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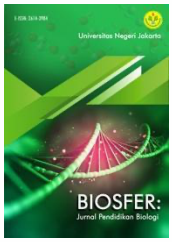

TGT-based crossword e-worksheets: interest, activity, and learning outcomes in biology education

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ABSTRACT

This study aims to determine the effect of the Team Games Tournament (TGT) learning with crossword puzzles-based E-student worksheet on students' learning interest, activity, and cognitive outcomes on the ecosystem material. This research is a quasi-experimental study using a pretest-posttest control group design. The subjects consisted of two classes: class X-2 (experimental) taught using the TGT model with crossword puzzles-based E-student worksheet, and class X-3 (control) taught using the Direct Instruction model. The TGT syntax included class presentation, team formation, games, tournament, and team recognition, while the Direct Instruction syntax included presentation of objectives and motivation, material delivery, guided practice, feedback, and independent practice. Data were collected using questionnaires (learning interest), observation sheets (learning activity), and tests (learning outcomes). The data obtained were analyzed using an independent sample t-test, which showed a significance value lower than 0.05. Students in the experimental class showed higher learning interest (71.2% > 58.9%), greater learning activity (81.15% > 59.04%), and higher cognitive outcomes (83.06 > 70.56) compared to the control class. It can be concluded that the TGT model with crossword puzzles-based E-student worksheet has a significant effect on improving students' learning interest, activity, and cognitive outcomes. Teachers are encouraged to apply this model as a student-centered strategy to improve the quality of biology learning and to use similar interactive media to create more engaging and collaborative learning experiences.

INTRODUCTION

Education is an important foundation in the development of quality human resources. Educators today face the challenge of continuously developing their skills. This is important in order to create a learning environment that is relevant and interesting for students, thereby increasing student activity and interest in the learning process (Rudianti & Rustini, 2024). In biology, teaching complex scientific concepts can be challenging, especially when it comes to encouraging student engagement and fostering deep understanding. Traditional methods may be less effective in encouraging active participation (Mariani & Devany, 2025). Students learn best when they are actively involved in meaningful, socially interactive, repetitive, and enjoyable learning (Blinkoff et al., 2023). Active learning involves students constructing new knowledge, and an iterative approach helps students learn by testing and revising their own understanding, which contributes to deep understanding and improves memory (Roediger et al., 2017). Interest in learning has a direct effect on learning outcomes, where the higher the interest of students, the better their achievements (Oktafia et al., 2022; Sholihah et al., 2024; Dahliani et al., 2020). A lack of interest can hinder motivation and knowledge acquisition in learning (Harefa et al., 2023).

Various studies show that students' interest in learning biology is still low because the lessons are hard to understand (Dahliani et al., 2020). This lack of interest results in a lack of enthusiasm, poor academic performance, and a reduced interest in continuing studies in the field of biology. (Mariati, 2024). Various studies also show that student learning activities in biology are still low, which is caused by the use of teaching models that lack variety (Nisak, 2021), and teachers still dominate the class (Astuti & Najuba, 2024). Such learning processes have a major influence on the quality of student learning outcomes (Thurrodliyah et al., 2023). Various studies show that student learning outcomes in biology are still a concern, as they have not yet reached the minimum competency standard (Anggraini et al., 2020). The causes of low student learning outcomes are a lack of understanding of learning concepts, a lack of engagement, and the incompatibility of the learning strategies, methods, and models that have been implemented. (Rosnidar, et al., 2021). In addition, conventional teaching methods and learning processes that are still teacher-centered result in low learning outcomes in biology (Irdawati et al., 2023).

