ISSN Online 2527-5933
MATH-EDU: Jurnal Ilmu Pendidikan Matematika
Volume 10, Nomor 2, Agustus 2025, pp. 221-235

Effectiveness of TGT Model on Communication Skills of Grade II Elementary School Students: Experimental Study

Afri Mardicko[1]*, Akmal Rijal[2], Rully Sulistiowati[3]
[1]Universitas Muhammadiyah Pringsewu, Lampung, Indonesia
[2]Universitas PGRI Silampari, Sumatera Selatan, Indonesia
[3]Universitas Muhammadiyah Pringsewu, Lampung, Indonesia
*Correspondence: Afrimardicko@umpri.ac.id

Article Information

Received:
June 6th 2025

Accepted:
August 26th 2025

Published:
August 31st 2025

Keywords
TGT Model, Mathematical Communication Ability, Elementary School Students, Cooperative Learning, True Experimental

Abstrak

Penelitian ini bertujuan untuk menguji efektivitas model pembelajaran *Teams Games Tournament* (TGT) terhadap kemampuan komunikasi matematis siswa kelas II SD. Metodepenelitian yang digunakan adalah *true experimental design* dengan *posttest-only control group*, melibatkan dua kelas di SDN 3 Podomoro (n=51). Instrumen terdiri dari enam soal uraian yang telah diuji validitas dan reliabilitasnya (α=0,708). Hasil analisis menggunakan uji Mann–Whitney U menunjukkan perbedaan signifikan antara kelas eksperimen dan kontrol (p<0,001), dengan nilai rata-rata masing-masing 67,6 dan 44,0. Besarnya pengaruh dihitung menggunakan Cliff's Delta (δ=0,808) yang menunjukkan efek sangat besar. Namun, instrumen tes didominasi butir soal berkategori mudah sehingga menyebabkan *ceiling effect* pada kelas eksperimen (36% siswa mencapai skor maksimum). Disarankan untuk merevisi instrumen dengan soal "sedang dan sulit" serta mengintegrasikan teknologi interaktif. Penelitian ini terbatas pada satu sekolah dan jenjang, sehingga generalisasi hasil perlu dilakukan secara hati-hati.

Abstract

This study aims to test the effectiveness of the Teams Games Tournament (TGT) learning model on the mathematical communication skills of grade II elementary school students. The research method used is a true experimental design with a posttest-only control group, involving two classes at SDN 3 Podomoro (n = 51). The instrument consists of six descriptive questions, which were tested for validity and reliability (α = 0.708). The results of the analysis using the Mann–Whitney U test showed a significant difference between the experimental and control classes (p < 0.001), with average values of 67.6 and 44.0, respectively. The magnitude of the effect was calculated using Cliff's Delta (δ = 0.808), which indicated a significant impact. However, the test instrument was dominated by easy items, causing a ceiling effect in the experimental class (36% of students achieved the maximum score). It is recommended to revise the instrument with "moderate and difficult" questions and integrate interactive technology. This study is limited to a single school and level, so the generalizability of the results needs to be done carefully.

How to Cite: Mardicko, A., Rijal, A. & Sulistiowati, R. (2025). Effectiveness of TGT Model on Communication Skills of Grade II Elementary School Students: Experimental Study. *Math-Edu: Jurnal Ilmu Pendidikan Matematika*, 10 (2), 221-235.

Introduction

Communication skills are one of the important aspects that students must have in learning mathematics. This ability itself includes understanding and organizing mathematical thinking, communicating with logistics and clarifying ideas, analyzing and assessing strategies, and using them appropriately (Khadka, 2024). However, in the implementation to achieve the development of students' mathematical communication skills, various challenges often occur. Various studies show that students' communication skills are still low, especially in changing problems into various mathematical models and explaining ideas in depth(Rusyda et al., 2020; Rohid et al., 2019). Only 42.5% of students can change contextual problems into mathematical models (Wandari & Anggara, 2021). The main problems experienced by students include weak conceptual understanding, understanding of mathematical symbols, and unfamiliarity with solving open-ended problems (Alfarisyi & Sutiarso, 2020; Putri & Musdi, 2020). Therefore, innovative and sustainable learning is needed to stimulate students' communication skills (Anisa et al., 2023;Khadka, 2024).

