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TEAM GAMES TOURNAMENT AND MEANS-ENDS ANALYSIS: LEARNING TYPES IN IMPROVING MATHEMATICAL CRITICAL THINKING

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ABSTRACT

The purpose of this research was to determine the effectiveness of Teams Games Tournament (TGT) and Means-Ends Analysis (MEA) learning types in improving mathematical critical thinking skills and to compare the effectiveness of the two learning types. This research used a quantitative approach with a purposive sampling technique. Two classes were selected from all XI classes at MA Ma'ahid Kudus: experimental class 1, which applied the TGT learning type, and experimental class 2, which applied the MEA learning type. Both experimental classes were chosen based on the pretest homogeneity test, and the two classes were homogeneous. The results obtained from this research are as follows: 1) There is an increase in students' mathematical critical thinking skills after being given the TGT learning type, 2) There is an increase in students' mathematical critical thinking skills after being given the MEA learning type, and 3) There is a difference in effectiveness between the TGT and MEA cooperative learning models.

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INTRODUCTION

The majority of teachers apply direct learning models in their teaching activities. The direct learning model is teacher-centered (Panjaitan, 2016). Students are asked to pay attention to the teacher and take notes. Additionally, students are expected to memorize the material and copy the teacher's explanations (Asri et al., 2022). In teaching and learning activities, teachers must consider various essential factors, including learning strategies, methods, models, and evaluations. One learning model that can enhance student engagement is cooperative learning. The cooperative learning model involves group work, with each group comprising members with different criteria and potential, encouraging students to be more active during learning (Fatimah et al, 2022). This model is applied to foster student engagement in the classroom.

Teachers can apply various types of cooperative learning models based on their students' needs. In this study, the researcher used two types of cooperative learning models: Teams Games Tournament (TGT) and Means-Ends Analysis (MEA). Both models involve group work. The groups in both models are heterogeneous, meaning they include members with different abilities. Furthermore, both learning models focus on enhancing student engagement in the classroom.

More specifically, the TGT-type cooperative learning model is a form of cooperative learning applied as a group game involving cooperation between students, allowing them to exchange knowledge in heterogeneously divided groups (Octariani & Panjaitan, 2020). By dividing groups heterogeneously, students can collaborate to share their understanding of the teacher's materials. Students' grades are determined by their respective groups, making group cooperation essential to achieving common goals. Additionally, this model encourages students to be competitive, more active, and more creative in their learning (Wikanengsih, 2005).

Meanwhile, according to Sweller, the MEA cooperative learning model maximizes problem-solving activities through a heuristic approach, using a series of questions as instructions or guidelines to help students solve problems (Maryam & Zainal, 2018). The MEA model begins by presenting problems for students to discuss (Mariani & Susanti, 2019). Students work together in their groups to solve these problems. Groups are divided heterogeneously so that members can guide each other. Through the MEA learning model, students are expected to solve problems systematically, critically, and logically.

Mathematical critical thinking ability is the proficiency in arguing and explaining mathematical concepts of a problem using previously acquired knowledge (Maulana, 2017). Critical thinking skills aim to evaluate and consider various opinions based on knowledge and accountable facts (Palupi & Rahayu, 2021). In reality, some students still have low critical thinking and mathematical abilities, as seen in their success rate when given problems by the teacher. Many students struggle with problems that require critical thinking. Therefore, students need to practice problems that enhance their potential for mathematical critical thinking.

Based on the characteristics of the TGT and MEA cooperative learning models, researchers are interested in applying these two types of learning to improve students' mathematical critical thinking abilities. Students are expected to solve problems systematically, critically, and logically. Additionally, researchers will compare the effectiveness of these two approaches. It should also be noted that there has been no prior research comparing the effectiveness of TGT and MEA cooperative learning models in improving students' mathematical critical thinking skills.

METHOD

The research was conducted at MA Ma'ahid Kudus. Researchers chose this location because they observed issues with the students' mathematical critical thinking abilities, which were still relatively low.

The research used a quantitative approach with a quasi-experimental design. The form of quasi-experimental design used in this research was a nonequivalent control group design. This means that the determination of the experimental group 1, group 2, or a control group was based on certain considerations (Hastjarjo, 2019).

