



## **Effectiveness of the TGT cooperative model in improving collaboration and understanding of biotechnology concepts**

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**Abstract.** The purpose of this study was to determine the effectiveness of the Team Games Tournament (TGT)-type cooperative learning model in improving students' collaboration and conceptual understanding of biotechnology material in grade X high school. This study used a quasi-experimental design, with a total sample of 69 students, divided into 2 classes: 36 students in the experimental class and 33 in the control class. Collaboration skills data collection used peer assessment questionnaires, while conceptual understanding data collection used multiple-choice tests. The data analysis technique used was inferential statistical analysis, consisting of prerequisite tests (normality and homogeneity) and hypothesis tests (independent-samples t-tests, Mann-Whitney U tests, and Wilcoxon tests). The results of this study indicate that: (1) The use of the Team Games Tournament (TGT) learning model in biotechnology material does not have a significant effect on the collaboration skills of grade X students with an average value in the experimental class of 84.53, while in the control class it was 82.61, with a significance value of  $0.521 > 0.05$ ; (2) The use of the Team Games Tournament (TGT) type cooperative learning model on biotechnology material is effective in improving the conceptual understanding of class X students with an average posttest score in the experimental class of 80, while in the control class it was 72.12, with a significance value of  $0.024 < 0.05$ . The TGT-type cooperative learning model can be recommended as an alternative learning strategy to improve conceptual understanding of biotechnology at the high school level, particularly by encouraging students' cognitive engagement through structured competitive activities. However, to optimize the improvement of collaboration skills, modifications to the learning design are needed, such as emphasizing individuals' roles in groups, strengthening process assessments, and integrating collaborative reflection.

**Keywords:** Collaboration skills, Concept understanding, Team Games Tournament (TGT)

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## **INTRODUCTION**

In this era of knowledge, all aspects of improving skills and meeting life needs are based on knowledge (Pertiwi et al., 2017). The relationship between knowledge is not far from how education in a place runs. The 21st-century learning process uses character, community, creativity, collaboration, problem-solving, communication skills, and critical thinking skills to improve the quality of education (Mardhiyah et al., 2021). So now learning not only pays attention to cognitive knowledge, but also to the affective aspect (Susilo et al., 2020).

To maximize learning activities in the classroom so that students can be properly facilitated, both in cognitive and affective aspects, a teacher needs to have the right strategy (Zahid & Nawab, 2025). Biology subjects are often considered boring because they contain a lot of writing and memorization. However, Biology material has different characteristics compared to other sciences (Gunawan et al., 2023). This material concerns not only scientific facts about concrete natural phenomena but also abstract concepts, such as biotechnology. Biotechnology is a topic in Biology that uses scientific principles to produce products and services from living things that benefit human life.

A teacher must have the right strategy to maximize learning activities in the classroom so that students enjoy optimal cognitive and affective experiences (Hamdani et al., 2025). Biology is often considered boring because it uses a lot of memorization and writing. Biology,

on the other hand, has unique characteristics that set it apart from other disciplines. This material not only discusses real-world phenomena but also abstract scientific concepts such as biotechnology (Rebello et al., 2010). One of the topics in the field of biology is biotechnology, which uses scientific principles to work with living things to produce goods and services that benefit human life.

According to observations at schools on the teaching and learning process in biology subjects, in class X, many students still tend not to be interested in listening to the teacher's explanations of the material. Students lack enthusiasm for learning biology. Based on interviews with several class X students, many felt that biology was a bit boring because it involved too much writing. They also said they were bored with learning methods that often took the form of lectures, question-and-answer sessions, summarizing, or assignments. (Apriani & Sudrajat, 2025). Therefore, a learning model is needed that can motivate students to be more active in the learning process.