One of the potential learning models that can answer the challenge of optimizing students' mathematical communication skills is the Teams Games Tournament (TGT) model. This model combines team collaboration, interactive games, and competitions that are in accordance with the characteristics of second-grade elementary school students who tend to be active and like to play (Muslim, 2020). Second-grade elementary school students are at the concrete operational stage which requires learning that involves manipulating real objects to build abstract concepts. This is in line with research by Kurniawan et al., (2019)which emphasizes that the use of concrete media such as number cards effectively engages students in mathematics learning.

In the games phase in the TGT model, students practice translating mathematical problems into symbolic models and compete in team-based games to solve problems. Students can use various concrete media to model mathematical problems according to Piaget's concrete operational stage. Meanwhile, in the tournament phase, students are encouraged to present solutions in a structured manner through presentations to train students in mathematical communication (Jafar et al., 2020). This is in line with research by Kholidah & Qohar (2021)which emphasizes that the TGT model is effective in training oral aspects such as discussions and presentations, then written aspects such as mathematical modeling and solution descriptions.

The TGT model is one of the cooperative learning models that has been widely studied to improve students' mathematical communication skills. The use of the TGT model can significantly improve mathematical communication skills compared to direct learning models that tend to be teacher-centered so that they provide less space for students to discuss or present mathematical ideas (Primadani et al., 2020; Rohid et al., 2019). The same study was also conducted by Muslim (2020)proving that learning using the TGT model can be used to improve learning outcomes, namely students' mathematical connection and communication skills in Elementary Schools.

Furthermore, Salsabil et al., (2017)also revealed that this increase occurred gradually and consistently along with the implementation of the model. The implementation of the TGT model in grade II students is in line with the principles of Cognitive Load Theory (CLT) which emphasizes the importance of managing cognitive load in learning. The material should be presented in stages that minimize cognitive load through the manipulation of concrete objects (game phase), collaboration in solving problems (team phase), and structured competition (tournament). This model is also consistent with the concrete operational development stage where learning will be effective through active physical and social activities(Sweller, 2020).

The TGT model emphasizes group work, discussion, and healthy competition through games and tournaments, enabling students to be more active, collaborative, and to help each other understand the material. Furthermore, there has been a significant increase in their activeness, ability to discuss, ask questions, and solve problems collaboratively. This collaboration also encourages students to share ideas and problem-solving strategies(Muslim, 2020). Research by Bela et al., (2018)found that in addition to improving communication skills, the TGT model can also help develop creativity, collaboration skills, and critical thinking in students.

Thus, the TGT model is not only relevant to improving academic abilities but also forms attitudes that certainly support the learning process. This study tests the implementation of the TGT model in grade II elementary school students who have not been widely explored in previous studies. Although TGT has been proven effective at the junior high schoollevel(Kholidah & Qohar, 2021), its implementation still requires adjustments to the characteristics of elementary school students whose cognitive development is still concrete. Thus, this study not only strengthens the theoretical and empirical foundations of the TGT model but also answers the need for innovative learning at the elementary level and as a solution to improve and enhance students' mathematical communication skills.

Previous studies on the TGT model are dominated by research at the junior high school level, while exploration of its implementation in grade II elementary school students is still limited. Therefore, this study will focus on the adaptation of TGT according to the cognitive characteristics of elementary school students. Related to the explanation of the background of the problem above, the objectives of this study are 1.) To test the significant differences in mathematical communication skills between students taught with the TGT model and direct learning based on the posttest results, 2.) To measure the magnitude of the influence of the TGT model on the mathematical communication skills of grade II elementary school students based on the posttest with Cliff's d effect size, 3.) To assess the achievement of minimal completeness (KKTP ≥ 65) of mathematical communication skills based on school standards.

Methods

Quantitative research will be used in this study using the True-experiment research method. All second-grade students from SDN 3 Podomoro, Pringsewu Regency, Lampung, consisting of 2 classes, namely IIA and IIB, will be used as the population. The sampling technique is using saturated sampling, namely taking all populations to be used as samples. Determination of the experimental class and control class is done randomly using the random selection by lottery, namely the class taken first will be used as the experimental class. The selected experimental classes are class IIB and control class IIA.Before implementing the TGT model in the experimental class and direct learning in the control class, the final test instrument (posttest) was first tested for expert validity and statistical validity. Expert validity was carried out by UMPRI lecturers and elementary school teachers. The results obtained from the two validators constituted a usable instrument. For statistical validation, the researcher conducted a trial of the test instrument at SDN 2 Podomoro, which consisted of 15 students outside the sample. The test consisted of 10 questions, arranged according to research indicators. Of the 10 questions, 6 were deemed valid, and the rest were deemed invalid. Only valid questions will be used to collect research data. Furthermore, the 6 valid questions will also be tested for reliability. Test results that are declared invalid will be discarded or eliminated. The results of the validation test can be seen in Table 1 below:

