Jurnal Didaktik Matematika
ISSN 2355-4185(p), 2548-8546(e)
DOI: 10.24815/jdm.v7i1.14932

The Effect of Think Pair Check Model on Students Understanding of Mathematical Concepts in Terms of Cognitive Style

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Abstract. *This quasi-experimental research aims to determine the effect of Think Pair Check (TPC) learning models on understanding of mathematical concepts in terms of cognitive style. A purposive sampling technique was used to select a sample of 54 students from a junior high school in Patamuan sub-district, Indonesia. The data were obtained from mathematical concept understanding tests and Group Embedded Figure Test (GEFT) to determine students' cognitive styles. Data were analyzed using t-test. The findings indicated that students who learned using TPC method had a better understanding of concepts than those learning using the conventional model. Furthermore, the TPC learning model positively influenced the understanding of mathematical concepts of students with the Field Independent cognitive style but had no influence on students with the Field Dependent cognitive style. Therefore, the TPC learning model can be used to improve the understanding of mathematical concepts, especially for students with the Field Independent cognitive style.*

Keywords: *think pair check, mathematical concept understanding, cognitive style.*

Introduction

In learning mathematics, students are required to understand and apply concepts to solve various problems. In line with the learning objectives of mathematics as stipulated in the Minister of Education Regulation of the Republic of Indonesia, No. 58 of 2014, students have to understand mathematical concepts, namely explaining the interrelationships between concepts flexibly, accurately and efficiently.

The understanding of concepts and problem-solving skills are interrelated and need to be addressed (Martunis, Ikhsan, & Rizal, 2014). For someone to be able to solve the problem given, s/he must first understand the concept well. Understanding of concepts is necessary because it will influence the subsequent application.

Understanding of concepts is a comprehensive understanding of the basic concepts of mathematical algorithms (Andamon & Tan, 2018). Husna (2017) argued that, in general, students have difficulty in understanding mathematical concepts. Consequently, when students are provided with questions that are different from the examples given by the teacher, they find it hard to solve them. Another study by Hadi and Kasum (2015) suggested that by understanding the concepts, students will more easily connect further concepts and apply them to solve problems. Furthermore, Rittle-Johnson and Schneider (2014) stated that understanding of concepts is an understanding with many connections to other information.

The two issues, understanding of mathematical concepts and mathematical problem-solving are problematic in Patamuan sub-district, Padang Pariaman, Indonesia, as indicated by the average score of national exam in the 2017/2018 academic year. The average mathematics score of four junior high schools in Patamuan sub-district, Padang Pariaman regency was below 50.

A teacher can make some efforts to help students to have a good understanding of concepts. One of them is using a variety of learning models that fit the characteristics of the students and the materials to teach. Yerizon, Putra, and Subhan (2018) believed that the learning model has a significant influence on student’s mathematics learning outcomes. One learning model that can be used by teachers is a cooperative learning model, that is, the Think Pair Check (TPC) type.

Sherman (2003) explained some factors causing students to work cooperatively, namely: 1) students' feeling that they belong in a group as a team with the same goals to achieve; 2) students in a group having an equal sense of responsibility and thinking that the group success is his/her success; 3) good communication between students in a group in solving group problems, and 4) students realizing that each member's work will lead to the group success. Rinanti, Sopyan, and Khanafiyah (2016) affirmed that the TPC learning model could improve students' scientific and mathematical abilities. TPC learning model is one type of cooperative learning model, developed by Spencer Kagan in 1990. The steps of TPC learning according to Kagan and Kagan (1998) are: 1) dividing students into groups, 2) giving each group several problems, 3) pairing the students in the group, the first student answer the first problem and the second student is the trainer if they agree with the answer they can continue the next problem; 4) the second question is solved by the second person, and the first person becomes the trainer when both agree with the answers they can continue to the next problem until all questions are solved; and 5) once all questions have been solved, the couple returns to the initial group to discuss their answers.

There are many factors that can also affect students' mathematical skills. Among others are learning style, cognitive style, motivation and independence (Suranata, Rangka, Ifdil, Ardi, Dharsana, Suarni, & Gading, 2019). Lack of teacher knowledge about cognitive styles would result in teachers paying less attention to cognitive styles in the learning process.