Student interest, activity, and learning outcomes are still issues that need serious attention. Several previous studies have reported that ecosystem learning in senior high schools often faces challenges related to low student engagement, learning interest, and learning outcomes. Ecosystem concepts are considered abstract and complex, requiring students to actively construct knowledge through interaction, discussion, and problem-solving activities. However, conventional teacher-centered instruction commonly used in biology classes tends to limit student participation and does not optimally stimulate learning interest or activeness, which consequently affects students' understanding of ecosystem concepts and learning achievement

The researchers considered it necessary to offer a new approach that had not been used by the teacher in learning. One learning model that can increase student participation in learning is the Team Games Tournament (TGT) model (Riyanti et al., 2024). TGT is a type or model of cooperative learning that is easy to implement, involves the activities of all students without any differences in status, involves the role of students as peer tutors, and contains elements of play and reinforcement (Banua et al., 2022). This model encourages students to engage in games and competitions that can create a fun learning atmosphere (Faturrahman et al., 2024). In TGT learning, Students are divided into small, heterogeneous groups, regardless of ethnicity, race, and culture, and work together with their groups (Adha et al., 2023). The main components of TGT include class presentation, groups, games, tournaments, and group awards (Fenezia et al., 2021). This is in line with previous research showing that the TGT model increases student interest and learning outcomes in biology learning (Lumbantobing et al., 2025). Previous research also states that there is an increase in activity and learning achievement with the TGT model (Hanjayani, 2022).

The E-student worksheet based on crossword puzzles are one innovation that can improve the learning experience of students. The application of E-student worksheet through liveworksheets, teachers can create various interactive exercises that can be accessed anytime to improve student learning outcomes (Christin et al., 2025). Crossword puzzles are games that require students to fill in blank boxes with appropriate words based on vertical and horizontal clues (Oktavia et al., 2023). Doing crossword puzzles makes learning fun because it is interactive, exciting, and provides an interesting experience so that students are actively learning (Shah et al., 2010; Zamani et al., 2021). Through this

approach, researcher hope to create a more interactive learning atmosphere and increase interest, activity, and learning outcomes.

Based on these studies, it is known that no research has simultaneously investigated three aspects of learning: learning interest, student activity, and cognitive learning outcomes using a comprehensive quasi-experimental research design. This research is important to expand the findings to develop innovative learning. Based on the above background, this study aims to determine the effect of the TGT learning model with a crossword puzzle-based E-student worksheet (CP-based E-student worksheet) on students' interest, activity, and learning outcomes in ecosystem material.

METHODS

Research Design

The research design used was a non-equivalent (pretest-posttest) control group design (Denny et al., 2012), involving two groups, namely the experimental group, which received treatment in the form of a TGT learning model with CP-based E-student worksheet, and the control group, which used learning with the Direct Instruction model (Table 1).

Table 1.
Research Design

Class	Pretest	Treatment	Postest
Experiment	O_1	X	O_3
Control	O_2	-	O_4

Table 1 shows O_1 refers to the experimental class that was given a pretest, while O_2 refers to the control class that was also given a pretest. The experimental class then received the treatment (X) in the form of the application of the Teams Games Tournament (TGT) model supported by a crossword puzzle–based e-student worksheet. After the treatment, the experimental class was given a posttest (O_3), whereas the control class was given a posttest (O_4).

Population and Samples

Table 2.
Population and sample

Group	Description	Number of student
Population	Grade X students	324
Sampel	X-2 and X-3	72

The population of this research was all 10th-grade students of SMA at Medan in the 2025/2026 academic year, totaling 324 students distributed in nine different classes (X-1 to X-9), with each class consisting of 36 students. Two classes (class X-2 and class X-3) were drawn by cluster random sampling as the sample.

Instrument

The instruments used in this study consisted of a learning interest questionnaire to measure students' interest in learning, an observation sheet to assess students' learning activities, and a learning achievement test to evaluate students' cognitive learning outcomes. Each instrument was developed based on the respective grid (Table 2, Table 3, and Table 4) and has been validated by experts in terms of design, content, and construct, and the test instruments have been tested on students. The results of the validity and reliability of the test instrument show that the instrument is suitable for use.

