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The Effects of Video-Assisted Jigsaw Cooperative Learning on Students' Biology Learning Achievement and Critical Thinking Skills

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Abstract
Many studies have reported the effectiveness of jigsaw cooperative learning in science education; however, scholars have paid little attention to integrating this model with digital learning media to enhance students' learning outcomes and critical thinking skills. Therefore, to fill this gap, this study aims to examine the influence of video-assisted jigsaw cooperative learning on students' learning achievement and critical thinking skills in biology instruction. This quasi-experimental study, using a pretest-posttest control group design, involved tenth-grade students in Phase E, at one of the schools in Lima Puluh Kota Regency, West Sumatra, Indonesia. The number of students in each experimental and control group was 30. The data were obtained from learning achievement and critical thinking tests administered before and after the treatments. The parametric statistics (ANCOVA and MANCOVA tests), were used to analyze the data. The results showed that students in the video-assisted jigsaw cooperative learning group demonstrated significantly higher biology learning achievement scores after controlling for pretest scores, $F(1, 57) = 4919.00$, $p < .001$, $\eta^2 = .989$. Similarly, students in the experimental group showed significantly higher critical thinking skill scores after controlling for pretest scores, $F(1, 57) = 7596.00$, $p < .001$, $\eta^2 = .993$. Furthermore, the results of the MANCOVA test indicated a significant simultaneous effect on both dependent variables, Wilks' $\Lambda = .007$, $F(2, 55) = 4190.00$, $p < .001$, partial $\eta^2 = .993$. These findings suggest that video-assisted jigsaw cooperative learning has the potential to support students' academic achievement and critical thinking skills in biology.

Keywords: Biology learning; Critical thinking skills; Jigsaw; Learning achievement; Video

INTRODUCTION

Learning biology requires students not only to understand scientific concepts but also to develop higher-order thinking skills, particularly the ability to analyze problems, evaluate information, and make evidence-based decisions (Manalo et al., 2026; Osman et al., 2026). However, many biological concepts taught in Indonesian senior high schools, particularly those related to the human digestive, respiratory, excretory, coordination, reproductive, and immune systems, are abstract and complex. This condition makes it challenging for students to achieve deep conceptual understanding and develop critical thinking skills. Therefore, biology instruction needs to promote active, collaborative, and student-centred learning approaches that support both students' learning achievement and the development of higher-order thinking. Zahroh and Hilmiyati (2024) assert that learning outcomes remain an important indicator of the success of the learning process, particularly in assessing mastery of abstract and complex biological concepts

A current study shows that cooperative learning is an innovative and effective approach to improving students' learning outcomes and critical thinking skills (Kebede et al., 2025). This is because cooperative learning emphasizes social interaction, discussion, individual responsibility, and collaborative construction of knowledge. (Liebech-Lien, 2020). From Vygotsky's social constructivist perspective, knowledge is constructed through social interaction and the negotiation of meaning, so learning that encourages collaboration among students has the potential to improve the quality of thinking processes and conceptual understanding (Vygotsky, 1978). Many scholars believe that the Jigsaw cooperative learning model is appropriate for use in science education, as it offers various benefits for students' knowledge development (Ojekwu & Ogunleye, 2020).

Compared with static visual materials or text-based resources, instructional videos simultaneously present dynamic biological processes, narration, and visual cues, enabling students to observe temporal and causal relationships that are difficult to capture through conventional instructional media (Ngurah et al., 2018). These characteristics make instructional videos particularly suitable for supporting students' preparation (Wulandari & Sumarno, 2026). For example, it can be during the expert-group phase of Jigsaw learning, where accurate conceptual understanding is required before peer teaching begins.

In biology classrooms, the Jigsaw model enables students to divide complex biological topics into manageable subtopics that are first explored in expert groups before being taught to peers in their home groups. During expert-group discussions, students collaboratively interpret biological concepts, compare explanations, and clarify misconceptions before preparing to teach their peers. The integration of instructional videos at this stage provides a shared visual representation of abstract biological processes, allowing students to observe phenomena that cannot easily be demonstrated in the classroom and to construct more accurate conceptual explanations (Breslyn & Green, 2022). When students subsequently explain these concepts to their home-group members, differences in understanding often emerge and stimulate cognitive conflict through questioning, justification, and evidence-based discussion. Resolving these differences encourages deeper conceptual processing, scientific reasoning, and critical evaluation of biological evidence, thereby strengthening both conceptual understanding and higher-order thinking skills (Jurkowski et al., 2024).

