Bioscientist: Jurnal Ilmiah Biologi
https://e-journal.undikma.ac.id/index.php/bioscientist

June 2026 Vol. 14, No. 2
e-ISSN: 2654-4571
pp. 945-957

The Effect of the Jigsaw Cooperative Learning Model on Students' Learning Outcomes in Ecology and Biodiversity

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Received: April 2026; Revised: May 2026; Accepted: June 2026; Published: June 2026

Abstract: This study aimed to analyze the effect of the Jigsaw cooperative learning model on students' learning outcomes in Ecology and Biodiversity among seventh-grade students at MTsN 1 Labuhanbatu. A quantitative approach was employed using a quasi-experimental design with a pretest-posttest control group. The sample consisted of 64 students from two classes: Class VII-I as the experimental group and Class VII-F as the control group, selected through cluster random sampling. Data were collected using a validated and reliable multiple-choice achievement test. Data analysis involved prerequisite testing and hypothesis testing using SPSS version 25. The results showed that the mean posttest score of the experimental group was 80.62, which was higher than that of the control group, with a mean score of 59.87. The hypothesis test indicated that the Jigsaw cooperative learning model significantly improved students' learning outcomes in Ecology and Biodiversity compared with conventional teaching methods, as indicated by Sig. (2-tailed) = 0.000 ($p < 0.05$). These findings suggest that students' engagement in home groups, expert groups, and peer-teaching activities contributed to improved conceptual understanding of Ecology and Biodiversity. This study implies that the Jigsaw cooperative learning model can serve as an alternative instructional strategy to enhance students' learning outcomes and active participation in science learning.
Keywords: Jigsaw cooperative learning; learning outcomes; ecology; biodiversity; science learning

How to Cite: Syarah, P. M., Dimenta, R. H., & Sari, N. F. (2026). The Effect of the Jigsaw Cooperative Learning Model on Students' Learning Outcomes in Ecology and Biodiversity. *Bioscientist: Jurnal Ilmiah Biologi*, *14*(2), 945–957. https://doi.org/10.33394/bioscientist.v14i2.20698

https://doi.org/10.33394/bioscientist.v14i2.20698

INTRODUCTION

Biology learning is not limited to the mastery of concepts; it also aims to develop students' critical thinking, communication, collaboration, and problem-solving skills through scientific reasoning processes (Faturrahman et al., 2023; Sahil et al., 2022; Deria et al., 2023). However, biology instruction in schools is still largely dominated by teacher-centered learning, which tends to reduce students' engagement in the learning process. Precious and Feyisetan (2020) reported that teacher-centered instruction results in significantly lower academic achievement than student-centered approaches. The dominance of this instructional approach causes students to receive information passively, leading to weak conceptual understanding and low learning outcomes (Siregar & Adlini, 2022; Hapsari et al., 2021). In addition, teacher-centered instruction limits students' opportunities to develop essential skills in biology. Ideally, biology learning should foster deep and contextual conceptual understanding (Winarso et al., 2023), enabling students to connect biological concepts with phenomena in everyday life.

This problem becomes more complex in the topics of Ecology and Biodiversity, as these topics require students to understand interrelated conceptual relationships. These include the influence of the environment on organisms in ecological contexts (Rinjani et al., 2022), interactions among ecosystem components (Kuroru & Rahmah, 2023), Indonesia's biodiversity in comparison with other regions of the world (Sari et al., 2023), the impacts of human activities on ecosystems, and efforts to conserve biodiversity (Karyanto et al., 2023; Rachmawati et al., 2020). Because these concepts are interconnected, students need learning experiences that help them integrate ecological and biodiversity concepts rather than memorize them separately. When instruction remains teacher-centered, students tend to experience difficulty connecting these concepts in a comprehensive and meaningful way (Firmansyah & Ramadhan, 2025).

Based on observations, interviews with science teachers, and documentation of daily test scores among seventh-grade students at MTsN 1 Labuhanbatu, the learning process was found to be dominated by conventional methods, with peer tutoring used only occasionally. The Jigsaw cooperative learning model had not previously been implemented in science instruction. In addition, approximately 60% of students had not achieved the school's Minimum Mastery Criterion (Kriteria Ketuntasan Minimal, KKM), which was set at 80. These findings indicate that students' engagement and learning outcomes in science need to be improved through the implementation of a more student-centered learning model. Thus, an instructional approach that encourages active participation, peer interaction, and shared responsibility for learning is needed to address this classroom problem.