Table 3.
The grid of the learning interest questionnaire

No	Indicators	Sub-indicator	Item Number		Number of question
			Positve	Negative	
1	Feelings of happiness	1. Enjoy learning 2. Don't feel bored 3. Be proud of the results 4. Be on time	1, 2,	3, 4	4

No	Indicators	Sub-indicator	Item Number		Number of question
			Positve	Negative	
2	Student interest	1. Interested in the material 2. Want to know more 3. Interested in the teacher's teaching methods	5, 6, 7, 8	9	5
3	Student attention	1. Focus while studying 2. Pay attention to explanations 3. Don't get distracted easily 4. Respond quickly to instructions	10, 11 12, 13	14, 15, 16	7
4	Student involvement	1. Ask questions actively 2. Express opinions 3. Participate in discussions 4. Complete assignments 5. Cooperate with friends	17, 19	18, 20	4
		Number	12	8	20

The learning interest questionnaire was developed based on four indicators, namely feeling of happiness, student interest, student attention, and student involvement. These indicators were elaborated into sub-indicators and items, and validated by expert lecturers before use (Table 2).

Table 4.
The grid of the observation sheet

No.	Indicators	Sub-indicator	Item Number	Number of question
1	Visual activities	1. Students read the instructions/work orders. 2. Students pay attention to the media provided.	1, 2,	2
2	Oral activities	1. Students ask questions 2. Students dare to express their opinions 3. Students dare to express their thoughts/ideas during discussions	3, 4, 5	3
3	Listening activities	1. Students listen to the teacher's explanation. 2. Students listen to their friends' opinions during discussions.	6, 7	2
4	Writing activities	1. Students take notes on the lesson material 2. Students write down the answers to the questions	8, 9	2
5	Mental activities	1. Students contribute to solving problems 2. Students respond to group discussions.	10, 11	2
6	Emotional activities	1. Students are enthusiastic and excited during lessons 2. Students enjoy participating in learning activities	12, 13	2
		Total		13

The observation sheet of student learning activities was developed based on six indicators, namely visual activities, oral activities, listening activities, writing activities, mental activities, and emotional activities. These indicators were elaborated into sub-indicators and observation items, and validated by expert lecturers before use (Table 3).

Table 5.
The grid of the learning achievement test

No	Indicator	Cognitive Domain						Number of question
		C1	C2	C3	C4	C5	C6	
1	Biotic components	2	6	8, 17	19			5
2	Abiotic components		10	15	7		20	4
3	Types of ecosystems			1			5	2
4	Interactions between biotic components	4		3, 9		11		4

5	Interactions between biotic and abiotic components	14	12, 16	13	18	5
	Number					20

The learning achievement test was developed based on the cognitive domain indicators of the revised Bloom's Taxonomy, namely C1 (remembering), C2 (understanding), C3 (applying), C4 (analyzing), C5 (evaluating), and C6 (creating). These indicators were elaborated into test blueprints and items, and validated by expert lecturers before use (Table 4).

Procedure

The research instruments were developed prior to the implementation of the study, consisting of a learning interest questionnaire, a student activeness observation sheet, and a learning achievement test. The learning interest questionnaire was constructed based on learning interest indicators relevant to ecosystem topics, using a four-point Likert scale, and was validated by an educational psychology expert. The student activeness observation sheet was developed according to activeness indicators aligned with the TGT learning model, using a five-point Likert scale, and was validated by an educational psychology expert. The learning achievement test was designed based on competency achievement indicators and the revised Bloom's Taxonomy (C1–C6) in the form of multiple-choice items related to ecosystem material. The test was validated by a biology subject matter expert, revised according to expert feedback, and then piloted to analyze item validity, reliability, discrimination index, and difficulty level.