Cognitive style is the difference in cognitive behavior, thinking and remembering that will affect the behavior and individual activities both directly and indirectly (Allinson & Hayes, 1996). As students have different cognitive learning styles, the teacher should pay attention to it during the lesson.

Cognitive style is a way of individuals to organize, represent, and understanding their knowledge based on the interaction with the environment (Widiana, Bayu, & Jayata, 2017). The student's cognitive style can be detected based on several conditions, as follows: 1) their approach in doing a task, 2) her/his communication method in daily life, 3) her/his perspectives into the objects around, 4) her/his favorite subject, 5) learning model selected, 6) her/his way of organizing the information, and 7) his/her way in interacting with the teacher (Witkin, Moore, & Goodenough, 1977). Hence, teachers should know the characteristics, trend, habit, feeling and cognitive style of students so they can teach them well. Students' cognitive style should be considered in preparing and doing the lesson. Witkin et al. (1977) classified cognitive styles into two types: Field Independence (FI) and Field Dependence (FD).

Cognitive style can affect one's mathematical abilities. Ulya (2015) argued that a person's mathematical skills are related to his cognitive style. A higher the cognitive value (more towards Field Independence) leads to higher mathematical skills because cognitive style is a way for someone to organize information. It is important for mathematics teachers to know in advance the cognitive styles of their students (Jantan, 2014).

According to Onyekuru (2015) the characteristics of FI students are (1) analytical, competitive, individual, having internal motivation, a hypothesis tester and preferring details; (2) having the ability to restructure cognitive and high self-confidence, but less sensitive to social stimuli; (3) being able to set goals and strategies for learning; (4) analytic thinkers in learning, focusing more on mastery, not easily distracted and more alert; (5) being able to solve complex problems, remember information, separate facts from non-facts, encode general information quickly and accurately; and (6) preferring science and mathematics as well as having a higher working memory capacity.

On the other hands, the characteristics of FD students are: (1) preferring to be in a group and external information structures, having external motivation, more sensitive to social interaction and criticism, and passive; (2) having great interpersonal skills, being recognized as a warm, friendly and fun person; (3) their learning outcomes are influenced by the learning interaction, and positive or negative reinforcement from the teacher and peers; (4) being generally global in their analysis, or not being able to divide the information into parts; (5) preferring direct interaction and having a difficulty using intuition; and (6) their learning tasks easily influenced by other people's comments and prefer to interact with students with more skills so that they rely on in times of crisis.

Based on the characteristics of the cognitive style delivered by Onyekuru (2015), it seems that TPC can facilitate the strengths and weaknesses of FI and FD students. In the learning process, teachers can train and teach empathy and try to reduce the individual nature of FI students. As for FD students, they need encouragement and assistance from the teacher and the environment to understand the materials. Therefore, this research aims to determine the effect of TPC learning models on the understanding of mathematical concepts in term of cognitive style.

Research on the application of the TPC model to improve understanding of mathematical concepts and mathematics learning outcomes has been done by previous researchers (Arnes, 2015; Fauzia, 2012; Lathifah, Hidayati, & Mahsun, 2016; Rejeki, 2019). However, research examining the influence of the TPC learning model on students' understanding of mathematical concepts in terms of students' cognitive styles is limited. Therefore, the research questions in this study are: 1) is the students who learned using the TPC model had a better understanding of the mathematical concepts than those learning using the conventional model, 2) does the TPC learning model positively influence students' understanding of mathematical concepts in terms of cognitive style?

Method

This study used a quasi-experimental with a factorial design, as presented in Table 1.

Table 1. Factorial design research design

Cognitive Style	Understanding of Concepts (Y_1)	
	Experiment (X_1)	Control (X_2)
FI (A_1)	$X_1Y_1A_1$	$X_2Y_1A_1$
FD (A_2)	$X_1Y_1A_2$	$X_2Y_1A_2$

Where:

FI (A_1) = The students' understanding of mathematical concepts with FI cognitive style
FD (A_2) = The students' understanding of mathematical concepts with FD cognitive style
$X_1Y_1A_1$ = The students' understanding of mathematical concepts in the experimental class with FI cognitive style
$X_1Y_1A_2$ = The students' understanding of mathematical concepts in the experimental class with FD cognitive style
$X_2Y_1A_1$ = The students' understanding of mathematical concepts in the control class with FI cognitive style
$X_2Y_1A_2$ = The students' understanding of mathematical concepts in the control class with FD cognitive style