One instructional model with the potential to address these problems is the Jigsaw cooperative learning model (Ramadhanti et al., 2025; Rezki, 2024; Halawa et al., 2022). This model places students at the center of the learning process through activities in home groups and expert groups, in which each student is responsible for learning specific material and explaining it to other group members (Syafitri, 2024; Wang, 2021). The characteristics of Ecology and Biodiversity, which consist of several interconnected subtopics, make this material suitable for implementation through the Jigsaw model. Each subtopic can be studied in depth by expert groups and then shared with home groups through discussion and information exchange. This structure enables students to develop both individual accountability and collective understanding, as each member contributes essential information to the group's overall comprehension. Therefore, the Jigsaw model allows students to develop a more comprehensive understanding of the conceptual relationships within the learning material.

Theoretically, the Jigsaw cooperative learning model is expected to improve students' learning outcomes because it promotes individual responsibility, peer interaction, and activities in which students explain material to one another. These activities help students understand concepts more deeply than instruction that relies solely on teacher-centered delivery. Moreover, group discussion and information exchange during the learning process allow students to construct understanding through social interaction and direct learning experiences. In this context, peer explanation is particularly important because students are required not only to receive information but also to reorganize, clarify, and communicate their understanding to others.

Previous studies have shown that the Jigsaw cooperative learning model can improve students' conceptual understanding through discussion and information exchange within groups (Harefa et al., 2022). In addition, Hikma et al. (2023), Nurhasanah (2025), and Rizki (2019) reported that the implementation of the Jigsaw model can develop students' communication and collaboration skills during the learning process. These findings are supported by Rahmi et al. (2023), who stated that group discussion in the Jigsaw model encourages students to become more actively involved in understanding learning material. Furthermore, Istihawa et al. (2024) found that the Jigsaw model increases student engagement during instruction. Similarly, Aeni et al. (2025), Zada et al. (2025), and Yuneva (2024) reported that the implementation of the Jigsaw learning model has a significant effect on students' learning outcomes in science learning. Collectively, these studies indicate that Jigsaw learning has strong potential to improve student engagement, communication, collaboration, and academic achievement.

Although previous studies have demonstrated that the Jigsaw cooperative learning model can improve student activity and learning outcomes, most of these studies were conducted at different educational levels or with different subject matter. Empirical evidence regarding the effectiveness of the Jigsaw cooperative learning model in teaching Ecology and Biodiversity at the Islamic junior secondary school level remains limited, particularly in classrooms where students demonstrate low mastery of interconnected ecological and biodiversity concepts. In fact, this material requires instruction that encourages discussion, information exchange, and collaborative conceptual understanding. Therefore, this study was conducted to provide empirical evidence regarding the effect of the Jigsaw cooperative learning model on students' learning outcomes in Ecology and Biodiversity at the Islamic junior secondary school level.

Based on the preceding discussion, this study aimed to analyze the effect of the Jigsaw cooperative learning model on students' learning outcomes in Ecology and Biodiversity among seventh-grade students at MTsN 1 Labuhanbatu. The Jigsaw model is expected to improve learning outcomes by fostering individual responsibility, peer interaction, and reciprocal explanation activities that help deepen students' conceptual understanding. The novelty of this study lies in its specific focus on the application of the Jigsaw cooperative learning model to Ecology and Biodiversity material in a madrasah tsanawiyah context, where students' initial mastery and classroom participation remain key instructional challenges. The findings of this study are expected to provide empirical contributions to the development of cooperative biology learning and serve as a reference for teachers in selecting appropriate instructional strategies to enhance student engagement and learning outcomes.

METHOD

This study employed a quantitative approach using a quasi-experimental research design. A quantitative approach was selected because the study aimed to examine the causal relationship between the independent and dependent variables through objective and systematic measurement (Creswell, 2014; Sugiyono, 2019). The research design used was a pretest–posttest control group design involving two groups, as presented in Table 1.

Table 1. Pretest–posttest control group design

Group	Pretest	Treatment	Posttest
Experimental group	O_1	X_1	O_2
Control group	O_3	X_2	O_4

Notes:
O_1 = Pretest of the experimental group
O_2 = Posttest of the experimental group
O_3 = Pretest of the control group
O_4 = Posttest of the control group
X_1 = Treatment using the Jigsaw cooperative learning model
X_2 = Treatment using conventional learning

The population of this study comprised all seventh-grade students at MTsN 1 Labuhanbatu, consisting of 11 classes with a total of 350 students. The sample was selected using cluster random sampling because the sampling process was conducted based on existing class groups rather than individual students (Sugiyono, 2019). The random selection process assigned Class VII-I as the experimental group and Class VII-F as the control group. Each class consisted of 32 students; therefore, the total sample comprised 64 students. The selection of these two classes also considered the equivalence of students' academic abilities based on preliminary observations and recommendations from the science teacher.