The learning media consisted of a crossword puzzle-based E-student worksheet, designed using Canva and converted into an interactive format via the Liveworksheet platform. The E-student worksheet was validated by an instructional media expert in terms of appearance, usability, and alignment with learning objectives. Both the experimental and control groups were administered a pretest to assess initial cognitive abilities. The learning interest questionnaire was administered before and after the treatment, while student activeness was observed during the learning process by two trained observers. The intervention was conducted over three meetings (2 × 40 minutes each). The experimental group was taught using the TGT model with the crossword puzzle-based E-student worksheet, whereas the control group received Direct Instruction. After the intervention, a posttest was administered to measure students' cognitive learning outcomes. Data were collected from the learning interest questionnaire, observation sheets, and posttest results. The data were analyzed using normality and homogeneity tests, followed by an independent samples t-test to determine differences between the experimental and control groups

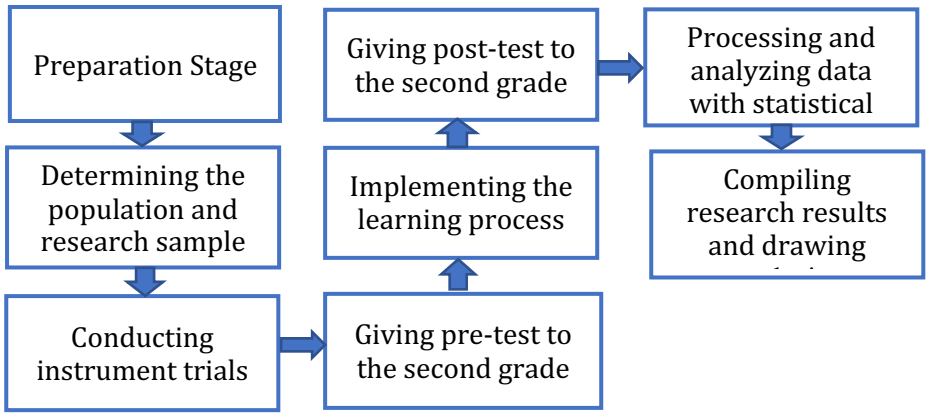

Figure 1. Research procedure

Data Analysis Techniques

All data obtained in this study were presented as mean ± standard deviation and analyzed using an independent sample t-test ($p < 0.05$). Prior to the independent sample t-test, the data were subjected to prerequisite tests, namely the Shapiro-Wilk test for normality and the Levene's test for homegeneity.

RESULTS AND DISCUSSION

1. Students' Interest in Learning Through the Application of the TGT Model with Crossword-Based E-Student Worksheet

The data on student learning interest were normally distributed and had homogeneous variance, so they met the prerequisites for hypothesis testing using an independent sample t-test. The results are presented in Figure 1.