One of the learning models that can be applied in the classroom so that students can take an active role in the teaching and learning process is the cooperative learning model (Faris et al., 2025). With cooperative learning, there is interaction among students. There are various types of this cooperative learning model. One of them is the *Team Games Tournament* (TGT) type cooperative model. The *Teams Games Tournament* (TGT) type cooperative learning model is divided into small groups of 4 to 5 students of different levels of ability, gender, and tribal or racial background, then combined and collaborating in small groups (Ismana & Wibowo, 2025).

Ulfa & Irwandani (2019) stated that learning with a TGT-type cooperative model can improve students' conceptual understanding compared to conventional models. In addition, learning with the TGT-type cooperative model can increase student collaboration in classroom interactions (Ismah & Ernawati, 2018), making this model suitable for improving learning outcomes in conceptual understanding and students' collaboration skills. Based on the description above, the purpose of this study is to determine the effectiveness of implementing a cooperative learning model of the Team Games Tournament (TGT) type in increasing collaboration and understanding of student concepts in class X biotechnology materials.

## **METHODS**

### **Research design**

This study uses a *quasi-experimental* design with a nonequivalent control group. This type of research was used because, at the time of the study, the researcher could not control all disruptive variables, such as the subject's age, learning experience, length of study, and so on. This study used 2 classes: an experimental class and a control class, in which the experimental class received the research treatment, namely, a cooperative learning model of the *Team Games Tournament* (TGT) type. In contrast, the control class received treatment using a discovery learning model with group discussions, interactive lectures, and presentations. The place was held at one of the State High Schools in Yogyakarta. The research will be conducted for class X phase E, in the 2nd semester of the 2024/2025 academic year. This research took place from March to April 2025.

### **Research subject**

The population in this study comprises all students in class X phase E at the relevant State High School, totaling 9 classes and 324 students. Then the sample was selected by a cluster random sampling technique, so that 2 classes were received from the entire X class. The two classes were divided into an experimental class with 36 students and a control class with 33 students.

## Research procedure

The research began with an observation of the relevant school, followed by initial data collection to assess students' knowledge before they received the material. Then, the implementation of learning takes place, where the treatment is carried out. After the material is given to the students, the experimental class will have a tournament game. In contrast, in the control class, there will be a group discussion of the students' worksheets, followed by a group presentation to the class. The last is the collection of final data, including written questions to assess conceptual understanding and an assessment questionnaire between friends to assess students' collaboration skills.

## Data collection techniques

The data collection technique used in this study is a measurement technique, as the desired data is quantitative, namely, an understanding of concepts and students' collaboration skills on biotechnology materials. The data collection tool used in this study is a multiple-choice test. The data collected are the pretest and posttest scores according to the ability to understand the concept. The data collection tool for collaboration skills is an assessment questionnaire administered to group friends.

## Data analysis techniques

The data analysis techniques used in this study make use of Microsoft Excel and SPSS version 25. The data analyzed were *pretest* and *posttest data* on concept understanding, and non-test questionnaires on collaboration skills. Data analysis uses instrumental analysis and inferential statistical analysis. Instrument analysis includes item analysis of questionnaire items and concept comprehension questions, difficulty-level tests for concept comprehension, and differential power tests for concept comprehension. Inferential analysis is in the form of a prerequisite test, namely a normality and homogeneity test, followed by a hypothesis test, namely *an independent sample t-test* for the analysis of the results of collaboration skills, and also *the Mann-Whitney U test*, the *Wilcoxon test*, and the *N-gain test*, for the analysis of the results of concept understanding.

## RESULTS AND DISCUSSION

### Results

The analysis of the questionnaire items and the concept understanding items included validity and reliability tests. The results showed that several questions were invalid and needed to be separated and not used again in the next analysis, namely, the reliability test. The reliability test indicated that the results were entirely reliable.

The difficulty level test and the differentiation test are only for problem-comprehension questions; the goal is to determine whether the questions can measure students' understanding of concepts. The difficulty level test was analyzed using SPSS and then categorized into 3 levels: easy, medium, and difficult, according to the difficulty index criteria listed in the journal [Masitoh & Aedi \(2020\)](#). The following table presents the percentages of results by difficulty level for the concept understanding question (Tables 1 and 2).