Table 1. Question Validation Test Results

Question Number	Pearson Correlation	R Tabel	Decision	Sig. (2-tailed)	Decision
1	.244	0,532	Invalid	.244	Invalid
2	.672**	0,532	Valid	.672	Valid
3	.210	0,532	Invalid	.210	Invalid
4	.550*	0,532	Valid	.550	Valid
5	.385	0,532	Invalid	.385	Invalid
6	.819**	0,532	Valid	.819	Valid
7	.648**	0,532	Valid	.648	Valid
8	.404	0,532	Invalid	.404	Invalid
9	.591*	0,532	Valid	.591	Valid
10	.830**	0,532	Valid	.830	Valid

In Table 1 above, out of 10 questions, 4 are invalid and the remaining 6 are valid. Invalid questions will be discarded and the remaining 6 questions will be tested for reliability. The results of the reliability test are presented in Table 2 below:

Table 2. Reliability Test Results

Cronbach's Alpha	N of Items
.708	6

Based on Table. 2 above, the reliability test value is 0.708. This value is "sufficient" because $\alpha \geq 0.7$ is considered good. This proves that the research instrument is reliable and has stable and consistent measurement results, both in different time spans and between versions of the measuring instrument. Furthermore, the researcher conducted a test of the question difficulty index which is useful for measuring how difficult a question is for students. The results of the question difficulty index test can be seen in Table 3 below:

Table 3. Table of Results of Question Difficulty Index Test with SPSS

	S2	S4	S6	S7	S9	S10
Valid	15	15	15	15	15	15
Missing	0	0	0	0	0	0
Mean	2.80	2.67	2.47	2.93	2.53	2.60
Maximum	3	3	3	3	3	3

In this study, the questions used were in the form of essays. The formula used for essay or descriptive-type questions was $\frac{\text{mean}}{\text{highest score}}$. The results of the question difficulty index test are presented from the results of the question difficulty index analysis based on the proportion of students who answered correctly, based on the following interpretation categories: Easy (Index $\geq 0{,}7$), Medium (Index $0{,}3 - 0{,}69$) and Difficult (Index $\leq 0{,}29$).

Table 4. Question Categorization Results

Question Number	Result	Category
S2	0,93	Easy
S4	0,89	Easy
S6	0,823	Easy
S7	0,976	Easy
S9	0,843	Easy
S10	0,866	Easy

Based on the table above, 100% of the questions are in the easy category with a difficulty index ranging from 0.823 to 0.976. Question number 7 is the easiest question, meaning that almost all students, or approximately 97.6% of students, answered it correctly. Question number 6 has the highest level of difficulty, but is still in the easy category. The test above is still unable to differentiate student abilities because there are no questions in the medium and/or difficult categories. These questions will be re-evaluated because they are likely too clear and not challenging enough. Test instruments that are categorized as easy can also cause a ceiling effect. Therefore, researchers need to readjust the composition of the questions so that the test can measure student abilities comprehensively and balance.

After conducting the Question Difficulty Level test, the problem-solving ability test questions were then tested with Distinction Power. The test results can be seen in Table 5 below:

Table 5. Table of Differential Power Test Results

Question Number	Score	Result
S2	.183	Not Working
S4	.283	Acceptable with revision
S6	.739	Good
S7	.707	Good
S9	.283	Acceptable with revision
S10	.752	Good

Instruction:
For differentiating power
<0,20 :does not work
0,20-0,29 :Acceptable with revisions
0,30-0,39 :Acceptable without improvement
0,4 – 1:Good

In Table 5 above, different results were obtained between questions. Question no. 2 showed the result “Not Functioning”. This indicates that the item is unable to differentiate between students with low and high abilities. Question no. 2 will be eliminated from the test instrument because the question fails to differentiate students’ abilities and therefore does not provide valid information for evaluation. Questions no. 4 and 9 are categorized as “Acceptable with revision”. This indicates that the question has the potential to differentiate students’ abilities but needs improvement, for example by clarifying the answer options or improving the wording of the question to minimize ambiguity. Questions no. 6,7 and 10 achieved results above 0.7 which are categorized as “good”. This reflects the item’s ability to differentiate participants optimally. Students with high abilities tend to answer correctly while students with low abilities answer incorrectly. Questions no. 6,7 and 10 are worthy of being retained in the instrument.

