66,000	,806
	Wilks' Lambda	,993	,217[a]	2,000	66,000	,806
	Hotelling's Trace	,007	,217[a]	2,000	66,000	,806
	Roy's Largest Root	,007	,217[a]	2,000	66,000	,806
PK	Pillai's Trace	,439	25,831[a]	2,000	66,000	,000
	Wilks' Lambda	,561	25,831[a]	2,000	66,000	,000
	Hotelling's Trace	,783	25,831[a]	2,000	66,000	,000
	Roy's Largest Root	,783	25,831[a]	2,000	66,000	,000
Strategy* PK	Pillai's Trace	,116	4,343[a]	2,000	66,000	,017
	Wilks' Lambda	,884	4,343[a]	2,000	66,000	,017
	Hotelling's Trace	,132	4,343[a]	2,000	66,000	,017
	Roy's Largest Root	,132	4,343[a]	2,000	66,000	,017

a. Exact statistic
b. Design: Intercept + Strategi + PK + Strategi * PK

The hypothesis testing on the effect of the cooperative learning strategies on learning outcomes (concept understanding and concept application) showed sig. = 0.806 (> 0.05), which means that both the learning outcomes on concept understanding and concept application did not show any significant difference between the NHT group and the TPS group.

The hypothesis testing on the effect of prior knowledge on learning outcomes (concept understanding and concept application) showed sig. = 0.000 (< 0.05), which means that there was a significant difference on concept understanding and concept application between students with high prior knowledge and students with low prior knowledge.

The hypothesis testing on the interaction between cooperative learning strategies and prior knowledge (strategy*PK) on learning outcomes (concept understanding and concept application) showed sig. = 0.017 (< 0.05), which means that there was a significant interaction between cooperative learning strategies and prior knowledge on learning outcomes (concept understanding and concept application).

TABLE 2. TESTS OF BETWEEN-SUBJECTS EFFECTS

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	UC	7119,590[a]	3	2373,197	19,871	,000
	AC	848,235[b]	3	282,745	6,353	,001

Intercept	UC	529512,475	1	529512,475	4433,644	,000
	AC	74054,354	1	74054,354	1664,058	,000
Strategi	UC	39,077	1	39,077	,327	,569
	AC	,905	1	,905	,020	,887
Prior Knowledge (PK)	UC	5927,953	1	5927,953	49,635	,000
	AC	634,704	1	634,704	14,262	,000
Strategi * PK	UC	835,443	1	835,443	6,995	,010
	AC	196,870	1	196,870	4,424	,039
Error	UC	8001,847	67	119,431		
	AC	2981,652	67	44,502		
Total	UC	74313,000	71			
	AC	82741,000	71			
Corrected Total	UC	15121,437	70			
	AC	3829,887	70			

a. R Squared = ,471 (Adjusted R Squared = ,447)
b. R Squared = ,221 (Adjusted R Squared = ,187)
UC = understanding of concepts ; AC = application of concepts

There was not any significant difference in concept understanding between the NHT group of students and the TPS group of students. It can be seen by Sig. = 0.569 (> 0.05). There was not any significant difference in concept application between the NHT group of students and the TPS group of students. It can be seen by Sig. = 0.887 (> 0.05).

There was a significant difference in concept understanding between students having high prior knowledge and students having low prior knowledge. It can be seen by Sig.= 0.000 (< 0.05. There was a significant difference in concept application between students having high prior knowledge and students having low prior knowledge. It can be seen by Sig.= 0.000 (< 0.05).

There was a significant interaction between learning strategies and prior knowledge on concept understanding. It can be seen by Sig.= 0.010 (< 0.05). There was a significant interaction between learning strategies and prior knowledge on concept application. It can be seen by Sig.= 0.039 (< 0.05).

DISCUSSION

The Effect of Cooperative Learning (NHT and TPS) on Physics Learning Outcomes (Concept Understanding and Concept Application)

The result of hypothesis testing using MANOVA showed there was not any significant difference on concept understanding and concept application on Basic Physics Course I between students who learned through the NHT strategy and students who learned through the TPS strategy. This finding supports the findings from the previous study which states that there is not any significant difference between the two cooperative learning strategies of TPS and NHT on students' learning outcomes (Lestari, 2009).

Some factors that may cause the non-significant difference are (1) the fact that NHT learning syntax and TPS learning syntax are quite similar, and (2) research subjects came from the same major and university (community).

The Effect of Prior Knowledge (High and Low) on Learning Outcomes (Understanding of Physics Concepts)

The result of MANOVA test showed that there was a significant difference on concepts

understanding between students with high prior knowledge and students with low prior knowledge. This finding supports the result of previous studies, which state that prior knowledge can affect learning outcomes (Dochi, 1992; Sudyana, et al., 2007; Prastiti, 2007; Hailikari, 2009; Beskeni, et al., 2011).