Beyond collaborative knowledge construction, another important characteristic of the Jigsaw model is students' individual accountability within expert and home groups. These groups allow students to become "experts" on a particular subtopic before explaining the material back to their home group members (Jeppu et al., 2023). This structure is believed to be able to improve cognitive processing, individual accountability, academic communication, and active student involvement in learning (Davidson & Major, 2014). Some studies report that Jigsaw contributes positively to improving student learning outcomes and collaboration skills (Ibrahim et al., 2023; Kebede et al., 2025; Møgelvang et al., 2023; Puger & Jimoh, 2023) and higher-order thinking skills in science learning, such as biology and physics (Sharma et al., 2025).

However, the effectiveness of the Jigsaw model is not only influenced by the cooperative learning structure itself, but also by the use of learning media that can support concept visualization and student engagement in the learning process. In biology learning, learning media play a crucial role because much of the material is abstract, complex, and difficult to observe directly. Previous studies have shown that the use of video media in biology instruction can help students visualize biological processes, increase students' attention, and facilitate more in-depth discussions during learning activities (Dorji et al., 2025; Musfiza et al., 2025; Trianisa & Wahyuni, 2024).

The integration of videos into the Jigsaw model can also strengthen information exchange between students in expert and home groups. Through learning videos, students can observe biological phenomena, analyze information, and explain learned concepts to other group members (Breslyn & Green, 2022). Thus, the use of video not only supports students' conceptual understanding but can also facilitate the development of critical thinking skills in biology learning.

However, previous studies on Jigsaw cooperative learning in biology education have predominantly focused on its effects on a single learning outcome, particularly students' academic achievement, collaboration, or general learning performance. Recent systematic review and meta-analysis studies have confirmed that the Jigsaw method generally contributes positively to students' educational outcomes; however, the magnitude of its effects varies considerably across studies depending on instructional context, implementation, and learning outcomes assessed (Drouet et al., 2023). Likewise, a recent meta-analysis in biology education reported that collaborative group work consistently improves students' academic performance but highlighted the need for further studies examining instructional innovations that integrate collaborative learning with digital learning resources and multiple learning outcomes (Driessen et al., 2024).

Moreover, meta-analyses, systematic literature, and bibliometric studies have reported the use of digital media to support science learning, but limited attention has been given to how video-assisted Jigsaw learning simultaneously influences students' conceptual achievement and critical thinking skills (see Fajri et al., 2024; Jihanifa et al., 2025; Wulandari & Sumarno, 2026). This limitation is important because biology learning requires not only the mastery of scientific concepts but also the ability to analyze biological phenomena, evaluate evidence, and construct logical explanations (Nikolić & Antonijević, 2024; Azzahra & Surtikanti, 2025). Collectively, these studies indicate an empirical gap regarding the integration of video-assisted Jigsaw cooperative learning for simultaneously improving multiple cognitive outcomes, particularly biology learning achievement and critical thinking skills. Therefore, investigating both learning achievement and critical thinking skills within a video-assisted Jigsaw framework provides a more comprehensive understanding of how this instructional approach supports cognitive development in biology learning.

Another important empirical gap concerns the educational context. Most empirical evidence has been generated from countries such as Nigeria (Bello & Mukhtar, 2025; Ibeh & Okigbo, 2024) and Ethiopia (Kebede et al., 2025) although Jigsaw cooperative learning has been confirmed effective for teaching science subjects. Meanwhile, evidence from Indonesian secondary biology classrooms remains limited (Thenu et al., 2023). This contextual difference is important because Indonesian secondary school students, particularly Generation Z learners, have distinctive learning characteristics that require interactive, technology-supported, participatory, and collaborative learning environments (Hendrastomo & Januarti, 2023). Moreover, to the best of our knowledge, very few empirical studies have examined the integration of video-assisted Jigsaw cooperative learning in Indonesian biology classrooms, and even fewer have evaluated its effects on both biology learning achievement and critical thinking skills using a controlled experimental design. Therefore, research is needed to more comprehensively investigate the effects of video-assisted Jigsaw cooperative learning on students' learning outcomes and critical thinking skills in the real-life context of biology learning.