Data were collected using an achievement test administered before the treatment, as a pretest, and after the treatment, as a posttest. The research instrument was a cognitive multiple-choice test on Ecology and Biodiversity. The instrument was developed based on learning outcomes and material indicators, including levels of biodiversity, interactions among ecosystem components, the effects of human activities on ecosystems, and biodiversity conservation. The test blueprint was prepared according to the learning indicators derived from the learning outcomes for Ecology and Biodiversity.

The instrument was designed to measure students' cognitive abilities based on the Revised Bloom's Taxonomy at the levels of C1, remembering; C2, understanding; C3, applying; and C4, analyzing. Before being used in the study, the instrument underwent validity, reliability, difficulty level, and discrimination index testing to ensure its quality. The distribution of indicators, cognitive levels, number of items, and sample questions used in the study is presented in Table 2.

Table 2. Distribution of test items based on material, indicators, cognitive level, number of items, and sample questions

No.	Material	Indicator	Cognitive Level	Number of Items	Sample Question
1	Levels of Biodiversity	Identifying genetic, species, and ecosystem diversity	C2–C3	8	Among the following living organisms, which has the smallest number of genes? A. bacteria; B. rabbit; C. cat; D. fungus
2	Interactions among Ecosystem Components	Analyzing relationships among living organisms in an ecosystem	C2–C4	10	The reciprocal relationship between living organisms and their environment is referred to as: A. ecosystem; B. community; C. ecology; D. population
3	Human Effects on Ecosystems	Analyzing the impacts of human activities on the environment	C2–C3	4	Renewable natural resources have the following characteristics, except: A. they can be developed; B. they can be depleted; C. they are easy to cultivate; D. they can be replenished easily
4	Biodiversity Conservation	Identifying threats to and conservation efforts for biodiversity	C2–C3	6	Biodiversity will decline rapidly and directly when the following occurs: A. superior seeds are planted in monoculture; B. invasion by exotic species; C. habitat loss and fragmentation; D. global climate change

At the initial stage, the research instrument consisted of 40 multiple-choice items developed based on the learning indicators for Ecology and Biodiversity. Before being administered in the main study, the instrument was piloted with eighth-grade students at MTsN 1 Labuhanbatu who had previously studied the material. Eighth-grade students were selected as the pilot participants because they had already received instruction on the assessed content and were therefore considered able to provide appropriate responses for evaluating the quality of the instrument. In addition, the students involved in the pilot test were not part of the research sample, thereby minimizing potential bias in the main study.

The pilot test data were analyzed using SPSS to examine the empirical validity of each item through the Pearson Product–Moment correlation between item scores and total scores. The validity test was conducted to ensure that each item accurately measured the intended construct. In addition, item difficulty and discrimination index analyses were performed to evaluate the quality of each test item.

The analysis showed that, of the 40 items piloted, 25 items met the validity criteria based on the empirical validity test. Meanwhile, the remaining 15 items did not meet the established criteria and were therefore excluded from the study. Thus, 25 items were declared appropriate for use as the research instrument to measure students' learning outcomes in Ecology and Biodiversity.

The research data were then analyzed using SPSS version 25. The analysis began with prerequisite tests, including normality and homogeneity tests. The normality test was conducted on the pretest and posttest data from both the experimental and control groups using the Shapiro–Wilk test at a significance level of 0.05. The data were considered normally distributed when the significance value, Sig., was greater than 0.05, whereas a significance value of Sig. ≤ 0.05 indicated that the data were not normally distributed (Zulfa et al., 2023).

The homogeneity of variance was subsequently tested using Levene's test on the pretest and posttest data to determine whether the variances of the experimental and control groups were equal. The decision criterion was based on the significance value: the data were considered homogeneous when Sig. > 0.05 and non-homogeneous when Sig. ≤ 0.05. After the assumptions of normality and homogeneity were met, hypothesis testing was conducted using an independent samples t-test to determine whether there was a significant difference in students' learning outcomes between the class taught using the Jigsaw cooperative learning model and the class taught using conventional learning on Ecology and Biodiversity. The statistical hypotheses tested in this study were as follows:

$\mathbf{H_0: \mu_e = \mu_k}$

$\mathbf{H_1: \mu_e \neq \mu_k}$

Notes:

μ_e = the mean learning outcome score of students in the experimental class taught using the Jigsaw cooperative learning model.

