Think Pair Share (TPS) Model Using Science, Technology, Engineering, Mathematics (STEM) Approach in Mathematics Learning

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ABSTRACT. The students' achievement in mathematics is low because the lack of learning innovation. This research was conducted to students' mathematics learning achievement by through the think pair share (TPS) model using science, technology, engineering and mathematics (STEM) approach designed in quantitative descriptive research. The population of this research was students in the eighth grade in the whole Junior High School in Karanganyar Districts, and the sample of the research was students in the eighth grade in SMP N 1 Matesih. The findings revealed that the TPS model using STEM approach had better mathematics learning achievement in geometry than students with TPS model. Moreover, students with TPS model had better mathematics learning achievement in geometry than students with direct learning.

1. Introduction
Learning innovation is one of the external factors influencing student achievement. The existence of various approaches and learning models is one of the ways of innovative learning. In the results of pre-research interviews, the most widely used model is the direct learning model. Direct learning is teacher-centered, interaction between students is lacking, and there are no cooperative groups. Lack of activity makes students face difficulties in understanding the learning material. Therefore, it should take a learning model that stimulates students' responses and activeness. Think Pair Share (TPS) models are one type of cooperative learning model. The procedures used in TPS give students more time to think individually and pair up to respond and help each other. Besides that, students also develop the ability to test ideas and understanding while comparing with the ideas expressed by other students. Hence, the interaction between students can occur, since the students are expected to understand the material. Therefore, the application of TPS-type cooperative learning model can be an effort to improve students' mathematics understanding abilities. The cooperative TPS model is a type of cooperative learning designed to influence student interaction patterns, this activity encourages students to be accustomed to think first independently, then work in pairs [1].

In addition to the TPS learning model, an approach that corresponds to daily life is also needed. Approach to Science, Technology, Engineering, Mathematics (STEM) is an integrated learning between science, technology, engineering, and mathematics to develop students' creativity through the process of solving problems in everyday life. Integrated STEM education is an interdisciplinary approach to learning, in which students use science, technology, engineering, and mathematics in a real context that
connects between school, the world of work, and the global world. Thus developing STEM literacy that enables students compete in the new economic era [2].

1.1. Direct Learning Model
Direct learning is the teaching and learning process used for problem solving with a common case, the use of maximum spoken language by educators, and the use of procedures that change students' errors into learning as experience [3]. Direct learning is teacher-focused learning with clear communication in the teaching process [4]. Direct learning is a potential learning method that can be implemented effectively in a learning environment that has a wide scale. In this study, direct learning is defined as a learning model that focuses on teachers with more active teachers and more communication during the learning process [5].

1.2. TPS Model
TPS learning model is a learning model designed to give students certain topics that enable them to formulate their ideas then share ideas they have with other students [6]. TPS learning model is designed to provide guidelines by providing students time and structure to think about the worksheets provided, allowing students to formulate ideas individually then share them with partners [7]. TPS is a type of cooperative learning designed to influence student interaction patterns. This technique requires students to work alone and work together to help each other with other students in a small group. With the classical method that allows only one student to advance and share the results for the whole class, TPS techniques give at least eight times more opportunities for each student to be recognized and show their participation to others [8]. Based on the description above, it can be concluded that the TPS type cooperative learning model is a learning model wherein the learning process students are required to actively think about problem solving, bring up their ideas, then share with each other so that they can improve their skills and creativity.

There are three steps in the TPS [9], namely:
1. Think: Teacher starts the teaching-learning process by seeking out specific questions about the topics. Students "think" about what they know or have learned about the topics for a given time slot,
2. Pair: Each student is paired with another student. Students share their solution to given problems in think phase, discuss ideas, and ask questions to each other. Teacher asks complex question and students are asked to solve the problem, and
3. Share: Pair has adequate time to share their thoughts and have a discussion; teacher expands the "share" into a whole-class discussion. Teacher allows each group to choose who will present their thoughts, ideas, and questions. After the class "share", teacher may again ask the pair to talk about how they changed as a result of the "share" element.

1.3. STEM Approach
STEM is a school-level meta-discipline where teachers of science, technology, engineering and mathematics teach an integrated approach in each discipline not divided but handled and treated as a dynamic whole [10]. STEM education is integrated as an approach that explores learning between two or more fields of STEM subjects and / or between STEM subjects with other school subjects [11].

STEM education is an important element of the global response to climate change or other technological problems facing contemporary society [12]. STEM education is focused on the development of workforce and research to meet the needs of industry, national security, and efforts to compete in the global market [13]. STEM is a learning approach that trains students to solve problems holistically [14]. Therefore, the STEM approach is an integrated learning between science, technology, engineering, and mathematics to develop students' creativity through the process of solving problems in everyday life that will later be useful to compete globally in the future. A STEM education curriculum should minimally [15]:

(1) use both problem-based and performance-based teaching and learning;
(2) use the 5E (Engagement, Exploration, Explanation, Elaboration, Evaluation) teaching and learning cycle to plan units and activities within the curriculum;
(3) be digital in format and coupled with digital teaching technologies such as whiteboards, tablets, student response systems, etc.;
(4) be both formative and summative assessment with task and non-task specific rubrics.