Result and Discussion

The Result of the Research

Descriptive Analysis of Hypothesis

a. Normality Test

Before conducting a hypothesis test, the data must first meet the assumption test. The prerequisite tests are the Normality test and the homogeneity test. The results of the normality test can be seen in Tabel 6 below:

Table 6. Results of Normality Test with SPSS

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Kelas	Statistic	df	Sig.	Statistic	df	Sig.
Results	Experimental class posttest	.275	25	.000	.714	25	.000
	Control class posttest	.131	24	.200*	.977	24	.831

Based on the table above, the normality test value for the experiment is 0.000 and the control class is 0.831. The test used is the Shapiro-Wilk test because the number of data is below 50. In the experimental class, the Shapiro-Wilk test shows sig <0.005. This means that the post-test data for the experimental class is not normally distributed. The statistical value of 0.714 also confirms a deviation from normality. For the control class, the significance value is> 0.05. This means that the post-test data for the control class is normally distributed. The statistical figure of 0.977 also shows conformity with the normal distribution. The difference in the results of the normality test for the two classes, then for the hypothesis test, a non-parametric test will be used because one of the class groups is not normal.

b. Homogeneity Test

Next, a homogeneity test is performed. The results of the homogeneity test can be seen in Figure 2 below:

Table 7. Results of Homogeneity Test with SPSS

		Levene Statistic	df1	df2	Sig.
Results	Based on Mean	3.898	1	47	.054
	Based on Median	4.663	1	47	.036
	Based on Median and with adjusted df	4.663	1	46.297	.036
	Based on trimmed mean	4.492	1	47	.039

Based on the test results with SPSS, the Levene test results showed inconsistencies between the mean-based methods. Homogeneity showed homogeneity $p = 0.054 > 0.05$, and the median showed $p = 0.036 < 0.05$. Because the normality assumption was violated, the decision was based on the median-based results, which indicated that the data variance was not homogeneous.

Based on the fourth analysis, there is inconsistency in the results. The mean-based method shows homogeneous results but the other three methods show heterogeneity. Considering that the experimental class data is not normal from the previous test, the median/trimmed mean-based method is more valid. Because the data is not normal and has non-homogeneous variance, the median or a trimmed mean is used as the primary reference. In the normality test, the results are not normal in the experimental class and the variance is not homogeneous, so for the hypothesis test, a non-parametric test will be used. The non-parametric test used is the Mann-Whitney U Test to compare the differences between the experimental class and the control class.

The Discussion of the Research

a. Hypothesis Testing

The results of this study describe students' mathematical communication skills when using the TGT model. Data will be presented inferentially and statistically. The description of data on mathematical communication skills is reviewed as follows:

1. **Differences in Mathematical Communication Skills between Students Taught with the TGT Model and Direct Learning Based on post-test results**

The data of the results of the mathematical communication ability test of students taught with the TGT model and direct learning obtained were analyzed inferentially first, namely described by the average, standard deviation, variance, minimum value, and maximum value. The description of the data regarding mathematical problem-solving ability can be seen in the following Table 8:

Table 8. Description of Data on Students' Mathematical Communication Skills from the Experimental and Control Classes

No.	Statistics	Mathematical Communication Ability Experimental Class	Mathematical Communication Ability Control Class
1.	Mean	67,6	44,00
2	SD	3,38	11,44
3	Varians	14,30	163,50
4	Minimum	63	30
5	Maximum	71	54
	N	25	26

Further analysis showed that the 23.6point difference was significant, indicating that the treatment given to the experimental class was effective. This impact is equivalent to a 53.6% increase over the average score of the control class. Based on the comparison of these scores, it can be understood that the experimental class has a much higher Mathematical communication ability than the control class. This shows that the treatment given to the experimental class proves the effectiveness of the TGT model.

The standard deviation (SD) score in the experimental class showed a score of 3.38 and the control class showed a score of 11.44. Then the variance of the experimental class got a score of 14.30 and the control class got a score of 163.50. The Standard Deviation (SD) of the experimental class is very small, this shows that there is almost no variation in ability between students or only around ~3.38 meaning 68% of the data is in the range of 64.22-70.98 based on the ideal score of 0-100. The control class is 11.4x larger, which identifies heterogeneous problems such as some students being very behind. The experimental class is much more homogeneous as seen from the Standard Deviation (SD) and its smaller variance. This means that the abilities of students in the experimental class are relatively uniform and consistent. The control class shows a wide spread of values as seen from the Standard Deviation (SD) and large variance, which means that the wide spread of values indicates that there are some students whose communication skills are very low/high.