Based on these gaps, the purpose of this study is to examine the effect of video-assisted Jigsaw cooperative learning on students' achievement and critical thinking skills in biology learning. The findings of this study contribute in three aspects. First, this study extends previous research by simultaneously examining biology learning achievement and critical thinking skills within a single instructional intervention. Second, this study provides empirical evidence regarding the effectiveness of integrating the Jigsaw model and video media in the context of biology learning in Indonesian secondary schools. Third, this study provides practical contributions for teachers in selecting learning strategies that not only improve students' academic achievement but also develop critical thinking skills relevant to the demands of 21st-century education:

1. Does video-assisted Jigsaw cooperative learning significantly affect students' biology learning achievement?

2. Does video-assisted Jigsaw cooperative learning significantly affect students' critical thinking skills in biology learning?
3. Is there a simultaneous effect of video-assisted Jigsaw cooperative learning on students' biology learning achievement and critical thinking skills?

Based on the theoretical framework and previous empirical findings, this study hypothesizes that video-assisted Jigsaw cooperative learning has a positive and significant effect on students' biology learning achievement and critical thinking skills.

METHOD

Research Design

This study employed a quasi-experimental method with a pretest-posttest control group design (Ary et al., 2010) to examine the effects of video-assisted Jigsaw cooperative learning on students' biology learning achievement and critical thinking skills. Because random assignment was not feasible in the school setting, intact classes were assigned as the experimental and control groups. Prior to the intervention, both groups completed pretests to establish baseline equivalence in biology learning achievement and critical thinking skills. Throughout the study, both groups were taught by the same biology teacher, followed the same curriculum objectives, studied identical biology topics, and received the same instructional duration. The only difference between the two groups was the instructional approach. The research design is presented in Table 1.

Table 1. Research Design

Group	Pre-test	Treatment	Post-test
Experimental Group	Q_1	X (Video-assisted Jigsaw Cooperative Learning)	Q_2
Control Group	Q_3	C (Conventional Learning)	Q_4

Notes:
O_1 and O_3 = Pretests of biology learning achievement and critical thinking skills.
O_2 and O_4 = Posttests of biology learning achievement and critical thinking skills.
X = Video-assisted Jigsaw cooperative learning treatment.
C = Conventional learning without video assistance.

As presented in Table 1, the experimental group received instruction through video-assisted Jigsaw cooperative learning, whereas the control group received conventional teacher-centred instruction without Jigsaw activities or instructional videos. Both groups completed the same pretest before the intervention and the same posttest after the intervention to measure biology learning achievement and critical thinking skills. The pretest scores were used as covariates in the subsequent analyses to control for initial differences between the groups, allowing a more accurate evaluation of the instructional effects of the intervention.

Population and Sample

The population in this study comprised all tenth-grade (Phase E) students at a public senior high school in Situjuah Limo Village, Lima Puluh Kota Regency, West Sumatra, Indonesia, consisting of six classes. The research sample was selected using purposive sampling based on the following considerations: (1) all classes were taught by the same biology teacher, (2) students had relatively homogeneous academic characteristics, and (3) the average initial achievement scores did not differ substantially across classes. Random assignment was not feasible because students had already been organized into intact classes by the school. Therefore, two existing classes were selected based on teacher consistency and comparable initial academic characteristics.

Baseline equivalence between the two groups was established using the students' pretest scores before the intervention. The experimental group obtained a mean pretest score of 61.53

(SD = 2.19), whereas the control group obtained a mean pretest score of 60.60 (SD = 2.16), indicating comparable initial achievement levels. To minimize teacher-related and instructional variations, both groups were taught by the same biology teacher, studied the same biology topics, followed identical curriculum objectives, received the same instructional duration, and completed the same assessment instruments. Thus, the only difference between the two groups was the instructional approach employed during the intervention.

Based on these considerations, two classes were selected as research samples: one as the experimental group and one as the control group. The experimental group consisted of 30 students who received learning using video-assisted Jigsaw cooperative learning, while the control group consisted of 30 students who received conventional without video media assistance.