**Table 1. Percentage of test results of the difficulty level of control class questions**

Category	<i>Pretest</i>		<i>Posttest</i>	
	Number of Questions	Percentage	Number of Questions	Percentage
Easy	4	31%	11	55%
Medium	9	69%	7	35%
Hard	0	0%	2	10%

**Table 2. Percentage of test results for difficulty level items for experimental class questions**

Category	Pretest		Posttest	
	Number of Questions	Percentage	Number of Questions	Percentage
Easy	11	55%	16	80%
Medium	7	35%	3	15%
Hard	2	10%	1	5%

The differentiating power test analysis assesses the question's ability to distinguish between students with high and low understanding of the material being tested. The criteria for the power test index are different, namely if the value of the Corrected Item- Total Correlation is  $< 0.20$  (poor),  $0.21 - 0.40$  (moderate),  $0.41-0.70$  (good),  $0.71 - 1.00$  (very good) (Nurhasanah et al., 2021). As stated in (Nurhasanah et al., 2021) if the questions in the category are very good and good, it means that the question item is accepted, and able to distinguish students well, while questions with a medium category mean that they need to be changed and improved, while questions with a bad category eat questions must be discarded and replaced with others. Based on the results of the differentiation test, both the control and experimental classes did not differ in the bad category, so no questions needed to be replaced. The following table presents the percentages of results for differences in concept understanding (Tables 3 and 4).

**Table 3. The percentage of power test results for different control class questions**

Category	Pretest		Posttest	
	Number of Questions	Percentage	Number of Questions	Percentage
Bad	0	0%	0	0%
Moderate	9	69%	10	50%
Good	4	31%	10	50%
Very good	0	0%	0	0%

**Table 4. The percentage of power test results differs in experimental class questions**

Category	Pretest		Posttest	
	Number of Questions	Percentage	Number of Questions	Percentage
Bad	0	0%	0	0%
Moderate	20	100%	10	50%
Good	0	0%	9	45%
Very good	0	0%	1	5%

Table 5 presents the results of an analysis of the descriptions of collaboration skills based on the total scores of both classes. Based on the table, the average score in the control class was 82.61, lower than that in the experimental class (84.53).

**Table 5. Description of collaboration skills**

Average Description	Collaboration Skills	
	Experiment	Control
Mean	84,53	82,61
Number of Samples	36	33
Std. Deviation	13,175	11,371
Maximum Value	100	100
Minimum Grade	56	60

Furthermore, in understanding the concept, the average pretest score for the experimental class was 63.33, and the posttest score was 80, out of a total of 36 students (Table 6). Meanwhile, in the control class, the mean pretest score was 64.09, and the posttest score was 72.12, with a total of 33 students. From this data, it can be seen that students' understanding

of concepts increases in both the control and experimental classes. Table 6 also presents the N-Gain results for both classes, which differ. In the control class, the N-Gain value was 0.0157, which was relatively low, whereas in the experimental class, it was 0.4231, which was moderate. In accordance with the N-Gain effectiveness interpretation category, if the N-Gain value is greater than 0.00 and less than 0.30, it is included in the low category. If  $0.30 \leq g < 0.70$ , then the criteria are moderate.

**Table 6. Description of concept understanding results**

Average Description	Concept Understanding			
	Experiment		Control	
	Pretest	Posttest	Pretest	Posttest
Mean	63,33	80	64,09	72,12
Number of Samples	36	36	33	33
Std. Deviation	17,889	18,4	22,274	18,372
Maximum Value	85	100	100	95
Minimum Grade	30	25	8	15
N-Gain	0,4231		0,0157	

### Normality test results

Normality tests are used to determine whether the data from both sample groups are normally distributed. The results of the normality test are shown in Table 7.