The population in this study was junior high school students or equivalent in Patamuan sub-district, Padang Pariaman Regency, Indonesia. The selected schools are SMPN 1 Patamuan and MTsN 4 Padang Pariaman. Both schools involved in this study were equal in term of student performance as because both are favorite schools and 'A' accredited. One experiment class and one control class were taken randomly from each school. The sample class at SMPN 1 Patamuan was class VII.2 (experiment class) and class VII.1 (the control class). While the experimental and the control classes at MTsN 4 Padang Pariaman were classes VII.3 and VII. 4. The learning process conducted in the experimental class using the TPC learning model and the conventional learning model used in the control class. Both classes learn the same material, algebra for six lessons, and the two classes sit for the test in the seventh meeting

The independent variable in this study is the learning method (TPC and conventional learning models, the dependent variable is understanding of concepts, and the moderator variable is cognitive style. Data were collected using the understanding of concepts test that has been validated and pilot-tested beforehand. Validation was carried out by three mathematics lecturers with a score of 0.86 (very valid criteria). The indicators of understanding of concepts used in this study are based on Permendikbud No. 58 of 2014. They are: 1) restating the concepts learned; 2) classifying objects based on whether or not the requirements forming the concept are fulfilled; 3) identifying the properties of operations or concepts; 4) applying the concept logically; 5) providing examples or non-example; 6) presenting concepts in various forms of mathematical representation; 7) linking concepts in mathematics or outside mathematics; and 8) developing the necessary or sufficient conditions of a concept.

The Group Embedded Figure Test (GEFT) developed by Witkin (in Khatib & Hosseinpur, 2011) was used to examine the students' cognitive style. The test consisted of 18 questions. If students answered 12 or more questions correctly, the student is classified as a FI student. Meanwhile, if students completed less than 12, the student is included in the FD category.

The research data were then analyzed using the t-test. Research hypotheses are 1) students who learned using TPC model had a better understanding of the concepts than those learning using the conventional model; and 2) TPC learning models positively influence the understanding of concepts of students in terms of cognitive style.

Results and Discussion

The Effect of the Learning Models on Students' Understanding of Mathematical Concepts

Based on the results of the test given to the experimental and the control class after six lessons, the average of students' understanding of mathematical concepts for each indicator is shown in Table 2.

Based on Table 2, the experimental class students have better scores for almost all indicators of the concepts compared to the control class. However, for the indicators 1, 4, 7, and 8, the score of the experimental class is different from the control class. Understanding of concepts in mathematics is a continuous process, meaning that if you understand the concept at the beginning, it will be easier to understand the next concept. Sari, Gistituati, and Syarifuddin

(2019) said that students who understand a concept would be easier to understand other concepts and apply them.

Table 2. Results of students understanding of mathematical concepts based on concept understanding indicators

No	Indicator Understanding of Concepts	Average Score of Experiment Class	Average Score of Control Class
1	Providing examples and non-examples of concepts learned	100	88.89
2	Applying concepts logically	63.1	59.26
3	Linking various concepts in mathematics	54.76	52.47
4	Classifying objects based on whether or not the requirements forming the concept are fulfilled	84	72.22
5	Presenting concepts in various forms of mathematical representation	49.64	45.7
6	Restating the concepts learned	53.6	57.4
7	Identifying the properties of operations or concepts	67.9	59.26
8	Developing necessary and sufficient conditions for a concept	58	51.85

During the learning using TPC, students were given the opportunity to independently try the problem given by the teacher, and discuss their solution with their partners. Thus, students can better understand the materials, and when they face similar problems, they will be able to solve them. This is in line with Lathifah et al. (2016) who argued that students who tried to solve the tasks and discuss it with their peers would find it easier to understand the concepts because s/he constructs her/his knowledge.

For the first indicator, all students in the experimental class can solve the problem correctly. The students are asked to determine the same terms. If students can distinguish the like terms, they will find it easier to understand the next material, which is the operation of algebra.

As for the sixth indicator, 'restating the concepts learned', the average score of the students' understanding in the experimental class was lower than the control class. The problem given was about adding algebraic fraction. Most students were unable to determine the Lowest Common Mulptiple (LCM) from the denominator in the form of algebra. Students immediately added the numerators and the denominators. This happened because students did not understand the concept of adding fractions that they learned at the elementary school. Thus, the students had difficulty when solving problems related to the addition operation of algebra fractions. This is consistent with Sierpinska, (1994) said in his book that most students have difficulty understanding mathematics because of an incomplete understanding of mathematical concepts.