2. Research methodology

The population of this research was students in the eighth grade in the whole Junior High School in Karanganyar Districts. The sample in this study were as many as 94 students of class VIII SMP N 1 Matesih in 3 classes. The first class uses the TPS model using the STEM approach, the second class uses the TPS model only and the third class as the control class uses direct learning models.

Data collection techniques are using documentation and mathematics learning achievement tests. The documentation used is the results of student achievement from the Semester Final Examination 1. Mathematics learning achievement tests are given in the form of a description of 15 questions. The problem of description was chosen so that researchers could find out the students' learning achievement from the process they were working on, so that it was not only from the final value because it was right or wrong. Before the test is given to the research subject, the test is validated and tested first. In this study, the validity test used is to test the validity of the contents by validators. Each test was validated by two experts consisting of two mathematics lecturers. After obtaining validation from two experts, the test was tested on 32 students outside the study sample.

The data that has been collected is then analyzed to get the difficulty level, the discrimination power, and the reliability. Taken from the 15 questions from the instrument description being tested, there are 12 questions having different discrimination power and having appropriate difficulty levels. There are 10 questions taken from 12 questions that fulfill the testing criteria. The results of the reliability test based on the Mathematics learning achievement is obtained by the reliability index $r_{11} = 0.744$. The data was analyzed using unbalanced anova to find out whether the TPS learning model using the STEM approach provided better learning achievement than TPS models and direct learning models.

3. Result

Learning using the TPS model includes the following steps, as follows. Step 1: Thinking: the teacher asks questions or problems that are related to the lesson, and ask students to use a few minutes to think about their own answers or problems [16]. Students need an explanation that emphasizes the point that talking or doing is not part of thinking. Step 2: Pairing: the teacher asks students to pair up and discuss what they have gained. Interaction during the time provided can unify the answer if a question is asked or unify the idea if a specific problem is identified. Normally, the teacher gives no more than 4 or 5 minutes to pair up. Step 3: Sharing: in the final step, the teacher asks pairs of students to share with the whole class what they have talked about. It is effective to get around the room from a partner to a partner and continue until around a couple of couples have the opportunity to report. The application of TPS cooperative learning models can improve students' scientific process skills as a whole [17]. One of the learning models that can be applied in classroom learning and theoretically able to develop students' self-confidence and also students to interact with each other is the TPS cooperative learning model [18].

Learning the TPS model using the STEM approach has a structure similar to the TPS model but modified by adding the STEM discipline process. TPS learning model uses the STEM approach using steps namely introduction, core activities, and closing. At the core activity, the syntax is given as in Table 1 below.
**Tabel 1. Syntax of TPS Model with STEM Approach**

| Phase  | The performed steps |
|--------|---------------------|
| **Phase 1** | (1) The teacher gives a problem that is related the material that will be delivered  
(2) The students pay attention actively to the explanation and questions from their teacher in relation to the problem related to the material that will be discussed.  
**STEM Discipline:**  
_Science Discipline:_ the teacher gives a problem related to the daily life, the students observe and pay attention. |
| **Fase 2** | (1) _Think_: the teacher gives time for the students to think about the given problem individually.  
(2) The students are asked to develop their ideas differently.  
**STEM Discipline:**  
_Science Discipline:_ this activity needs the use of skills and sciences process such as observing, measuring, clarifying, concluding, and predicting. |
| **Phase 3** | (1) _Pair_: the teacher divides the class into pairs.  
(2) The teacher asks the students to discuss the result of the their thinking and ideas with their partners, then conclude about the results of their ideas.  
**STEM Discipline:**  
_Engineering Discipline:_ students work in groups, then the teacher asks them to plan a project in relation to the given material.  
The teacher motivates the students to be active in their groups. The application of this model uses LKS as a working field to be done in groups.  
**STEM Discipline:**  
_Mathematic Discipline:_ the students are asked to solve the problems related to the given material. |
| **Phase 4** | (1) _Share_: the students present the results of their group to the whole class.  
(2) The other students are given the opportunity to ask and give their opinions about the group discussions results.  
(3) The teacher helps the students to make reflections about the discussion results  
**STEM Discipline:**  
_Technology Discipline:_ the students are given guidance, video or power point about the given material. |

In each learning model there are 6 meetings. Mathematics learning achievement tests are given after 6 meetings are finished. _Before_ the learning achievement test is given, a test of achievement is carried out as many as 15 items in the description. The results of the trial of the mathematics learning achievement test were carried out by testing different discrimination power and appropriate difficulty levels of each item, and ended with Kuder Richardson 20's reliability test of 0.744. Based on the results of the test analysis obtained 10 items of description questions on the mathematics learning achievement test to be used as research instruments.