Prior knowledge can be used as a reference in studying new knowledge easily, in testing the relevance and accuracy in finishing the new tasks. The more relevant the prior knowledge with the new tasks, the more meaningful learning will be. Prior knowledge is a base for learners to study, which will also help them to understand.

The Effect of Prior Knowledge (High and Low) on Learning Outcomes (Application of Physics Concepts)

The result of hypothesis testing showed that there was a significant difference on concept application between students having high prior knowledge and students having low prior knowledge. This finding is in line with the findings from studies which report that prior knowledge can affect students' learning outcomes (Sudyana, et al., 2007; Prastiti, 2007; Hailikari, 2009; Beskeni, et al., 2011).

Learners' abilities in applying concepts in Physics are determined by the existence of good cognitive structure. Problem solving skills need easily transferred knowledge, referring to the knowledge relevant to new knowledge or new materials learned. This is supported by a cognitive theory on transfer (Ausubel, 1968), which states that transferability mostly depends on relevance function, meaningfulness, clarity, stability, integrity, and the strength as well as the clarity of previously learned sources.

The Interaction Effect of Cooperative Learning Strategies and Prior Knowledge on Learning Outcomes (Understanding of Physics Concepts)

The significance level on interaction between cooperative learning strategies and prior knowledge on concept understanding was 0.010 (< 0.05), which made H_0 rejected. This means that there was significant interaction between cooperative learning strategies and prior knowledge on learners' understanding of Physics concepts. The interaction plot of prior knowledge and cooperative learning strategies on concept understanding can be seen in Figure 1. On Fig.1, it is clear that the two lines are not parallel, which means that there was an interaction between cooperative learning strategies and prior knowledge on learners' understanding of Physics concepts.

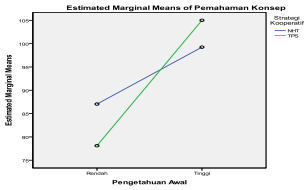

Fig. 1 Interaction Plot Between Cooperative Learning Strategies (NHT and TPS) and Prior Knowledge on Learning Outcomes (Understanding of Physics Concepts)

The findings suggest that either type (NHT or TPS) of the cooperative learning strategies alone does not produce such significant effects on students' understanding of Physics concepts; yet, when the cooperative learning strategies are combined with prior knowledge, it will result in such significant effects on students' understanding of Physics concepts.

The Interaction Effect of Cooperative Learning Strategies and Prior Knowledge on

Learning Outcomes (Application of Physics Concepts)

The significance level on interaction between cooperative learning strategies and prior knowledge on concept understanding was 0.039 (< 0.05), which made H_0 rejected. This means that there was significant interaction between cooperative learning strategies and prior knowledge and learners' ability in applying Physics concepts. The interaction plot of prior knowledge and cooperative learning strategies on concept application can be seen in Fig.2. On Fig. 2, it is clear that the two lines are not parallel, which means that there was an interaction between cooperative learning strategies and prior knowledge and learners' ability in applying Physics concepts

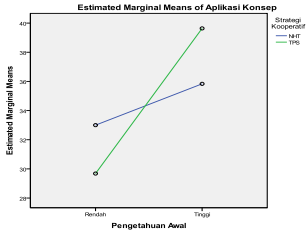

Fig. 2 Interaction Plot Between Cooperative Learning Strategies (NHT and TPS) and Prior Knowledge on Learning Outcomes (Application of Physics Concepts)

The findings suggest that either type (NHT or TPS) of the cooperative learning strategies alone does not produce such significant effects on students' ability in applying Physics concepts; yet, when the cooperative learning strategies are combined with prior knowledge, it will result in such significant effects on students' ability in applying Physics concepts.

CONCLUSION

1. The learning outcomes on understanding of Physics concepts between the NHT group and the TPS group, both were the students of Mathematics Department of Unirow, Tuban, did not differ significantly.
2. The learning outcomes on the ability to apply Physics concepts between the NHT group and the TPS group, both were the students of Mathematics Department of Unirow, Tuban, did not differ significantly.
3. The learning outcomes on understanding of Physics concepts between students having high prior knowledge and students with low prior knowledge, both were the students of Mathematics Department of Unirow, Tuban, differed significantly.
4. The learning outcomes on the ability to apply Physics concepts between students having high prior knowledge and students with low prior knowledge, both were the students of Mathematics Department of Unirow, Tuban, differed significantly.
5. There is an interaction effect of the implementation of cooperative learning strategies and prior knowledge on students' understanding of Physics concepts for the students of Mathematics Department of Unirow, Tuban.
6. There is an interaction effect of the implementation of cooperative learning strategies and prior knowledge on students' ability in applying Physics concepts for the students of Mathematics Department of Unirow, Tuban.

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