Table 1. Research Design

Class	Pretest	Treatment	Posttest
NR_1	O_1	X_1	O_2
NR_2	O_3	X_2	O_4

Description:

NR_1 = Experimental class 1 treated with TGT learning type

NR_2 = Experimental class 2 treated with MEA learning type

O_1 = Giving pretest to experimental class 1

O_2 = Giving posttest to experimental class 1

O_3 = Giving pretest to experimental class 2

O_4 = Giving posttest to experimental class 2

X_1 = Treatment learning with the TGT type

X_2 = Treatment learning with the MEA type

The population is a group with certain characteristics that are identified for research, allowing conclusions to be drawn (Sugiyono, 2017) The population in this study consists of 203 students in class XI at MA Ma'ahid Kudus. The samples for this research were class XI Social 2 and XI Religion 2, selected using a purposive sampling technique. Based on the pretest homogeneity test, both experimental classes were determined to have homogeneous initial abilities. The total sample size in this study was 45 students.

This research involved three variables: two independent variables (X1 and X2), namely the TGT and MEA cooperative learning models, and one dependent variable (Y), namely mathematical critical thinking ability. The indicators of mathematical critical thinking ability for this research were adopted from Facione. According to (Facione, 2020), there are six indicators of critical thinking: interpretation, analysis, inference, evaluation, explanation, and self-regulation.

The instruments used in this research were observation and tests. Observations were made of mathematics teachers and students at MA Ma'ahid Kudus to gather information related to students' challenges when learning mathematics in class. The tests consisted of pretests and posttests, using essay questions to allow students to design their answers (Retnawati, 2016). The validity of the research instruments is crucial to ensure valid research results (Arikunto, 2018). The expert validation process is essential as it determines the suitability of the instrument based on the assessments and considerations of experts in the field (Adib, 2017).

To test the validity of the items, a validation test was conducted with several subject matter experts before testing the experiment on students who were not in the experimental classes. The expert validation test was analyzed using the Aiken validity formula. Subsequently, an instrument trial was conducted, followed by testing the validity, reliability, differentiation, and difficulty level to identify the items suitable for use in the research.

In this research, the sample size was 45 students, with 33 students in experimental class

1 and 12 students in experimental class 2. Because of the small sample size, a nonparametric statistical test was used. The data normality test employed the Shapiro-Wilk method (Fakhriyana et al., 2021). Additionally, the homogeneity test is a prerequisite for hypothesis testing, alongside the normality test, before conducting the hypothesis testing. This research compares pretest and posttest data for the experimental classes. Data analysis for hypothesis testing uses nonparametric statistics. There are three pairs of hypotheses in this research as follows:

$H0_1$: There is no increase in the average mathematical critical thinking ability of students who are given the TGT learning type.

$H1_1$: The average mathematical critical thinking ability of students who are given the TGT learning type increases.

$H0_2$: There is no increase in the average mathematical critical thinking ability of students who are given the MEA learning type

$H1_2$: There is an increase in the average mathematical critical thinking ability of students who are given the MEA learning type.

$H0_3$: There is no difference in effectiveness between the TGT and MEA learning types in improving students' mathematical critical thinking skills.

$H1_3$: There is a difference in effectiveness between the TGT and MEA learning types in improving students' mathematical critical thinking skills.

RESULT AND DISCUSSION

This research uses a quantitative approach and aims to determine whether there are differences in the improvement of students' mathematical critical thinking skills when given the TGT and MEA types of cooperative learning models. For this research, two experimental classes were needed: experimental class 1 (treated with the TGT learning type) and experimental class 2 (treated with the MEA learning type).

The research instruments used were tests in the form of essay questions for the pretest and posttest. Before being administered to students, the tests were validated by two lecturers and one mathematics teacher. The validated instruments included 8 pretest questions and 8 posttest questions. The pretest and posttest instruments, while different, were equivalent in measuring critical thinking skills. After validating the instruments with experts, Aiken's validation calculation was carried out to determine which questions were valid. The following

are the results of V-Aiken's calculation for the pretest and posttest items.

Table 2. Results of V_{Aiken} on Pretest and Posttest Items.

