Mathematical Reasoning and Communication in TGT Learning Model with PQ4R Strategy

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Abstract. This study aims to determine the effect of the TGT learning model with the PQ4R strategy on students' reasoning abilities and mathematical communication skills. This study is a quasi-experimental design. The study population was all students of eight-grade in SMP Negeri 1 Gemolong, Indonesia. While the research sample was students of class VIII F and VIII G. Data collection techniques were the observation and test methods. Analysis of the data used is one-way Manova. In the statistical test, it was found that the reasoning ability had a value of $F = 18.165$ while the communication skills had a value of $F = 8.139$, both of which had a significance of less than $\alpha = 0.05$ so that $H_0$ was rejected. Therefore, the results show that (1) the TGT learning model with the PQ4R strategy is better than the direct learning model of students' mathematical reasoning abilities. (2) The TGT learning model with the PQ4R strategy is also better than the direct learning model for students' mathematical communication skills.

1. Introduction
Mathematics is a very dominant subject in developing science and technology. Mathematics is used in all fields of science and tools to solve problems in everyday life, so Mathematics is given to students ranging from elementary and secondary schools. One of the learning of mathematics in class is the process of solving mathematical problems starting from simple and producing complex results, it needs to be step by step [1]. However, mathematics is valued by students as material that is difficult to learn so that it impacts on student enthusiasm. Students often complain not understand, do not like and even often avoid. In interviews with teachers, the model that teachers often use is direct learning. Direct learning is more centered on the teacher, one-way learning and there is no cooperative group [2]. Direct learning does not develop the activeness and creativity of students, so students find it difficult to convey, communicate, and appreciate their opinions.
It is time for teachers to leave the learning process that tends to prioritize memorization or just find one correct answer to a problem. Learning models must begin to be well implemented. The learning model is one of the important aspects of the maximum learning process. The one-way learning model, where the teacher explains and the student listens, has a bore effect. Students need to be encouraged to think, reason, and evaluate. Students need to have their learning motivation and learning goals. The hope, students feel excited and challenged to learn.

One learning model that can activate students in the classroom is the Teams Games Tournament (TGT). TGT is cooperative learning, cooperative learning is effective in increasing students' knowledge, social, and motivation [3]. Cooperative learning in the form of small groups of students. Slavin states cooperative learning is a learning method that involves students actively in learning to understand and learn the subject matter [4]. Meanwhile, TGT is game-based learning, where students are heterogeneously grouped. After that, each group will compete with the group according to their ability to collect scores. Scores are accumulated from each group member who competed. The highest score will win the match [4]. The TGT learning model makes students challenged, motivated, and active. In this industry 4.0 era, students can also learn more freely with a variety of technologies. To improve this, the TGT learning model can be combined with the PQ4R supporting learning strategy. PQ4R is a learning strategy that helps students to read, understand, and maintain learning topics towards real learning. Students need to understand the contents of the reading topics so students can use them in real learning [5,6]. The PQ4R syntax is Preview, Question, Reading, Reflect, Recite, Review.

The learning process in the classroom has an impact on student development. The teacher expects the learning process to give maximum results in improving students' learning abilities, one of which is students' mathematical reasoning and communication skills. NCTM provides an overview of the learning process standards including reasoning and communication skills [7].

Mathematical reasoning is the core of mathematics, because if the reasoning ability is good, then the mathematical ability is good [8]. The reasoning process will occur if students construct their knowledge [9]. So, the students' mathematical reasoning process is in the form of (1) analyzing the problem, (2) submitting an assumption, (3) drawing conclusions or making generalizations, (4) checking the validity of the arguments. It can also be interpreted that reasoning can help students to express their ideas logically [10]. The use of interesting learning models such as TGT with the PQ4R strategy is one solution so that students can develop their mathematical reasoning abilities. If learning is just monotonous, it can result in low student achievement because student reasoning is also less than optimal [9].