**Table 7. Results of the normality test of collaboration skills**

Data	Sig. (p)	Interpretation
Experimental Class	0.131	Significance > 0.05 = <b>normal</b>
Control Class	0.200	Significance > 0.05 = <b>normal</b>

Based on Table 7, the distribution of students' collaboration skills data is normal. In contrast to the distribution of concept comprehension data, which is abnormal, the hypothesis test uses non-parametric tests, namely the *Mann-Whitney U* and *Wilcoxon tests*. The following table presents 8 results from the normality test for concept understanding.

**Table 8. Results of the normality test for conceptual understanding**

Data	Sig. (p)	Interpretation
Pretest Experiment	0.001	Significance < 0.05 = <b>Abnormal</b>
Experiment Posttest	0.000	Significance < 0.05 = <b>Abnormal</b>
Control Pretest	0.026	Significance < 0.05 = <b>Abnormal</b>
Control Posttest	0.050	Significance = 0.05 = <b>Abnormal</b>

### Homogeneity test results

Because the analysis of normally distributed data can be continued, the collaboration skills can be further examined with a homogeneity test. The following table presents the results of the homogeneity test for collaboration skills (Table 9).

**Table 9. Homogeneity test of collaboration skills data based on the mean value**

Learning Outcomes	Sig. (p)	Interpretation
Based on Mean	0,260	Significance > 0,05 = <b>homogeneous</b>

Based on Table 9, the data on students' collaboration skills are homogeneous.

### Hypothesis test results

The first hypothesis in this study is whether the application of the Team Games Tournament (TGT)- type cooperative model is effective for the collaboration skills of class X students in biotechnology materials. The results of the analysis of collaboration skills are

known to be distributed normally and homogeneously, so hypothesis tests can then be carried out using the t-test (*independent sample t-test*). The following is a table of the results of the collaboration skills t-test (Table 10).

**Table 10. Collaboration skills t-test results**

Class	Mean Rank	Sig. (2-tailed)	Result	Interpretation
Control	82.61	0.521	Sig. (2-tailed) > 0,05 = <b>Ha rejected</b>	There is no significant difference
Experiment	84.53			

Based on Table 10, there was no significant difference in the average collaboration skills of learners between the control and experimental classes. However, if you look at the mean rank, there is a difference, although not too big, where the experimental class has a mean value of 84.53, higher than the mean value of the control class of 82.61, which shows that the collaboration skills of students in the experimental group are generally better than those of the control group.

The second hypothesis in this study is whether the application of *the Team Games Tournament* (TGT)- type cooperative model is effective in helping class X students understand the concept of biotechnology materials. The analysis used was a non-parametric test, namely *the Mann-Whitney U* test and the Wilcoxon test (Table 11).

**Table 11. Mann-Whitney U test results based on the *posttest* value of concept understanding**

Class	Mean Rank	Sig. (2-tailed)	Result	Interpretation
Control	29.36	0.024	Sig. (2-tailed) < 0,05 = <b>Ha accepted</b>	Significant differences
Experiment	40.17			

Based on Table 11, there is a significant difference in students' conceptual understanding between the control and experimental classes. This difference is also evident in the mean rank, with the experimental class at 40.17, higher than the control class at 29.36, indicating that students' understanding of concepts in the experimental group was generally better than in the control group. The results of the next test are shown in Table 12.

**Table 12. Wilcoxon test results on understanding concepts**

<i>Posttest</i> Experiment- <i>Pretest</i> Experiment	Negative Ranks	6 <sup>a</sup>
	Positive Ranks	29 <sup>b</sup>
	Ties	1 <sup>c</sup>
	Total	36
	<b>Sig. (2-tailed)</b>	<b>0.000</b>
<i>Posttest</i> Control- <i>Pretest</i> Control	Negative Ranks	15 <sup>d</sup>
	Positive Ranks	18 <sup>e</sup>
	Ties	0 <sup>f</sup>
	Total	15 <sup>d</sup>
	<b>Sig.(2-tailed)</b>	<b>0.136</b>

Based on Table 12, there is a significant average difference between the pretest and posttest results for students in the experimental class in concept understanding. On the other hand, in the control class, there was no significant difference between the pretest and posttest results for concept understanding.