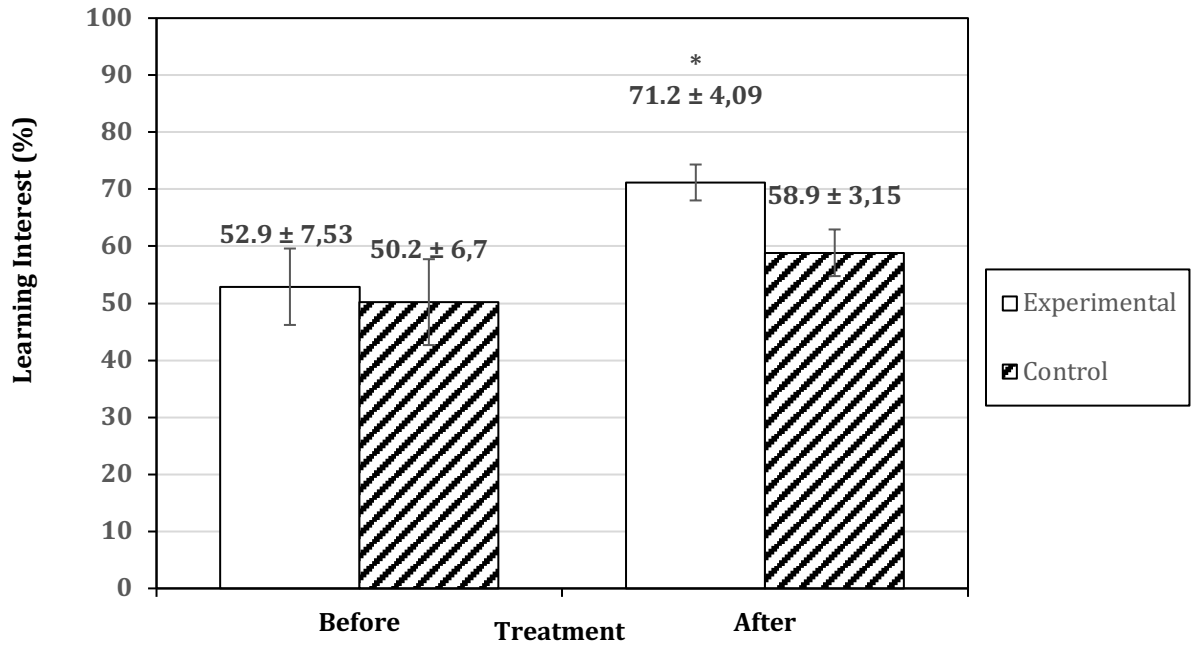

Figure 2. The Effect of the TGT Learning Model with Crossword Puzzle-Based E-Student Worksheet on Students' Interest in Learning.

Based on Figure 1, the final results of student learning interest showed differences between the experimental class taught with the TGT model and the control class taught with the Direct Instruction model. The independent sample t-test obtained $p = 0.000 < 0.05$, indicating a significant difference between the two groups. The average final interest in the experimental class reached 71.2% (SD = 4.09) and was categorized as high, while in the control class, it was only 58.9% (SD = 3.15) and categorized as moderate. These findings indicate that Ha is accepted, meaning the use of the TGT model with CP-based E-student worksheet had a significant positive effect on student learning interest.

The difference in student learning interest between the two classes can be explained by the fact that the TGT model provides a more interactive learning atmosphere through group discussions, competitions, and games that motivate students to participate. The results of this study are in line with the findings of Rahmayanti et al. (2023), who concluded that the use of the TGT cooperative learning model can increase student learning interest. This is also in line with the research by Sya'adah et al. (2023), which states that during the learning process, game activities packaged in the form of tournaments can make the learning atmosphere more active, attract students' attention, and be enjoyable. Thus, students feel happier and are less likely to get bored compared to when they participate in learning that only uses conventional models. This study is supported by Self-Determination Theory, proposed by Deci and Ryan (2012), which states that intrinsic motivation, including interest in learning, plays an important role in increasing student engagement in the learning process. Such high engagement has a positive impact on student learning outcomes.

Based on the results of statistical analysis of learning interest data, it can be concluded that the application of the TGT learning model has an effect on students' learning interest. This is in line with the report by Damayanti et al. (2025), which states that the TGT cooperative learning model has an effect on students' interest. The elements of games, cooperation, and healthy competition make students more interested, focused, active, and happy while participating in biology lessons. Coupled with the use of CP-based E-student worksheet, students become more interested in participating in the game. Crossword puzzles are an innovative learning medium that incorporates game elements into the learning process, creating a learning environment that is enjoyable for students and encourages them to be active in their

learning (Syafmen & Indri, 2023). Meanwhile, in the control class using the Direct Instruction model, many students were unprepared and passive. Although they studied in groups, only a few were active while the others simply received information. The lack of interaction with the teacher made learning monotonous, resulting in low student interest and engagement.

This study has limitations, such as the presence of students with low learning interest at the beginning of the treatment, a short research period, and limited media to CP-based E-student worksheet. To increase learning interest, the researcher provided guidance, encouragement, and simple rewards. The results of the study show an increase in student learning interest through the TGT model with CP-based E-student worksheet, in line with learning motivation theory that emphasizes a competitive, collaborative, and enjoyable atmosphere. These findings can be used as a basis for developing more varied digital teaching media. It is recommended that further research be conducted with a longer time frame, more interactive digital learning media, and on different materials and grade levels.