To find out which one gives better mathematics learning achievement between students who are given learning using the TPS model with the STEM approach, students who are given learning by the TPS model, and students who are given a direct learning model, are analyzed using one-way analysis of variance. In this study because the size of each sample in each class is not the same, then the statistical test in this study uses variance analysis one way with unbalanced cells. The descriptive statistics of the data is in Table 2.
Table 2. The descriptive Statistics of the Data

| Leaning Model Category       | n  | Mean   | Standard Deviation | Min Score | Max Score |
|-----------------------------|----|--------|--------------------|-----------|-----------|
| TPS Model using STEM approach | 32 | 85.703 | 8.572              | 70        | 100       |
| TPS Model                   | 32 | 78.125 | 9.439              | 65        | 95        |
| Direct learning model       | 30 | 74.16  | 29.92              | 60        | 90        |
| Total                       | 94 | 81.914 |                    |           |           |

Based on Table 4, the data that will be used for statistical tests will be tested by using one way anova statistical test with unbalanced cells. This is to determine whether the three learning models have the same effect on students' mathematics learning achievement (as H₀), or at least there are two types that do not give the same effect on students' mathematics learning achievement (as H₁). The results of statistical tests can be seen in the following table.

Table 3. Summary of the Analysis of Variance

| Sum of Squares | df | Mean Square | F_obs | Sig. | p   |
|----------------|----|-------------|-------|------|-----|
| Between Groups | 2144.33 | 1072.165 | 12.336 | .000 | <0.05 |
| Within Groups  | 7909.128 | 86.913 | -     | -    | -   |
| Total          | 10053 | 93 | -     | -    | -   |

Based on Table 3, it can be concluded that the H₀ is rejected. In conclusion, the TPS learning model using the STEM approach, the TPS learning model and the direct learning model give a different effect on mathematics learning achievement.

In this study, a post hoc test was carried out by the Scheffe method to find out which one gave better mathematics learning achievement between students with the TPS learning model using the STEM approach, TPS learning model and direct learning model. The results of the post hoc test analysis using the Scheffe method are as follows.

Table 4. Result of Post Hoc Test Using Scheffe Method

| [I] AQ | [J] AQ | Mean Difference (I-J) | F_obs  | Sig. |
|--------|--------|-----------------------|--------|------|
| Scheffe | TPS   | 7.89                  | 10.572 | .003 |
|        | direct| 11.442                | 254.528 | .000 |
| TPS    | TPS   | -7.89                 | -      | .003 |
|        | direct| 3.552                 | 2.801  | .412 |
| direct | TPS   | -11.442               | -      | .000 |
|        | TPS   | -3.552                | -      | .412 |

Based on Table 4, it can be concluded as follows. The students who are given a TPS learning model using the STEM approach have a different achievement from students who are given a TPS learning model. Because the students with the TPS learning model using the STEM approach has a higher mean than students with TPS learning models on students' mathematics learning achievement, it was concluded that students with TPS learning models using the STEM approach had better mathematics learning achievement than students with TPS learning models.

Likewise, students with the TPS learning model using the STEM approach have very different achievement from students who are given direct learning models. Because the students with the TPS learning model using the STEM approach has a higher mean than students with direct learning models on mathematics learning achievement, it can be concluded that students with TPS learning models using the STEM approach have better mathematics learning achievement than students students with direct
learning models. Finally, the students with TPS learning models have same effect as students who are given a direct learning model.

Based on the test statistical analysis it can be concluded that, students with TPS learning model using the STEM approach have better mathematics learning achievement than students with TPS learning models and students with direct learning models. Students with TPS learning models have as good as results mathematics learning achievement with students who are given a direct learning model.

Figure 1. Result research

4. Discussion
The TPS learning model is an effective learning model that enhances student learning activities, and the TPS learning model provides opportunities for students to work individually or in groups [19]. The TPS learning model provides an opportunity for students to interact more with other friends so as to increase their independence and confidence [18].

Science based education, Technology, Engineering and Mathematics (STEM), technological development can be improved to face global challenges. The STEM approach is suitable for applying to most Mathematical material [20]. In mathematics learning, using the STEM concept will make students more often apply material in everyday life so that students will be accustomed to solving mathematical problems in daily life by thinking scientifically, using technology to obtain various information, and processing data with technical abilities. STEM is a teaching and learning approach that involves the application of STEM knowledge, skills and values to solve real life problems in the context of everyday life, society, and the environment. STEM education has provided the best opportunities for students to understand the world holistically [21].

5. Conclusion
One-way anova test results prove that learning with TPS models using the STEM approach provides better learning achievement than TPS models and direct learning models. The use of the TPS learning model using the STEM approach can increase the activeness and enthusiasm of student learning because students are required to study individually and in groups. Students will also be more creative because they are given integrated learning in science, technology, engineering and mathematics. The combination of learning with the TPS learning model using the STEM approach will be useful for students in facing global competition later.
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