μ_k = the mean learning outcome score of students in the control class taught using conventional learning.

The null hypothesis, H_0, states that there is no difference in the mean learning outcomes between students in the experimental and control groups. Conversely, the alternative hypothesis, H_1, states that there is a difference in the mean learning outcomes between students in the experimental and control groups. The decision criterion for hypothesis testing was based on the significance value: if Sig. > 0.05, H_0 was accepted, whereas if Sig. ≤ 0.05, H_1 was accepted (Sudjana, 2014).

RESULTS AND DISCUSSION

The study began with the administration of a pretest to both sample groups. The experimental class then received instruction according to the research design, whereas the control class participated in conventional learning activities. After all instructional activities had been completed, both groups were administered the same posttest. The learning outcome test data were analyzed, and the results are presented as follows.

Normality Test

The normality test was conducted to determine whether the research data were normally distributed. In this study, the normality test was performed using SPSS version 23. The data were considered normally distributed when the significance value was greater than 0.05. The results of the normality test are presented in Table 3.

Table 3. Normality test

Class	Shapiro–Wilk Statistic	df	Sig.	Description
Pretest Class A (Control)	0.941	32	0.082	Sig. > 0.05
Posttest Class A (Control)	0.946	32	0.110	Normal
Pretest Class B (Experimental)	0.945	32	0.103	Normal
Posttest Class B (Experimental)	0.948	32	0.130	Normal

As shown in Table 3, the significance values for the experimental class were 0.103 for the pretest and 0.130 for the posttest, both of which were greater than 0.05. Similarly, the significance values for the control class were 0.082 for the pretest and 0.110 for the posttest, also exceeding 0.05. Therefore, all data sets in this study met the assumption of normality.

Homogeneity Test

The homogeneity test was conducted to determine whether the variances of the control and experimental classes were equal. The test was performed using Levene's test with IBM SPSS version 23 at a significance level of 0.05. The results are presented in Tables 4.

Table 4. Homogeneity test results for pretest and posttest data

Data	Levene Statistic	df1	df2	Sig.	Description
Pretest	6.112	1	62	0.016	Not homogeneous
Posttest	1.238	1	62	0.270	Homogeneous

Based on Table 4, the homogeneity test showed that the pretest data had a Levene statistic of 6.112 with a significance value of 0.016. Since this value was below 0.05, the pretest variances between the experimental and control classes were not homogeneous, indicating differences in the variability of students' initial abilities across the two groups. In contrast, the posttest data showed a Levene statistic of 1.238 with a significance value of 0.270. Because this value exceeded 0.05, the posttest variances were homogeneous.

These results indicate that the posttest data met the homogeneity assumption required for parametric analysis. Therefore, the analysis was continued using an Independent Samples t-test to determine whether the Jigsaw cooperative learning model had a significant effect on the learning outcomes of seventh-grade students at MTsN 1 Labuhanbatu in Ecology and Biodiversity. The results of the hypothesis test are presented in Table 5.

Table 5. Hypothesis test

Class	F	Sig.	t	df	Sig.
Learning outcomes	1.238	0.270	-6.206	62	0.000

Based on the Independent Samples t-test results presented in Table 5, the significance value of Levene's test was 0.270, which was greater than 0.05. This indicates that the variances between the experimental and control classes were homogeneous. Therefore, the interpretation of the hypothesis test was based on the equal variances assumed output. The test yielded a t-value of -6.206 with 62 degrees of freedom and a two-tailed significance value of 0.000. Since the significance value was lower than 0.05, H_0 was rejected and H_1 was accepted. Accordingly, there was a statistically significant difference in students' learning outcomes between the experimental and control classes.

Table 6. Percentage of learning outcomes in the control class

No.	Score	Category	Pretest		Posttest	
			∑ Students	Percentage	∑ Students	Percentage
1	>80	Achieved mastery	0	0%	5	15.63%
2	<80	Did not achieve mastery	32	100%	27	84.37%
Total			32	100%	32	100%
Mean			32.125		59.875	

As shown in Table 6, the pretest results in the control class, which received conventional instruction through lectures and question-and-answer activities, indicated that no students reached the minimum mastery criterion, which was set at 80. All students scored below the mastery criterion and therefore had not achieved learning mastery. The mean pretest score was 32.13, indicating that students' initial understanding of Ecology and Biodiversity was still low before instruction was implemented.