2. Students' Learning Activities Through the Application of the TGT Model with Crossword-Based E-Student Worksheet

The data on student learning activities were normally distributed and had homogeneous variance, so they met the prerequisites for hypothesis testing using an independent sample t-test. The results are presented in Figure 3.

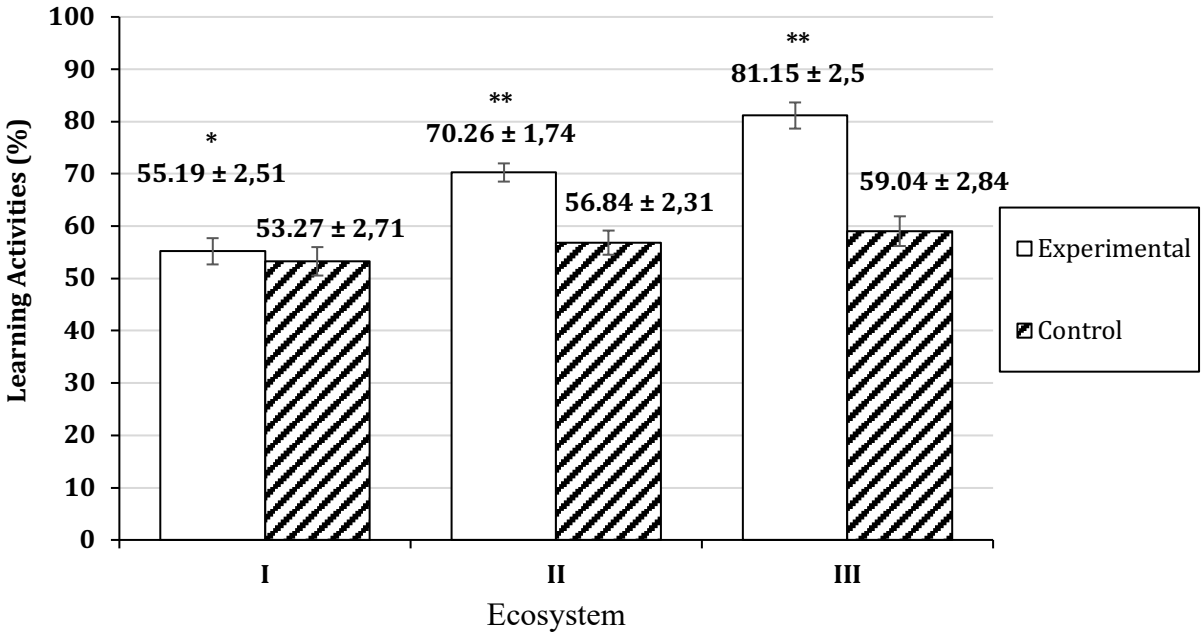

Figure 3. The Effect of the TGT Learning Model with Crossword Puzzle-Based E-student worksheet on Students' Activities in Learning.

Based on Figure 3, the final results of student learning activities showed differences between the experimental and control classes. The independent sample t-test obtained $p = 0.000 < 0.05$, indicating a significant difference. The experimental class reached an average activity percentage of 81.15% (SD = 2.50), categorized as very active, while the control class only reached 59.04% (SD = 2.84), categorized as moderately active. These findings indicate that Ha is accepted, meaning that the TGT model with CP-based E-student worksheet had a significant effect on improving student learning activities.

Based on this, it can be concluded that student activity in the experimental class using the TGT learning model was higher than in the control class using the Direct Instruction learning model. The results of this study are in line with research conducted by Prihatin et al. (2025), which found that the TGT cooperative learning model was proven to increase student learning activity. According to Pratama & Lestari (2023), with the application of the TGT model, students are more actively involved in the learning process. TGT allows students to learn in a more relaxed manner, fostering a sense of responsibility, cooperation, healthy competition, and commitment to learning, as well as easily adapting to all concepts.