## Discussion

The absence of significant differences in collaboration skills between the experimental

and control classes may be due to several factors. Such as the learning environment, each student's attitude toward the learning process (internal factors), and the influence of a lack of variety in media, strategies, methods, or models used in learning (Fauziyah et al., 2019). The learning environment is not suitable for the cooperative model, such as classically arranged seating, where the teacher is the center of the class's attention. In groups, many still sit with their backs to each other, play alone, and do not focus on discussing with their group, so that only a few children, or even one, focus on answering questions, which leads to a lack of collaboration among group members. According to Sudjana & Wijayanti (2018), seating arrangements may be a factor in the lack of activity and interaction in groups.

The second factor is how each student responds to changes in the application of the learning model. For example, students are not used to the TGT-type cooperative learning model, they do not understand the rules of the game, so the time used to play becomes longer. as stated by Huzani and Agustina (2025), that the weakness of TGT is that when team learning takes a relatively long time so that students who have more abilities will feel hampered by other students who have abilities below them.

Other internal factors that can affect students' collaboration skills in biology materials are physical, psychological, and fatigue factors (Agustin, 2021). Biology learning in one of the classes in this study was conducted after the PJOK subject hours, during which, in the 2 meetings, they did physical exercises for sports maps. This causes students' performance to be suboptimal during biology learning due to fatigue.

Based on the results of this study, the effectiveness of *Team Games Tournament* (TGT)-type cooperative learning in improving students' understanding of concepts is significant, as evidenced by *the Mann-Whitney U test*. This statement is also supported by the results of *the Wilcoxon test*, which show that, in the experimental class, there is a difference after treatment, namely the use of a cooperative learning model of *the Team Games Tournament* (TGT) type. In contrast, in the control class, there is no difference after treatment, namely, with *the discovery learning model*. Another research that supports this statement is the study. Based on the research results by Aryani et al (2021), the discovery learning model had no significant influence on student learning outcomes, whereas the cooperative learning model did.

The use of a cooperative learning model, such as the *Team Games Tournament* (TGT), can increase students' understanding of concepts in experimental classes by actively involving them in the learning process. They not only passively receive information from the teacher but also competitively try to determine whether a certain concept has been discovered. During the games tournament, students are motivated to study hard to answer questions and earn as many points as possible. Because the concept of this TGT model is a *game tournament*, students will compete positively with classmates across academic areas, races, genders, and other categories, so that students can be responsible and actively contribute to earning points for their group. As stated by Fauziyah et al (2019), there are several advantages of the TGT-type cooperative model, including student involvement in learning, increasing students' enthusiasm for learning, students can construct their own knowledge, motivating students to achieve higher results because of the award, and making it easier for teachers to supervise students in learning and collaborating.

## CONCLUSION

Based on the description of the data and research analysis of the application of *the Team Games Tournament* (TGT) type cooperative learning model for understanding the concept and collaboration skills of students of biotechnology materials in class X of high school, it can be concluded that: (1) The use of *the Team Games Tournament* type cooperative learning model (TGT) in biotechnology materials does not affect students' collaboration skills. The ineffectiveness of the application of the TGT type cooperative model to collaboration skills can

be caused by internal and external factors, such as the factors of the student's learning environment, the readiness of students for the application of the new learning model, and also the physical condition of the students; (2) The use of the Team Games Tournament (TGT) type cooperative learning model in biotechnology materials has a positive effect on concept understanding. This makes the TGT-type cooperative learning model effective in improving students' understanding of concepts.

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