The minimum and maximum value ranges of the experimental and control classes also have different results. The experimental class has a narrow range (8 points). This shows that the experimental class does not have extremely low/high values, which means that all students have relatively stable abilities above the average of the control class, because the minimum value of the experimental class, which is 63, is greater than the average value of the control class, which is only 44. For the control class, there is a large disparity, the lowest value is very far from the lowest value of the experimental class. Even the highest value is still below the average value of the experimental class.

The control class score range was 24 points, which is 3x wider than the experimental class score, implying that there was extreme inequality without intervention. The lowest score of the control class was 30, which is in the very low category, below 55.5% of the maximum score of its class and 52.4% below the lowest score of the experimental class. This finding strengthens the assumption that the experimental class intervention is not only able to improve students' mathematical communication skills but also equalize student achievement.

The average score of students' mathematical communication skills was also compared between the experimental class and the control class, which can be seen in Figure 1 below:

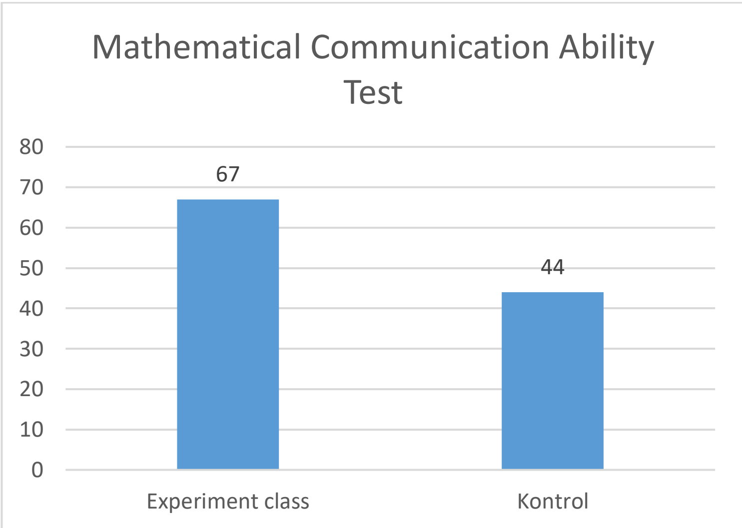

Figure 1. Comparison Chart of Average Results of Mathematical Communication Ability Test

Based on the results of the average mathematical communication ability of students in the experimental class and the control class, the average is 67.6 > 44. In the diagram above, it can also be seen that the experimental class bar diagram is longer than the control class diagram. So it can be concluded that there are differences in ability between the experimental class and the control class.

Students' mathematical communication skills are very important in mathematics learning, especially in elementary school. Mathematical communication skills will help organize and connect mathematical thinking through communication, communicate mathematical thinking correctly, analyze and assess thinking, and use mathematical language, notation, and symbols correctly (Anisa et al., 2023; Sutopo & Waluya, 2023). In its implementation, teachers can use various learning models that can certainly help improve and enhance students' mathematical communication skills, one of which is by using TGT and direct learning.

The findings of the homogeneity of students' mathematical communication skills in the experimental class (SD = 3.38) indicate that the use of the TGT model has succeeded in creating an inclusive environment for students with low to moderate abilities. The structure in the TGT model triggers group dynamics that encourage students to have a better understanding naturally helping and guiding lagging members (peer teaching). Wulandari et al., (2024) in their research proved that the Kahoot-assisted TGT model can increase classical completeness by up to 90% and reduce ability variance through a point system and collaborative competition. Ristyanti & Widiyono (2024)research also revealed that the Kahoot-based TGT model increases motivation by > 35% and student engagement becomes higher. This effect is in stark contrast to direct learning which tends to be teacher-centered, so it is less able to accommodate individual student differences.

The homogeneity of student abilities in the experimental class reflects the peer teaching mechanism in the use of the TGT model. What is meant here is that high-ability students act as knowledge brokers (Slavin, 2020), who act not only as conveyors of information but also as facilitators of understanding to their peers through structured group discussions. Meanwhile, support (scaffolding) through games designed in stages that allow them to build understanding gradually. This interactive dynamic is direct learning that tends to be one-way and involves student interaction.

2. The magnitude of the influence of the TGT model on the mathematical communication skills of grade II elementary school students based on the posttest with Cliff's effect size.