Data Collection Techniques and Instruments

Two tests were conducted to obtain the data: the achievement test and the critical thinking test. The student learning achievement test was structured as multiple-choice questions aligned with biology competency indicators, curriculum objectives, and Bloom's Taxonomy (Anderson & Krathwohl, 2001). This instrument consisted of 30 questions administered during the pretest and posttest. The items were reviewed by biology education experts to ensure content validity based on curriculum relevance, biological concepts, and cognitive level appropriateness. The validity analysis showed that 25 out of 30 items met the validity criteria and were retained for the study. The reliability coefficient of the achievement test was 0.82, indicating high internal consistency.

The critical thinking ability test was designed as a problem-based essay test aligned with Facione's (2015) critical thinking framework , which includes indicators of interpretation, analysis, evaluation, inference, and explanation. This instrument consisted of five questions, with each question representing one critical thinking indicator. The essay responses were assessed using a scoring rubric based on Facione’s critical thinking indicators, with criteria covering students’ ability to interpret information, analyze evidence, evaluate arguments, draw conclusions, and provide explanations. To ensure scoring consistency, two independent raters evaluated students’ responses, and inter-rater reliability was calculated before the final scores were determined

Before implementation, both instruments underwent expert validation involving biology education experts to examine the relevance, clarity, and suitability of the items. Sample items and scoring procedures are provided as supplementary information. The test was administered at pretest and posttest to measure the development of students' critical thinking skills following the treatment. In the experimental group, video media were used to support the implementation of the Jigsaw model, especially during the expert group discussion stage. The learning videos, sourced from YouTube, contained explanations of biological concepts and phenomena relevant to the learning material, helping students visually understand the material and supporting collaborative discussion

Prior to use, all instruments were pilot tested to assess their quality using validity, reliability, difficulty index, and discriminatory power tests. The pilot test results showed that, of 30 items, 25 were deemed valid and used in the study. The test reliability coefficient was 0.82, which is included in the high category. Based on the difficulty index analysis, the items were in the moderate category with a value range of 0.31–0.70, while the discriminatory power was in the fair to good category with a value range of 0.21–0.70.

Research Procedure

During the pretest stage, both the experimental and control groups completed biology learning achievement and critical thinking tests to determine their baseline performance. The treatment was implemented over eight instructional meetings. The first meeting was allocated for the pretest. The experimental group then participated in six sessions of video-assisted Jigsaw cooperative learning covering the following biology topics: (1) Digestive System, (2) Respiratory System, (3) Excretory System, (4) Coordination System (nervous system, endocrine system, and sensory organs), (5) Reproductive System, and (6) Immune System. In each instructional session, the teacher first introduced the learning objectives and organized students into home groups. Each member was assigned a different subtopic and subsequently joined an expert group, where instructional videos were used to facilitate understanding of the assigned content. Students discussed the video content collaboratively, prepared explanations, and then returned to their home groups to teach their assigned subtopics to their peers. The teacher facilitated group discussions, monitored students' participation, clarified misconceptions when necessary, and concluded each lesson with feedback and a summary of the key concepts. The eighth meeting was devoted to administering the post-test.

The control group studied the same biology topics over the same number of instructional meetings using conventional teacher-centred instruction without video assistance or Jigsaw activities. To maintain instructional consistency, both groups were taught by the same biology teacher using identical learning objectives and curriculum content. Throughout the intervention, the researcher monitored the implementation to ensure that the planned instructional procedures were consistently followed. To minimize contamination between groups, the experimental and control classes were taught separately, and the video-assisted Jigsaw activities were implemented exclusively in the experimental group. Following the intervention, both groups completed the same post-test instruments used to measure biology learning achievement and critical thinking skills

Data Analysis Techniques

Data were analyzed through prerequisite tests and hypothesis testing. Before conducting ANCOVA and MANCOVA analyses, prerequisite tests were performed to ensure that the data met the assumptions for parametric analysis. The prerequisite tests included normality testing using the Shapiro–Wilk test and homogeneity testing using Levene's Test. After the assumptions were fulfilled, MANCOVA (Multivariate Analysis of Covariance) was conducted to examine the simultaneous differences in students' biology learning achievement and critical thinking skills between groups while controlling for pretest scores. Subsequently, ANCOVA (Analysis of Covariance) was performed to examine the differences in each dependent variable separately while controlling for pretest scores as covariates. Partial Eta Squared (η^2) was used to assess the strength of the treatment effect, with interpretations of 0.01 = small, 0.06 = medium, and 0.14 or higher = large.