The increase in student activity in the experimental class was also influenced by competition activities (Hidayah & Sari, 2020). Students who are usually less active are encouraged to participate because of the enthusiastic learning environment (Adiyono et al., 2023). Thus, each individual feels that they have a role and a contribution to the success of the group. According to Maghfira & Khikmah (2023), the elements of TGT encourage students to interact with each other in groups so that students appear active, brave enough to come to the front of the class, and express their opinions. In addition, the CP-based E-student worksheet encourages students to actively work on games with their groups. According to Herawati & Mohamad (2023), the use of crossword puzzles as a game medium provides a unique challenge for students in completing the questions given by the teacher. In addition, it helps students understand the material being studied more easily, as it reduces the boredom that usually arises when working on multiple-choice or essay questions. In line with the theory of constructivism, which states that the learning process is centered on student independence with social interaction, so that the discovery of new knowledge and understanding is obtained in depth (Efgvia et al., 2021).

Meanwhile, in the control class with the Direct Instruction model, student activity increased but was relatively slow compared to the experimental class. This is because this model is more teacher-centered, so students receive more explanations, interaction between students is not optimal, and they only follow instructions. According to Rahmasafitri (2024), the Direct Instruction model has advantages in terms of well-structured learning delivery and direct instruction. However, this model is less than optimal in encouraging active student involvement and is not yet fully capable of adapting to the different learning styles of each student.

This study has limitations, such as some students not being accustomed to active discussion, the short research period, and the limited media with the CP-based E-student worksheet. The researcher acted as a facilitator by providing guidance and motivation to encourage student participation. The results of the study show a significant increase in learning activity through the TGT model with CP-based E-student worksheet, in line with social constructivism theory, which emphasizes group interaction. These findings can be used as a basis for teachers to develop a variety of collaborative activities, and further research is recommended with a longer duration, more challenging activities, and other materials.

3. Students' Learning Outcomes Through the Application of the TGT Model with Crossword-Based E-Student Worksheet

The data on student learning outcomes were normally distributed and had homogeneous variance, so they met the prerequisites for hypothesis testing using an independent sample t-test. The results are presented in Figure 4.