Mathematical communication is also an important component in mathematics because communication includes students' skills to understand concepts in the form of pictures, graphics, and words, communicating concepts, and finding solutions [11]. The form of communication from the teacher in the classroom also influences learning success, the form of multi-directional communication helps students express their ideas especially in mathematics [12]. Cooperative learning models with small groups have a higher likelihood of developing student communication skills [13]. From the description above, the researcher wants to know the effect of the TGT learning model with PQ4R strategy on mathematical reasoning abilities and mathematical communication of junior high school students.
2. Method
This research is an experimental research with quasi-experimental design. The aims of this research are (1) the TGT learning model with the PQ4R strategy has a positive effect on students' mathematical reasoning ability better than direct learning. (2) The TGT learning model with the PQ4R strategy has a positive effect students' mathematical communication skill better than direct learning. The population of this research is all students of eight-grade in SMP Negeri 1 Gemolong, Sragen, Central Java, Indonesia. The research sample was taken two classes, namely the experimental class, and the control class. The experimental class VIIIIG was treated with the TGT learning model with the PQ4R strategy, while the control class VIIIIF was treated with the direct learning model. Samples were obtained randomly by cluster random sampling. Data collection methods include test and documentation methods. The test method is used to measure students' mathematical reasoning abilities and the students' mathematical communication skills.

Analysis of the data used in this study is one-way MANOVA. The independent variable is the TGT learning model with the PQ4R strategy, besides the dependent variable in the form of mathematical reasoning abilities and mathematical communication skills. Before the MANOVA test is carried out, the assumptions need to be fulfilled first, namely the multivariate normality test of the population and the homogeneity test of the variance-covariance matrix. The statistical test used in this study is Pillai’s Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root.

3. Result and Discussion
Research that is applied to both classes can be seen in the following table 1. Each class studied includes two independent variables, namely students' reasoning abilities and mathematical communication skill. Results are obtained through tests of understanding mathematical reasoning and communication skills. Table 1 shows the average ability of students for each independent variable (Mean), Standard Deviation, and sample size (N). The highest average is 73.25 (in the area of communication ability) and the lowest is 33.58 (in the area of reasoning ability).

| Tabel 1. Descriptive Statistics of Student’ Mathematics Ability for Learning Models |
| Learning Models | Mean | Std. Deviation | N |
|-----------------|------|----------------|---|
| **Reasoning**   |      |                |   |
| TGT with PQ4R   | 51.75| 17.807         | 32|
| Direct Learning | 33.58| 15.943         | 31|
| Total           | 42.81| 19.115         | 63|
| **Communication**|    |                |   |
| TGT with PQ4R   | 73.25| 11.924         | 32|
| Direct Learning | 64.45| 12.553         | 31|
| Total           | 68.92| 12.923         | 63|

To conduct a one-way MANOVA test, assumptions must be met first. Assumptions in the form of multivariate normality of population and homogeneity of multivariate variance-covariance matrices. Figure 1 is a scatter-plot to find out whether data is normally distributed or not.
Figure 1. Scatterplot Between Mahalanobis Distance and Chi Square

If the scatter-plot tends to form a straight line and more than 50% of the mahalanobis distance is less than or equal to Chi Square, then \( H_0 \) is accepted, meaning that the sample is normally multivariate. From figure 1 it can be seen that the scatter-plot, mahalanobis distance is less than or equal to chi square \((q_i)\), so it can be concluded that the sample comes from a multivariate normal distribution population. In Homogeneity Test, we use Box M Test. More can be seen in table 2.

Table 2. Box's M Test of Equality of Covariance Matrices and Levene's Test

|          | F     | df1 | df2        | Sig. |
|----------|-------|-----|------------|------|
| Box's M  | 0.521 | 0.168 | 3          | 693137.195 | 0.918 |
| Levene's | reasoning | 0.083 | 1 | 61 | 0.775 |
|          | communication | 0.016 | 1 | 61 | 0.900 |

MANOVA assumes that each group has the same covariance matrix and each dependent variable has the same variance in all groups [14]. From Table 2 it is known that Box's M test is not significant with \( p = 0.918 > \alpha = 0.05 \) which shows that the variance-covariance matrix originates from a homogeneous population. Moreover, in the Levene's Test, the \( H_0 \) is rejected if the significance of the Levene's Test is small or equal to 0.05. From these data, we can see that \( H_0 \) is accepted, namely the significance of reasoning ability is 0.775 > 0.05 and communication skills is 0.900 > 0.05. Therefore, the assumption of variance homogeneity is fulfilled. Because the assumptions have been met, then we continue the MANOVA test one way.
Table 3. Multivariate Tests

| Statistical Test       | Value | F     | Error df | Sig. |
|------------------------|-------|-------|----------|------|
| Pillai's Trace Learning Model | 0.283 | 11.841 | 2        | .000 |
| Wilks' Lambda          | 0.717 | 11.841 | 2        | .000 |
| Hotelling's Trace      | 0.395 | 11.841 | 2        | .000 |
| Roy's Largest Root     | 0.395 | 11.841 | 2        | .000 |