After knowing the difference in the results of the mathematical communication ability test of students between the experimental class and the control class, the next step was to measure the effect size of the test using Cliff's Delta (δ) as a non-parametric alternative. The calculation results can be seen in the following table 9:

Table 9. Results of Mann-Whitney U Calculation with SPSS

Class	N	Mean Rank	Sum of Ranks
Experimental class posttest	25	34.70	867.50
Control class posttest	24	14.90	357.50
Total	49		

	Results
Mann-Whitney U	57.500
Wilcoxon W	357.500
Z	-4.894
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Class

Based on the table above, the Mann-Whiteney test shows a significant difference between the experimental and control classes with a value of Z = -4.894, p < 0.001. The Mean Rank in the experimental class scored 34.70 higher than the control class which scored 14.90. On the other hand, based on the calculation of effect size using Cliff's Delta using the formula below:

$$\delta = 1 - \frac{2(U)}{n_1.n_2}$$
$$= 1 - \frac{2(57,5)}{25.24}$$
$$= 1 - \frac{(115)}{600}$$
$$= 1 - 0,1917 = 0,808 \text{ (very large)}$$

Interpretation:
δ ≤ 0,147 : small
δ > 0.33 : medium
δ > 0.474 : large

Based on calculations using the Cliff's Delta test δ = 0.808 (95% CI: 0.68 - 0.94), the effect of the TGT model is included in the large category (δ > 0.474). Interpretation in this study must be careful by considering several factors, such as instrument limitations. The limitations of the questions are caused by the non-dominance of questions in the "easy" category, with a difficulty index between 0.82 and 0.98, thus potentially inflating the effect size. There are 9 students in the experimental class who achieved the maximum score, so the variance of ability in the experimental class narrowed (SD = 3.38) and artificially inflated the δ value. Therefore, the test given failed to measure student abilities optimally. The control class itself did not experience the ceiling effect phenomenon because its scores were spread between 30 and 54. The maximum score of the control class was also smaller than the maximum score of the experimental class (54 <71). Thus, without the ceiling effect, the average score of the experimental class could have been more than 71.

This finding aligns with the meta-analysis of Siagian et al., (2023)regarding the use of cooperative models in Elementary Schools that have been converted to Cliff's with δ = 0.68 (n = 35). Although in this study the value of δ = 0.808 was 18.8% higher (0.808 / 0.68.100%). This difference is suspected to be due to measurement bias, not just the superiority of the TGT model. However, pedagogical effectiveness is still confirmed through completeness. So the instrument failed to distinguish between superior and average students' mathematical communication skills. The Cliff's Delta δ value of 0.808 > 0.474 is scarce in educational research. This is strongly suspected to be due to the ceiling effect of the easy instrument.

The value of δ=0.808 in this study is much higher, which is likely due to the ceiling effect of the instrument. The gap with previous studies is 1.19x greater than the report by Siagian et al., (2023). However, the TGT model has proven to be pedagogically effective as indicated by the completeness between the experimental and control classes (92% vs 0%), the homogeneity of the experimental class' abilities with a small standard deviation, and strong statistical significance (p <0.001). Therefore, the instrument needs to be revised by adding questions with moderate difficulty to expand the score range.

The TGT model successfully created an inclusive learning climate, as evidenced by the homogenous class performance. This result aligns with the core principle of cooperative learning, namely positive interdependence(Slavin, 2020), which optimizes active student engagement cognitively, affectively, and psychomotorically by enabling students to rely on each other for success (Pahargyan & Harendita, 2022; Ghaemi et al., 2023).

However, homogeneous classes can also limit challenges for high-ability students due to the lack of variation in differentiation activities. High-ability students sometimes do not get enough challenges, especially when teachers are unable to provide in-depth material or varied activities. In addition, it can also reduce students' learning motivation because their learning needs are not met (Smedsrud, 2018).

3. Assessing the Minimum Completion Achievement (KKTP ≥ 65) of Mathematical Communication Skills Based on School Standards.

Based on the school's minimum completion standard (KKTP ≥ 65),a stark contrast in learning outcomes was observed between the experimental and control classes, as detailed in Table 10.

Table 10. Achievement of Minimum Completion Standard (KKTP ≥ 65)

Class	Total Studens	Number of Students Passing	Percentage Pass (%)
Experimental (TGT)	25	23	92%
Control (Direct)	26	0	0%

This dramatic difference in the proportion of students passing (92% vs. 0%) unequivocally shows the effectiveness of TGT in ensuring equal mastery of basic competencies. This comparison reflects two critical phenomena: first, the TGT model succeeded in raising the communication skills of marginal students to a minimal level, and second, direct learning failed to provide adequate scaffolding for low-ability students.