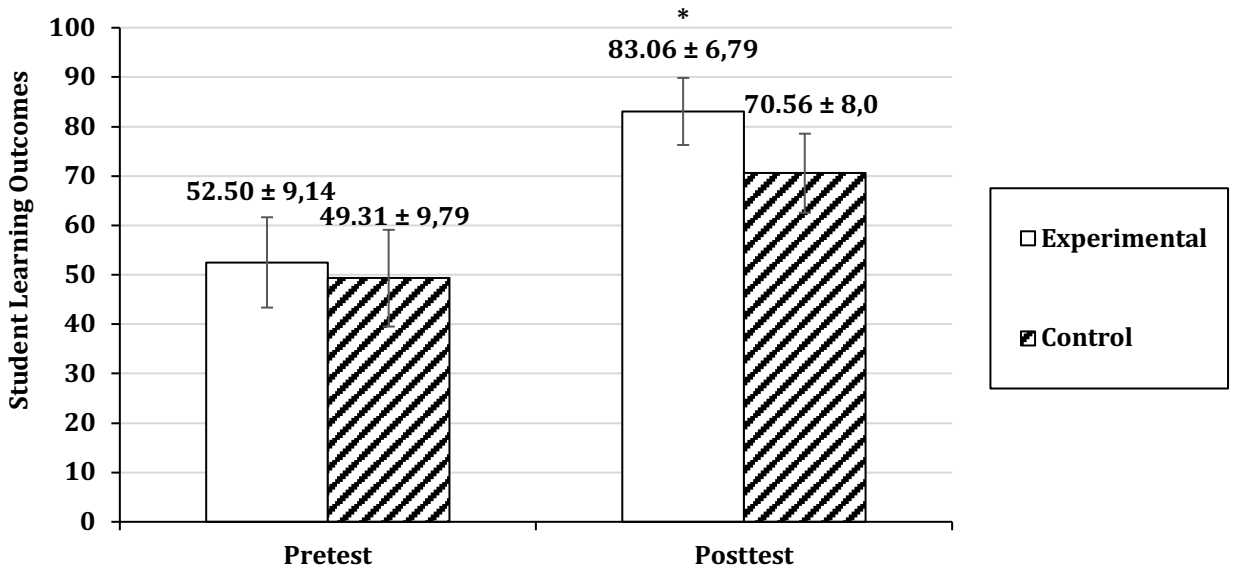

Figure 4. The Effect of the TGT Learning Model with Crossword Puzzle-Based E-student worksheet on Students' Learning Outcomes.

Based on Figure 4, the final results of students' cognitive learning outcomes showed differences between the experimental and control classes. The independent sample t-test obtained p = 0.000 < 0.05, indicating a significant difference. The experimental class achieved an average post-test score of 83.06 (SD = 6.79), while the control class only achieved an average score of 70.56 (SD = 8.00). These findings indicate that Ha is accepted, meaning that the TGT model with CP-based E-student worksheet had a significant effect on improving students' cognitive learning outcomes.

The results of descriptive analysis show that the average learning outcomes of students in the experimental class using the TGT model were higher than those in the control class using the Direct Instruction model. Siregar (2024) states that the factors that influence student learning outcomes are divided into two categories, namely internal factors and external factors. Internal factors include two main aspects, namely psychological and physical. The psychological aspect includes students' cognitive, affective, psychomotor, and personality abilities. Meanwhile, external or social factors include family conditions, the role of teachers and their teaching methods, the surrounding environment, and the learning opportunities available to students. Thus, the learning model and teaching methods used by teachers can affect student learning outcomes. Teachers who only teach using methods that are not interesting will make students bored and affect their learning outcomes.

The results of the hypothesis test using an independent sample T-test show that there is a significant difference in student learning outcomes in the experimental class that applies the TGT model compared to the control class that uses the Direct Instruction model after the learning process is completed. Thus, it can be concluded that the application of the TGT learning model affects student learning outcomes. This is in line with Widyastuti et al. (2023) and Liantri et al. (2024), whose research explains that the use of the TGT learning model can improve student learning outcomes. The game and tournament elements in the TGT model attract students' attention and challenge them to win for their team, which makes them more eager to learn. The tournament pattern in TGT can encourage students to discuss, compete, and apply their knowledge more deeply so that they can contribute to their team (Matitaputty et al. 2023). The game also combines CP-based E-student worksheet media, which makes students interested in answering questions, thereby improving their understanding of difficult vocabulary and even helping them to remember it. Tejeswini et al. (2024) and Titisari & Pratiwi (2021) Crossword puzzles are useful in encouraging fun active learning and help in solving problems as well as helping in better remembering and understanding of concepts. The Benefits Crossword puzzles train patience, help students understand concepts, solve problems, work with friends, and develop students' motor and cognitive skills.

This study has limitations, such as some students still having difficulty understanding the concept of ecosystems, the short research period, and the limited media to with CP-based E-student worksheet. With additional guidance and discussion facilitation, student learning outcomes improved significantly through the TGT model with CP-based E-student worksheet**.** These findings support constructivist theory that competitive and collaborative activities facilitate understanding and can be the basis for developing varied learning tools. Further research is recommended with a longer time frame, interactive digital media, and application at different grade levels.

CONCLUSION

The implementation of the TGT learning model with CP-based E-student worksheet had a positive influence on students' learning activity, learning interest, and cognitive learning outcomes in the ecosystem topic among 10th-grade students. Teachers, as learning designers, are encouraged to apply this model as a student-centered learning strategy to improve the quality of biology learning. In addition, teachers can utilize similar interactive media to create a more engaging and collaborative learning process.

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have been tested for validity and are suitable for use as data collection tools.

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