Overall, the average score of students in the experimental and control class are 65.29 and 55, respectively. Furthermore, to test the hypothesis that students' understanding of mathematical concepts in the experimental class is better than in the control class, a t-test was performed. The normality test, the prerequisite test of t-test, was conducted, and the results are as shown in Table 3.

Table 3. Test for students' understanding normality

	Kolmogorov- Smirnov [a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistics	df	Sig
Experiment Value	0.107	54	0.181	0.974	54	.290
Control	0.133	54	0.018	0.958	54	.059

a. Lilliefors Significance Correction

The results of the Shapiro-Wilk normality test show that the sample is normally distributed. Then the homogeneous test is performed (sign. = 0.290 and sign. = 0.059). Hence the sample is homogeneous. Next, t-test was conducted, and the results are presented in Table 3.

Table 4. Independent samples test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Student	Equal variances assumed	0.001	.975	2.295	100	.024	7.65642	3.33640	1.04310	14.26973
	Equal variances not assumed			2.293	107.443	.024	7.65642	3.33856	1.3842	14.27441

Based on the results of the t-test in Table 3, there was a significant difference between the understanding of concepts of students in experimental and control class; t= 2.295, p=0.012. This indicates that the understanding of the concepts of students learning with the TPC model is better than students using the conventional learning model. This finding is consistent with research conducted by Capar and Tarim (2015) that the use of cooperative learning in mathematics learning has a positive influence and needs to be considered.

In the learning process, the group were given the opportunity to train themselves to solve the problems. They had each responsibility to do some problems so that there were no students who did not participate in groups. High-achieving students will help their friends so that in TPC learning, peer tutors occur. Students have the opportunity to learn and be taught by high-achieving friends who had better understand the material.

Nurmi (2017) said that with cooperative learning, students could cooperate with each other, so their independence and confidence in learning increase. Students, who initially has a lack of understanding of the material presented, can discuss and immediately try to work on the problem so that the obstacles faced can be resolved. This activity brings a sense of satisfaction and self-confidence of students in learning mathematics.

The Effect of the Learning Models on the Understanding of Mathematical Concepts in Terms of Cognitive Style

During the learning, students were grouped based on GEFT scores, combining the FI students and FD students. This was done by considering the strengths of FI students who are generally more analytic, more focused on mastery, and able to solve complex problems but are lacking in the social field and more likely to be individualistic. Whereas FD students prefer to be social, are more sensitive to the surrounding environment, and are not able to divide information into parts. FD students need support from the surrounding environment to set goals. Therefore, FI and FD students will complement each other when they are placed in the same group. Through this collaboration, it is possible that there is a change in attitude and way of thinking for both FI students and FD students (Pithers, 2002).

In addition, in determining the group of four people, the researcher also asked the mathematics teacher for his consideration. In the learning, the experimental class students were given the opportunity to read the material first, and the teacher explained when questions arose. In the practice session, the teacher asked students to sit with the designated pair in their respective groups. The student solved the problem according to the agreement made with the group members to determine who solved the first problem. The first student who solved the problem card at each pair was named partner A, and his partner was named partner B. Next, the teacher gave the first card to partner A, and partner B acted as the coach.

After finishing solving the first question, A and B discussed the answers from their group. The question card was placed in the middle of the group when completed. The teacher then gave the second question; partner B solved the problem, and partner A acted as a coach. The first and second problems were equivalent in term of its difficulty. These activities were repeated until all the cards had been completed.

When all questions were done, each pair joined a large group of four people. They were asked to match their answers, discussed and agreed on the best answers. In the final stage, the teacher randomized one group to present the solutions of the group.

Table 5. Results of students understanding of mathematical concepts based on cognitive style

Characteristics	Understanding of Concepts (Y_1)			
	Cognitive style FI (A_1)		Cognitive Style FD (A_2)	
	Ex (X_1)	Control (X_2)	Ex (X_1)	Control (X_2)
N	19	17	37	37
Min	56.25	56.25	25	25
Max	100	93.75	81.25	81.25
$\bar{x}$	79.6	68.35	58.11	52.87
St. Dev.	12.47	11.42	14.57	18.19

Table 5 presents the results of the students' understanding of the concept test in terms of students' cognitive styles. Based on Table 5, it can be concluded that the average score of understanding of mathematical concepts of FI and FD students in the experimental class is higher than that of the control class. To test the hypothesis, the normality and variability homogeneity tests were first performed.