The high proportion of completion in the experimental class which reached 92% cannot be separated from the mastery learning mechanism in TGT. Where the games and tournament phases provide repeated opportunities to correct conceptual errors until they reach the standard. Similar findings were also reported by Wulandari et al., (2024) that the TGT model assisted by Kahoot was able to increase classical completion by up to 90% in the mathematical communication skills of elementary school students.

The failure of direct learning to achieve mastery (0%) illustrates the limitations of the direct learning approach (teacher-centered) in providing adequate scaffolding for all levels of student ability. Traditional methods often only serve students with medium to high abilities while students with low abilities are left behind without structured remedial opportunities. A meta-analysis by Siagian et al., (2023)reported that cooperative models including the TGT model consistently showed a significant impact on mathematical thinking skills with an average effect size of 0.792 which falls into the medium to large category.

The success of the TGT model in improving and encouraging classical completion is due to the Games and tournament structure that provides opportunities for students to correct conceptual errors. Research by Hardiyanti et al., (2023)revealed that the integration of the TGT model in the PQ4R strategy resulted in an increase in students' mathematical concepts and communication due to systematic repetition, reflection, and peer teaching. Thus, the TGT model not only increases the average value but also facilitates remedial learning which is crucial to achieving KKTP.

Conclusion

This study demonstrates that the Teams Games Tournament (TGT) model is significantly more effective than direct instruction in enhancing the mathematical communication skills of second-grade elementary students. Key evidence includes the notable difference in average posttest scores (67.6 for the experimental class vs. 44.0 for the control class) and a very large effect size (Cliff's Delta $\delta = 0.808$). By integrating teamwork, educational games, and tournaments, the TGT model fostered an active, collaborative environment that effectively encouraged both oral and written mathematical communication. Furthermore, it successfully leveled student achievement, as indicated by the high completion rate (92%) and low score variance within the experimental class.

This study contributes to elementary mathematics education by affirming the value of cooperative learning models like TGT in optimizing communication skills and promoting inclusivity. However, its findings are subject to limitations. The primary limitation was the test instrument, which was dominated by easy-level questions. This caused a pronounced ceiling effect in the experimental class, limiting the instrument's ability to measure the full variability of high-achieving students' abilities and potentially inflating the effect size. Additionally, the study's scope was confined to a single school and grade level, so generalizing these results requires caution.

References

Alfarisyi, D., & Sutiarso, S. (2020). Mathematical Communication Skills Based on Gender. *MaPan*, *8*(2), 300–314. https://doi.org/10.24252/mapan.2020v8n2a9

Anisa, Y., Fahruza, R., & Hafiz, M. (2023). Students' Mathematical Communication Skills in Mathematics Learning. *International Journal of Innovative Research in Computer Science and Technology*, *11*(6), 39–43. https://doi.org/10.55524/ijircst.2023.11.6.7

Bela, S., Rohman, & Erviana, R. (2018). KEMAMPUAN PEMAHAMAN KONSEP MATEMATIS SISWA MELALUI MODEL PEMBELAJARAN KOOPERATIF TIPE TEAM GAME TOURNAMENT. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *2*(2), 101–110.

Ghaemi, M., Esmail Ebrahimi, & Pariyaporn Ocak. (2023). Knowing the Role of the (TGT) Cooperative Learning Model on Student Learning Activeness. *Bioeduscience*, *7*(2), 209–214. https://doi.org/10.22236/jbes/12400

Hardiyanti, B. T., Riyadi, & Usodo, B. (2023). *Profile of Primary School Students' Mathematical Communication Skill* (Issue Icliqe 2022). Atlantis Press SARL. https://doi.org/10.2991/978-2-38476-114-2_33

Jafar, M. I. 1, Rahmadani, & Asriad. (2020). PENGARUH MODEL PEMBELAJARAN KOOPERATIF TIPE TGT TERHADAP KEMAMPUAN KOMUNIKASI MATEMATIS SISWA PADA MATA PELAJARAN MATEMATIKA KELAS V SD INPRES 3/77 BAJOE 1 KABUPATEN BONE Muh.Idris. *AKSIOMA : Jurnal Matematika Dan Pendidikan Matematika*, *11*(1), 27–36. https://doi.org/10.26877/aks.v11i1.4078

Khadka, J. B. (2024). *Role of Mathematical Communication for Learning Mathematics*. 68–76.