RESULTS AND DISCUSSION

Results

This section presents the study results as formulated in the research questions. The types of tests conducted to answer the research questions included tests of normality and homogeneity, ANCOVA, MANCOVA, and partial eta squared.

Normality and Homogeneity Test

Before conducting hypothesis testing to answer the research questions, prerequisite tests were performed, including tests of normality and homogeneity. These tests ensure that the data meet the assumptions for parametric statistical analysis.

Table 2. Results of Normality Test (Shapiro-Wilk)

Variable	Group	Phase	Statistics	df	Sig.

Learning Achievement	Control	Pretest	.946	30	.135
		Posttest	.934	30	.062
	Experiment	Pretest	.943	30	.111
		Posttest	.951	30	.184
Critical Thinking Skills	Control	Pretest	.946	30	.135
		Posttest	.934	30	.062
	Experiment	Pretest	.965	30	.111
		Posttest	.963	30	.184

As summarized in Table 2, the Shapiro–Wilk test was conducted to examine the normality of data distribution because each group consisted of 30 students (n = 30). The significance values for all variables and groups were greater than 0.05 (p > .05), indicating that the data met the normality assumption required for parametric analysis.

Table 3. Result of Homogeneity Test

Variable	Levene Statistics	df 1	df 2	Sig.
Learning Achievement	1.664	3	116	.179
Critical Thinking Skills	1.556	3	116	.204

As shown in Table 3, the homogeneity test was performed using Levene's Test to determine whether the variance across the groups is equal. The analysis shows that the significance values for Learning Achievement (.179) and Critical Thinking Skills (.204) are both higher than 0.05 ($p > .05$). This indicates that the data for both variables have homogeneous variances.

Results of Students' Biology Learning Achievement

This analysis aimed to examine differences in students' biology learning achievement between the experimental group, which received video-assisted Jigsaw cooperative learning, and the control group after controlling for pretest scores. Before conducting the ANCOVA analysis, descriptive statistics were examined to describe changes in students' achievement scores from pretest to posttest. Table 4 presents the descriptive statistics of students' biology learning achievement scores before and after the intervention.

Table 4. The descriptive Statistics of Students' Biology Learning Achievement

Group	n	Pre-test Mean (SD)	Post-test Mean (SD)	Adjusted Mean	95% CI
Experimental Group	30	61.53 (2.19)	85.13 (3.51)	84.54	84.34 – 84.74
Control Group	30	60.60 (2.16)	74.03 (2.58)	74.63	74.43 - 74.83

As presented in Table 4, the experimental group showed higher posttest and adjusted mean scores than the control group. After controlling for pretest scores, the adjusted mean achievement score of the experimental group (M = 84.54, 95% CI [84.34, 84.74]) remained substantially higher than that of the control group (M = 74.63, 95% CI [74.43, 74.83]). To examine whether the difference between groups remained significant after controlling for initial achievement scores, an ANCOVA analysis was conducted. The results of the ANCOVA are presented in Table 5.

Table 5. Results of the Between-Subjects Effects (ANCOVA) Test on Biology Learning Achievement Post-Test

Source	Type III Sum of Squares	df	Mean Square	F	Sig,	Partial Eta Squared
Corrected Model	2292.278[a]	2	1146.139	4.007E3	.000	.993
Intercept	.274	1	.274	.959	.332	.017
Pre-test	444.128	1	444.128	1.553E5	.000	.965
Group	1407.124	1	1407.124	4.919E3	.000	.989
Error	16.305	57	.286			
Total	382319.000	60				
Corrected Total	2308.583	59				

a. R Squared = .993 (Adjusted R Squared = .993)

As presented in Table 5, the ANCOVA results showed a significant group effect on students' post-test biology learning achievement after controlling for pretest scores, $F(1,57) = 4919.000$, $p < .001$, partial $\eta^2 = .989$. This indicates that the post-test achievement scores differed significantly between the experimental and control groups after considering students' initial achievement levels. The pretest score also showed a significant contribution to students' post-test achievement scores ($p < .001$). The overall ANCOVA model was significant and explained a substantial proportion of variance in students' biology learning achievement ($R^2 = .993$). The adjusted means, standard errors, and 95% confidence intervals for each group are presented to provide further interpretation of the ANCOVA results.