Item	V_{Aiken} pretest	V_{Aiken} posttest	Description
1	0,79	0,81	Valid
2	0,81	0,82	Valid
3	0,82	0,82	Valid
4	0,82	0,82	Valid
5	0,82	0,82	Valid
6	0,82	0,82	Valid
7	0,82	0,82	Valid
8	0,82	0,82	Valid

A question item can be considered valid if $V_{Aiken} \geq 0.75$ (Kurniawati, 2021). Based on Table 2, all pretest and posttest questions were deemed valid as all of $V_{Aiken} \geq 0.75$. The valid questions were then administered to the subjects. Subsequently, the validity (VL), reliability (RL), differentiation analysis (DA), and difficulty level analysis (DL) were calculated for each pretest and posttest item, using 18 test subjects for each. An instrument is considered valid if $r_{xy} > r_{tabel}$ (0,468) (Arikunto, 2018), reliable if RL ≥ 0,70 (Sunarti & Rahmawati, 2014), differentiation analysis is utilized if DA > 0,4 (Purba et al., 2021), and the difficulty level is considered medium (Farida, 2017). The instruments used for research must meet these four criteria. The results of the pretest and posttest instrument trials are presented in Table 3.

Table 3. Results of the Validity, Reliability, Differentiation Analysis, and Difficulty Level on Pretest and Posttest Items

Pretest						Posttest					
No	VL	RL	DA	DL	Result	No	VL	RL	DA	DL	Result
1	0,894	0,948	0,41	0,57	V	1	0,862	0,933	0,41	0,69	V
2	0,915	0,948	0,51	0,41	V	2	0,884	0,933	0,42	0,52	V
3	0,903	0,948	0,44	0,63	V	3	0,916	0,933	0,51	0,49	V
4	0,753	0,948	0,11	0,76	X	4	0,851	0,933	0,43	0,53	V
5	0,948	0,948	0,41	0,39	V	5	0,851	0,933	0,41	0,44	V
6	0,950	0,948	0,43	0,32	V	6	0,849	0,933	0,42	0,44	V
7	0,949	0,948	0,42	0,33	V	7	0,922	0,933	0,44	0,38	V
8	0,764	0,948	0,22	0,24	X	8	0,488	0,933	0,28	0,31	X

Considering the timing and interrelationship of questions between the pretest and posttest, a total of 16 questions were analyzed, resulting in 5 items selected for each, namely numbers 1, 2, 3, 5, and 7. These five items cover all indicators of mathematical critical thinking skills. The chosen topic for enhancing mathematical critical thinking is "Sequence and Series," focusing on Class XI Semester II.

Normality and homogeneity tests are essential prerequisites for this research, conducted before hypothesis testing. The following presents the results of the normality and homogeneity tests for the pretest and posttest data.

Data are considered normally distributed if the significance value (Sig.)> α (0.05)

(Fakhriyana et al., 2021).

Table 4. Results of Normality Test of Pretest Data

Class	Sig.
Experiment 1	0,068
Experiment 2	0,185

Based on Table 4, the significance value of the pretest data for experimental class 1 is 0.068, which is greater than α(0.05), indicating that the data is normally distributed. Similarly, the significance value of the pretest data for experimental class 2 is 0.185, also greater than α(0.05), indicating normal distribution of the data.

Table 5 Results of Normality Test of Posttest Data

Class	Sig.
Experiment 1	0,001
Experiment 2	0,819

Based on Table 5, the significance value of the posttest data for experimental class 1 is 0.001, which is less than α (0.05), indicating that the data is not normally distributed. However, the significance value of the posttest data for experimental class 2 is 0.819, which is greater than α (0.05), indicating the normal distribution of the data. After conducting normality testing, we proceeded to test the homogeneity of pretest and posttest data between experimental classes. The homogeneity test for pretest data was conducted to determine the comparability of the two experimental classes used in this research. Similarly, the homogeneity test for post-test data is utilized as a prerequisite test for statistical hypothesis testing regarding the third problem formulation.

In the homogeneity prerequisite test, data are considered homogeneous if the significance value (Sig.) is greater than α (0.05) (Fakhriyana et al., 2021).