Kholidah, N., & Qohar, A. (2021). Students' mathematical communication in teams games tournaments (TGT) learning model on trigonometry topic. *Journal of Physics: Conference Series*, *1806*(1). https://doi.org/10.1088/1742-6596/1806/1/012110

Kurniawan, D., Yuwono, I., Irawan, E. B., & Susanto, H. (2019). Mathematical communication of prospective teachers in mathematics learning in senior high school. *International Journal of Innovation, Creativity and Change*, *10*(2), 75–84.

Muslim, A. (2020). The effect of cooperative learning Type Teams-Games-Tournaments (TGT) on mathematical connection and communication ability in elementary schools. *Journal of Physics: Conference Series*, *1469*(1). https://doi.org/10.1088/1742-6596/1469/1/012170

Pahargyan, T., & Harendita, M. E. (2022). *Submitted : 2021-10-18 Accepted : 2022-03-15*. *5*(1), 29–38.

Primadani, A. I., Mardiyana, & Triyanto. (2020). Mathematical Reasoning and Communication in TGT Learning Model with PQ4R Strategy. *Journal of Physics: Conference Series*, *1613*(1). https://doi.org/10.1088/1742-6596/1613/1/012022

Putri, N. D., & Musdi, E. (2020). Analysis of students Initial mathematical communication skills in mathematics learning. *Journal of Physics: Conference Series*, *1554*(1), 12064. https://doi.org/10.1088/1742-6596/1554/1/012064

Rusyda, N. A., Ahmad, D. ., Rusdinal, R., & Dwina, F. (2020). Analysis of students' mathematical communication skill in calculus course. *Journal of Physics: Conference Series*, *1554*(1). https://doi.org/10.1088/1742-6596/1554/1/012043

Ristyanti, A., & Widiyono, A. (2024). Model Teams Games Tournament (TGT) Berbasis Kahoot Terhadap Motivasi Belajar Siswa Sekolah Dasar. *Jurnal Riset Pendidikan Dasar (JRPD)*, *5*(1), 53. https://doi.org/10.30595/jrpd.v5i1.17385

Rohid, N., Suryaman, S., & Rusmawati, R. D. (2019). Students' Mathematical Communication Skills (MCS) in Solving Mathematics Problems: A Case in Indonesian Context. *Anatolian Journal of Education*, *4*(2), 19–30. https://doi.org/10.29333/aje.2019.423a

Salsabil, M. Y., Inganah, S., & Cholily, Y. M. (2017). Students Mathematical Communication Skills on Cooperative Learning of Tgt Type To Set Material. *Mathematics Education Journal*, *1*(2), 49. https://doi.org/10.22219/mej.v1i2.4629

Siagian, Q. A., Darhim, & Juandi, D. (2023). The Effect of Cooperative Learning Models on The Students' Mathematical Critical and Creative Thinking Ability: Meta-Analysis Study. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *7*(1), 969–990.

Slavin, R. E. (2020). Evidence-Based Policies in Education: Initiatives and Issues. *Slavin, Educational Research for Policy and Practice*, *19*(1), 21–33.

Smedsrud, J. (2018). Mathematically Gifted Accelerated Students Participating in an Ability Group: A Qualitative Interview Study. *Frontiers in Psychology*, *9*(July), 1–12. https://doi.org/10.3389/fpsyg.2018.01359

Sutopo, L. A., & Waluya, S. B. (2023). Systematic Literature Review: Kemampuan Komunikasi Matematis Siswa Ditinjau dari Gaya Berpikir. *Jurnal Pendidikan Matematika*, *1*(2), 15. https://doi.org/10.47134/ppm.v1i2.164

Sweller, J. (2020). Cognitive load theory and educational technology. *Educational Technology Research and Development*, *68*(1), 1–16. https://doi.org/10.1007/s11423-019-09701-3

Wandari, W., & Anggara, B. (2021). Analysis of students difficulties in completing mathematical communication problems. *Journal of Physics: Conference Series*, *1918*(4). https://doi.org/10.1088/1742-6596/1918/4/042090

Wulandari, A., Hendrastuti, Z. R., & Krisma, D. A. (2024). *Journal of Mathematics Education PENGARUH MODEL PEMBELAJARAN TEAMS GAMES TOURNAMENT (TGT) BERBANTUAN KAHOOT TERHADAP*. *c*, 155–165.