Computed using alpha = .05

In Pillai's Trace (0.283) the value of \(F = 11.841\) with \(p < 0.05\), Wilks' Lambda (0.717) the value of \(F = 11.841\) with \(p < 0.05\), Hotelling's Trace and Roy's Largest Root (0.395) the value of \(F = 11.841\) with \(p < 0.05\). Thus, from the four tests it can be concluded that there are statistically significant differences between learning models of the independent variables, namely the average student reasoning ability and the average mathematical communication skills. Therefore, H0 is rejected. It can be concluded that the TGT learning model with the PQ4R strategy provides better learning than the direct learning model of students' reasoning abilities and students' mathematical communication skills. After learning that MANOVA is significant, a univariate ANOVA test is then performed.

Table 4. Univariate Tests (Between-Subject Effects)

| Dependent Variable | Type III Sum of Squares | Df | Mean Square | F     | Sig. | Observed Power |
|--------------------|-------------------------|----|-------------|-------|------|----------------|
| Reasoning          | 5198.166^a              | 1  | 5198.166    | 18.165| .000 | .987           |
| Communication      | 1218.926^b              | 1  | 1218.926    | 8.139 | .006 | .802           |

a. R Squared = .229 (Adjusted R Squared = .217)
b. R Squared = .118 (Adjusted R Squared = .103)

Computed using alpha = .05

Univariate test, for mathematical reasoning abilities obtained \(F = 18.165\) with \(p < 0.05\), it can be concluded there are differences in the effect of students' mathematical reasoning abilities. For students' mathematical communication skills obtained \(F = 8.139\) with \(p = 0.006 < 0.05\), it can be concluded that there are also differences in the effect on students' mathematical communication skills.

Furthermore, on table descriptive statistics (table 1) shows that students who are treated using the TGT learning model with the PQ4R strategy have better reasoning abilities (51.75 – 33.58 = 18.17) and also better mathematical communication skills (73.25 – 64.45 = 8.8). These results confirm that the statistically significant difference is that the TGT learning model with the PQ4R strategy is more effective than the direct learning model in improving students' mathematical reasoning ability and communication skills.

Students with good reasoning ability must not only explain their strategies and reasons, but must also analyze, compare solutions and be able to draw conclusions together [15]. The results of the study confirmed that students who were treated using the TGT learning model with the PQ4R strategy had better reasoning abilities than students who were treated using the direct learning model. In accordance with previous research, the TGT learning model provides better learning outcomes than conventional learning [16]. Students are more interested and highly motivated when given the TGT learning model. This is because the TGT learning model...
helps students to master subject matter better. The use of the PQ4R strategy also helps students maximize their abilities, so that the TGT learning model with the PQ4R strategy provides a better effect on students' mathematical reasoning abilities than the direct learning model.

In this study, students' mathematical communication skills have a higher average on the TGT learning model with the PQ4R strategy than the direct learning model. Students are able to express ideas into mathematical form, read and describe images, and give arguments from statements in their own words. In accordance with the results of previous studies that the mathematical communication skills of students in cooperative learning type TGT learning are generally quite good [17]. Not only solving problems, mathematical communication skills will also help students to explore their abilities to the maximum [18].

4. Conclusion
TGT is a cooperative learning model that helps students build their own learning processes to achieve expected goals, using tournament games. The PQ4R strategy becomes the foundation of student learning so that these goals can be achieved optimally. The TGT learning model with the PQ4R strategy has a significant impact on classroom learning. Students cooperatively solve problems, express and exchange opinions, and finally compete to collect scores and check self-understanding of the material being taught. The results show that the TGT learning model with the PQ4R strategy has a positive effect on students' mathematical reasoning and communication skills rather than direct learning. the use of the TGT learning model with the PQ4R strategy is better than the direct learning model. In more detail, the mathematical communication skills of students have a better effect than students' reasoning abilities. This can be seen from the average of each independent variable, the average score of students 'mathematical communication skills are higher than students' reasoning abilities.

This research was conducted at one school in Sragen, Central Java, Indonesia namely SMP Negeri 1 Gemolong. However, we hope this research can be used as a reflection on the larger population. In addition, it can be used as a reference in further research.

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