Table 6. Results of Homogeneity Test of Pretest and Posttest Values

Test	Levene Statistic	df1	df2	Sig.
Pretest	1,408	1	43	0,242
Posttest	9,587	1	43	0,003

From Table 6, the pretest yielded a significance value (Sig) of 0.242, which is greater than α (0.05), indicating homogeneity between the pretest data of experimental class 1 and experimental class 2. However, for the posttest, the significance value is less than α (0.05), specifically 0.003, indicating that the posttest data of experimental class 1 and experimental class 2 are not homogeneous.

In hypothesis testing, it's crucial to consider prerequisite tests before proceeding. If the

data is normally distributed and homogeneous, parametric statistics are typically used. However, in this research, the data is not normally distributed, not homogeneous, and there is a small sample size in experimental class 2. Consequently, hypothesis testing in this study is conducted using nonparametric statistics, specifically the Wilcoxon Signed Ranks test and the Mann-Whitney U test.

The null hypothesis (H_0) for hypothesis testing 1 is "There is no increase in the average mathematical critical thinking ability of students who are given the TGT learning type." Since the posttest data in experimental class 1 were not normally distributed, the hypothesis test was conducted using an alternative to the paired sample t-test, namely the Wilcoxon Signed Ranks test (Norfai, 2021).

Table 7. Results of Wilcoxon Signed Ranks Test in Hypothesis 1

Pretest – Posttest Experiment Class 1	Z	Asymp. Sig. (2-tailed)
	-5,017	0,000

Based on Table 7, we conclude that H_0 is rejected because the calculated value of $|Z_{calculated}| = 5.017$ is greater than the critical value of $1.645 = Z_{0.05}$. With a significance level of 5%, it is determined that there is an increase in students' mathematical critical thinking skills after being exposed to the TGT-type cooperative learning model. Factors contributing to this improvement include the novelty of the TGT model, which had not been previously implemented by mathematics teachers at MA Ma'ahid Kudus, and the enthusiastic participation of students during the tournament activities. During the tournament, students compete in groups to answer questions presented via PowerPoint slides. If a group provides an incorrect answer, another group can attempt to answer, earning points for correct responses. This setup fosters open discussion and mutual understanding among students within their groups, eliminating any discomfort when seeking clarification. This observation aligns with research by Veloo and Chairhany, which asserts that the TGT cooperative learning model promotes active engagement among students and teachers, fostering a conducive environment for problem-solving and discussion (Veloo & Chairhany, 2013).

This increase is consistent with the findings of a study by Masitah Sri Rezki Harahap titled "The Effect of the Teams Games Tournament (TGT) Cooperative Learning Model on the Mathematical Critical Thinking Ability of Class VIII Students at SMP Negeri 13 Pekanbaru." The research results revealed that the calculated t-value (6.06) exceeded the

critical t-value (1.67) at a significance level of 0.05. Consequently, it was concluded that the Teams Games Tournament (TGT) cooperative learning model significantly enhanced the mathematical critical thinking abilities of class VIII students at SMP Negeri 13 Pekanbaru (Harahap, 2020).

For hypothesis testing 2, the null hypothesis (H_0) states that there is no increase in the average mathematical critical thinking ability of students exposed to the MEA learning type. In conducting hypothesis testing 2, it was observed that both the pretest and posttest results followed a normal distribution. However, the sample size in experimental class 2 was considered small. Consequently, hypothesis testing was conducted using nonparametric statistics. To test hypothesis 2, the Wilcoxon Signed Ranks test will be employed (Norfai, 2021).

Table 8. Results of Wilcoxon Signed Ranks Test in Hypothesis 2

Pretest – Posttest Experiment Class 2	Z	Asymp. Sig. (2-tailed)
	-3,062	0,002

Based on the results presented in Table 8, we observe that $|Z_{calculated}| = 3.062$ which exceeds $1.645 = Z_{0.05}$. Thus, H_0 is rejected. With a significance level of 5%, the conclusion drawn is that there is an increase in students' mathematical critical thinking skills after they have been exposed to the MEA-type cooperative learning model. One contributing factor to this enhancement in mathematical critical thinking skills is that the MEA type has not previously been utilized by mathematics teachers at MA Ma'ahid Kudus. Additionally, students are encouraged to apply their reasoning skills when discussing answers in the Student Worksheet, enabling them to move beyond mere adherence to formal formulas.