The posttest results showed an improvement in learning outcomes after students participated in conventional instruction. A total of five students, or 15.63%, achieved learning mastery, whereas 27 students, or 84.37%, remained in the non-mastery category. The mean posttest score also increased to 59.88. Although this result indicates improvement compared with the pretest, the mean posttest score remained below the established minimum mastery criterion.

The comparison between pretest and posttest scores shows that learning outcomes in the control class improved after instruction. The mean score increased from 32.13 in the pretest to 59.88 in the posttest, representing an increase of 27.75 points. In addition, the percentage of students who achieved learning mastery increased from 0% to 15.63%. Nevertheless, most students still did not meet the minimum mastery criterion by the end of the learning process. These findings suggest that conventional instruction through lectures and question-and-answer activities can improve students' learning outcomes, but the improvement was not optimal because most students remained in the non-mastery category.

Table 7. Percentage of learning outcomes in the experimental class

No.	Score	Category	Pretest		Posttest	
			∑ Students	Percentage	∑ Students	Percentage
1	>80	Achieved mastery	0	0%	19	59.38%

No.	Score	Category	Pretest		Posttest	
			∑ Students	Percentage	∑ Students	Percentage
2	<80	Did not achieve mastery	32	100%	13	40.62%
Total			32	100%	32	100%
Mean			47.78125		80.625	

As presented in Table 7, the pretest results showed that all students in the experimental class had not yet reached the minimum mastery criterion of 80. Of the 32 students who took the test, none achieved learning mastery, while all students were categorized as not having achieved mastery. These results indicate that students' initial understanding of Ecology and Biodiversity was still relatively low before the implementation of the Jigsaw cooperative learning model.

After instruction was conducted using the Jigsaw cooperative learning model, the posttest results showed an increase in students' learning mastery. A total of 19 students, or 59.38%, achieved the minimum mastery criterion, whereas 13 students, or 40.62%, remained in the non-mastery category. The increased proportion of students who achieved mastery indicates an improvement in learning outcomes following the implementation of the Jigsaw cooperative learning model.

The improvement in learning outcomes was also reflected in students' scores. The mean pretest score was 47.78125, equivalent to 47.78% of the maximum score, while the mean posttest score increased to 80.625, equivalent to 80.63% of the maximum score. Thus, the mean score increased by 32.84375 points, or 32.84%. These results indicate that the implementation of the Jigsaw cooperative learning model improved students' learning outcomes in Ecology and Biodiversity. This finding was further supported by the hypothesis test, which demonstrated a statistically significant difference between the learning outcomes of students in the experimental and control classes.

Overall, the findings indicate that the Jigsaw cooperative learning model had a positive effect on students' learning outcomes in Ecology and Biodiversity among seventh-grade students at MTsN 1 Labuhanbatu. This effect was reflected in the greater increase in the mean learning outcome score of the experimental class compared with the control class after the learning process. The results suggest that the Jigsaw model created a more active and student-centered learning environment, thereby improving students' conceptual understanding. This finding is consistent with Halawa et al. (2022), who reported that cooperative learning can increase students' learning interest, classroom activity, and understanding of the material through group collaboration. Similarly, Aulia et al. (2025) found that the implementation of the Jigsaw cooperative learning model significantly improved students' motivation and learning outcomes. The similarity between these previous findings and the present study lies in the increased student engagement during the learning process, particularly through group discussion, information exchange, and the presentation of discussion results to peers.

The findings of this study are also supported by Wulandari et al. (2023), who stated that the Jigsaw model is a potential instructional alternative for enhancing student collaboration, communication, and enthusiasm during learning. Nurhasanah (2025) further explained that social skills, such as communication, contribute to the creation of a more conducive learning environment, enabling students to understand the material more easily. However, the present findings differ from several previous studies that reported relatively even student participation across all stages of learning. In this study, some students were less active in asking questions and tended to be reluctant to express their opinions, particularly during the material review stage and group presentation activities. This difference may have been influenced by student characteristics, variation in initial ability, levels of self-confidence, and limited prior experience with cooperative learning (Moin et al., 2024). These findings indicate that the effectiveness of the Jigsaw model is determined not only by instructional design but also by students' internal factors and the extent to which the learning environment supports active participation.