Table 6 shows the results of normality test for students' understanding of matehmatical concepts based on cognitive style

Table 6. Results of normality test for students' understanding of matehmatical concepts based on cognitive style

No.	Classification	Groups	Significance	Decision
1	FI	Experiment	0.434	Normal
		Control	0.156	Normal
2	FD	Experiment	0.157	Normal
		Control	0.064	Normal

Once the data was confirmed to be normally distributed, a homogeneity test was performed. The homogeneity test results for the understanding of concepts of FI and FD student indicates that both variance data are homogeneous samples (p=0.699 and p=0.71 for FI and FD, respectively). Next, the t-test was performed, and the results are showed in Table 7.

Table 7. T-test results understanding the mathematical concept in terms of cognitive style

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
FI	Equal variances assumed	0.152	0.699	2.811	34	0.008	11.25232	4.300355	3.11614	19.38851
	Equal variances not assumed			2.825	33.975	0.008	11.25232	3.98391	3.15643	19.34821
FD	Equal variances assumed	3.361	0.071	1.366	72	0.176	5.23549	3.83276	-2.40398	12.87695
	Equal variances not assumed			1.366	68.719	0.176	5.23549	3.83276	-2.41022	12.88319

The results of the t-test in Table 7 shows that there is a significant difference of understanding of concepts for FI students learning with TPC learning model and conventional model; t=2.881, p=0.008. This means that the TPC learning model influence FI students. In contrast, there is no significant difference showed for FD students (p=0.176). Aldarmono (2012) said that students with the FI cognitive style are more independent, more analytical and systematic. By using the TPC model, students' independence is better trained. FI students quickly understand the material and the TPC learning model also enable FI students to help and discuss with their group members. Thus, the analytical thinking skill of students with FI cognitive style is strengthened. In addition, students also required to present the discussion results. This activity triggers positive interdependence, mutual help and mutual motivation so that there are positive interactions that can support and increase students' understanding of concepts and mathematical problem-solving skills.

Hanifah, Juniati, and Siswono (2018), in their research, revealed that FI students are more focused and not easily distracted, while FD students are less focused and have low concentration. With a better concentration, the understanding of the concepts of FI students is also better than that of FD students. While the average score of FD students in the experimental class was higher than those in the control class. However, the difference was not significant (t= 1.366, p=0.176). This study indicates that the TPC model has a positive influence on FI students, but not on FD students.

Based on the characteristics of FI and FD students, both have obvious differences. FD students focus their attention on the social environment and depend on the external social standard. In contrast, FI students orientate less to the social environment and use more internal standard. In other words, FD students have better interpersonal skill than FI students who feel comfortable to work independently.

Students with FI cognitive style tend to be individual, respond well and independent (do not relate to others). They have intrinsic motivation and tend to work for an individual goal. On the other hand, students with FD cognitive learning style tend to learn in a group, depending on the teacher, and have extrinsic motivation. For this type of students, teachers have to design each activity in detail, what they should do, and how to do it. They will work well if the teacher helps and motivate them using praise and encouragement. These research results are in line with Davis (in Tinajero & Páramo, 1998), who found that there is a consistent pattern with FI dimension shown significantly better than FD students. The characteristics of the two cognitive style can be used as a reference for the teacher to adjust the learning strategy to be more varied so that it can increase students' learning outcome in general.

Conclusion

Based on the results of data analysis, it can be concluded that the understanding of mathematical concept of students who learn by TPC Model was better than those who learn in a conventional way. Furthermore, the TPC model has a positive influence on the understanding of mathematical concept of students with Field Independent (FI) cognitive style. Yet, it did not affect the understanding of mathematical concept of students with Field Dependent (FD) cognitive style.

The researcher faced an obstacle in this study. Many FD students had difficulty working on their own so that they were unable to complete assignments well. Consequently, the learning did not run well. However, learning with the TPC model can be used as an alternative to learning in schools to improve students' understanding of concepts. Future researchers should pay more attention to students with FD learning style so that they can be more independent.

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