The findings of this research align with those of a study conducted by Devi Ariyanti et al., titled "The Effect of Implementing the Means-Ends Analysis (MEA) Learning Model on the Mathematical Critical Thinking Ability of Class VIII Students at SMP N 1 Rao." The research revealed a calculated $t_{calculated}(2,61)$ exceeding the tabulated $t_{table}(1,67)$ at a significance level of 0.05. Consequently, it was concluded that there is an increase in students' mathematical critical thinking abilities following the implementation of the Means Ends Analysis (MEA) learning model (Ariyanti et al., 2019). Furthermore, other research also supports the notion that MEA learning types can enhance mathematical critical thinking skills

(Hanifiah & Prabawati, 2019; Nurafiah et al., 2013; Taubah et al., 2018).

For hypothesis testing 3, the null hypothesis (H_0) posits that there is no difference in effectiveness between the TGT and MEA learning types in improving students' critical mathematical thinking skills. Since the posttest data for experimental class 1 was not normally distributed and the posttest data for experimental class 1 and 2 were not homogeneous, hypothesis testing 3 utilized nonparametric statistics. Therefore, an alternative test to the independent sample t-test, namely the Mann-Whitney U test, was employed for hypothesis testing (Adinurani, 2022).

Table 9. Results of Mann-Whitney U Test in Hypothesis 3

Mann Whitney U	Z	Asymp. Sig. (2-tailed)	Exact Sig. [2*(1-tailed Sig.)]
105,000	-2,395	0,017	0,016

Based on the results presented in Table 9, the calculated value of $Z_{calculated}$ = -2.395 which is less than -1.96 = $-Z_{0.025}$. Therefore, H_0 is rejected. This indicates that there is a difference in effectiveness between the TGT and MEA learning types in improving mathematical critical thinking skills. It is noteworthy that there has been no prior research comparing the effectiveness of TGT and MEA-type cooperative learning models in enhancing students' mathematical critical thinking skills.

The disparity in the enhancement of mathematical critical thinking skills between the classes subjected to the TGT and MEA learning types can be observed through the mean pretest and posttest data and the percentage of N-Gain (%).

Table 10. Mean Value and N-Gain (%) of Pretest and Posttest Data

	Pretest Mean	Posttest Mean	N-Gain (%)
Experiment Class 1	58,97	88,73	73,76%
Experiment Class 2	56,33	77,17	51,51%

From Table 10, the average posttest score for experimental class 1 was 88.73, while for class 2 it was 77.17. Additionally, the N-Gain for experimental class 1 was 73.76%, compared to 51.51% for class 2. Based on the percentage N-Gain, it can be concluded that the TGT learning type is more effective in enhancing students' mathematical critical thinking skills than the MEA type.

The difference in the average improvement of mathematical critical thinking skills between experimental class 1 and experimental class 2 can be attributed to the implementation

of learning with the TGT type. In TGT learning, students are encouraged to solve problems quickly and precisely, leading to faster engagement and understanding of the material compared to learning with the MEA type. The MEA type necessitates a deeper understanding of reasoning, which may prolong comprehension. Moreover, during discussions, experimental class 1 demonstrated higher levels of engagement by actively asking questions and seeking clarification on less understood material compared to experimental class 2. This increased level of participation contributes to a deeper mastery of the material in experimental class 1.

CONCLUSION

From the research results, the following conclusions have been obtained: 1) The Wilcoxon Signed Ranks test conducted on the pretest and posttest scores of experimental class 1 demonstrated an improvement in students' mathematical critical thinking skills after exposure to the TGT-type cooperative learning model, 2) Similarly, the Wilcoxon Signed Ranks test conducted on the pretest and posttest scores of experimental class 2 showed an enhancement in students' mathematical critical thinking skills following the MEA-type cooperative learning model, dan 3) Analysis of the post-test data for experimental classes 1 and 2 using the Mann Whitney U test revealed a difference in effectiveness between the TGT and MEA cooperative learning models. The percentage increase in experimental class 1 was 73.76%, while in experimental class 2 it was 51.51%. Therefore, it is concluded that the TGT type is more effective in improving students' mathematical critical thinking skills than the MEA type.

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