The improvement in students' learning outcomes in this study can be explained through the learning mechanisms embedded in the Jigsaw cooperative learning model (Juwita et al., 2025). According to Dewanti (2020), the initial stage of implementing the Jigsaw cooperative learning model involves forming heterogeneous home groups. The formation of diverse groups enables interaction and collaboration among students, allowing them to exchange information, express opinions, and assist peers who experience difficulty understanding the material. Through these interactions, students have opportunities to learn together and support one another during the learning process. This condition increases student engagement from the beginning of instruction and creates a more active and collaborative learning atmosphere (Dhani et al., 2023).

Students then join expert groups according to the assigned subtopics. At this stage, students discuss the material in greater depth with peers who are responsible for the same topic. According to Harahap et al. (2022), expert groups provide students with opportunities to study subtopics more intensively through discussion and information exchange with peers who have similar learning responsibilities. Through these activities, students can clarify concepts they do not yet understand, support one another in mastering the material, and deepen their conceptual understanding before returning to their home groups to explain the topic. This finding is consistent with Alkaromi (2022), who stated that interaction and collaboration in Jigsaw groups contribute to improved material comprehension and student achievement.

In the final stage, groups draw conclusions from the discussion, and the teacher reinforces the key concepts that have been learned. This stage helps students integrate various concepts so that their understanding becomes more comprehensive. Through discussion, peer teaching, and individual responsibility in explaining the material, the Jigsaw model promotes deeper and more meaningful conceptual understanding and contributes to improved learning outcomes (Harahap et al., 2022; Hasibuan et al., 2020).

In the context of Ecology and Biodiversity, the implementation of the Jigsaw model helped students understand the relationships among the concepts studied. Through discussion and information exchange, students not only learned concepts separately but also connected the relationships between biotic and abiotic components, interactions within ecosystems, the impacts of human activities on the environment, and the importance of biodiversity conservation (Kartika et al., 2023). This process made learning more meaningful, enabling students to develop deeper and more memorable conceptual understanding.

The successful implementation of the Jigsaw model in this study was evident in the increased student participation during learning activities. Students became more active in discussions, more willing to express opinions, and demonstrated better collaboration skills than students in the control class. These findings indicate that the Jigsaw model not only contributes to improved learning outcomes but also has the potential to support the development of communication skills, collaboration, and responsibility within groups. Overall, the improvement in students' learning outcomes occurred because each stage of the Jigsaw model provided opportunities for students to learn actively, engage in discussion, exchange information, and re-explain the material they had studied. These processes helped students understand Ecology and Biodiversity concepts more deeply than conventional instruction.

CONCLUSION

Based on the findings, the Jigsaw cooperative learning model had a significant effect on students' learning outcomes in Ecology and Biodiversity among Grade VII students at MTsN 1 Labuhanbatu. The hypothesis test showed a significance value (Sig. 2-tailed) of 0.000 ($p < 0.05$), indicating that H_0 was rejected and H_1 was accepted. The mean learning outcome score of the experimental class was 80.62, which was higher than that of the control class, which obtained a mean score of 59.87. These results indicate that the implementation of the Jigsaw model produced better learning outcomes than conventional instruction. The findings further suggest that the Jigsaw model encouraged students to engage actively in discussions, collaborate with peers, and re-explain learning materials to their group members, thereby supporting a deeper understanding of Ecology and Biodiversity concepts.

RECOMMENDATION

Based on the findings, science teachers are encouraged to implement the Jigsaw cooperative learning model as an alternative instructional strategy to enhance students' active participation, collaboration, and learning outcomes, particularly in Ecology and Biodiversity topics. Schools are also expected to support the implementation of this model by providing adequate learning facilities. Future researchers are advised to involve larger samples and incorporate additional variables to obtain more comprehensive research findings.

ACKNOWLEDGMENT

The authors would like to express their sincere appreciation to the Biology Education Study Program, Faculty of Teacher Training and Education, Universitas Labuhanbatu, for the academic support and facilities provided throughout the research process. Appreciation is also extended to MTsN 1 Labuhanbatu, particularly the science teacher and all participating students, for their active involvement and valuable contribution in providing the data required for this study. The authors also gratefully acknowledge the supervisors for their guidance, scientific direction, and constructive feedback during the preparation of this research.

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