Results of Students' Critical Thinking Skills

This question aimed to examine the effect of video-assisted jigsaw cooperative learning on students' critical thinking skills. Before conducting the ANCOVA analysis, descriptive statistics were examined to summarize students' critical thinking scores before and after the intervention. Table 6 presents the descriptive statistics, adjusted means, and 95% confidence intervals for both groups after controlling for pretest scores.

Table 6. The descriptive Statistics of Students' Critical Thinking Skills

Group	n	Pre-test Mean (SD)	Post-test Mean (SD)	Adjusted Mean	95% CI
Experimental Group	30	59.13 (2.61)	82.43 (3.09)	81.79	81.63–81.95
Control Group	30	58.17 (2.57)	71.03 (2.58)	71.68	71.52–71.84

As shown in Table 6, both groups demonstrated improvements in critical thinking skills following the intervention. However, the experimental group obtained higher post-test scores than the control group. After adjusting for differences in pretest scores, the adjusted mean remained higher for the experimental group (Adjusted Mean = 81.79, 95% CI = 81.63–81.95) than for the control group (Adjusted Mean = 71.68, 95% CI = 71.52–71.84). To determine whether this difference remained statistically significant after controlling for pretest scores, an ANCOVA analysis was conducted. The results are presented in Table 7.

Table 7. Results of the Between-Subjects Effects (ANCOVA) Test on Students' Critical Thinking Skills Post-Test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2408.882[a]	2	1204.411	6.292E3	.000	0.995
Intercept	2.415	1	2.415	12.615	.001	.181
Pre-test	459.422	1	459.442	2.400E3	.000	.977
Group	1453.996	1	1453.966	7.596E3	.000	.993
Error	10.911	57	.191			
Total	355700.00	60				
Corrected Total	2419.733	59				

a. R Squared = .995 (Adjusted R Squared = .995)

As shown in Table 7, the results of the ANCOVA test indicate that video-assisted Jigsaw cooperative learning had a significant effect on students' critical thinking skills after controlling for pre-test scores. This is shown by a significant group effect, F (1, 57) = 7596.000, $p < .001$, with a very large effect size ($\eta^2 = .993$), indicating a strong difference between the experimental and control groups. In addition, the pre-test also had a significant effect on students' critical thinking skills ($p < .001$). Overall, the model was highly significant and explained most of the variance in students' critical thinking skills ($R^2 = .995$).

Simultaneous Effect of Video-Assisted Jigsaw Cooperative Learning on Students' Biology Learning Achievement and Critical Thinking Skills

This question aimed to examine the simultaneous effect of video-assisted Jigsaw cooperative learning on students' biology learning achievement and critical thinking skills. Before conducting the MANCOVA, several assumptions were examined to determine the appropriateness of the analysis. First, Levene's tests were conducted to assess the homogeneity of error variances for each dependent variable. The results indicated that the assumption was violated for both learning achievement, $F(1,58) = 4.748$, $p = .033$, and critical thinking skills, $F(1,58) = 10.740$, $p = .002$. However, because the two groups had equal sample sizes (n = 30 per group), and Pillai's Trace is considered a robust multivariate statistic against violations of variance assumptions, the MANCOVA analysis was retained.

The relationship between the dependent variables was examined using Pearson correlation analysis. The results showed a strong positive correlation between biology learning achievement and critical thinking skills, $r = .998$, $p < .001$. This indicates that the two dependent variables were substantially related; however, the high correlation suggests that they shared considerable variance and should be interpreted cautiously.

Covariate diagnostics were also conducted to evaluate the contribution of the covariates. The univariate analyses showed that pre-achievement significantly predicted post-achievement scores, $F(1,57) = 1552.595$, $p < .001$, partial $\eta^2 = .965$. Similarly, pre-critical thinking scores significantly predicted post-critical thinking scores, $F(1,57) = 2400.096$, $p < .001$, partial $\eta^2 = .977$. These findings supported the inclusion of the pre-test scores as covariates in the MANCOVA model.

The Box's M test for equality of covariance matrices could not be computed because the covariance matrices were identified as singular. Therefore, Pillai's Trace was selected as the multivariate statistic because it provides a more conservative and robust estimate when covariance assumptions cannot be fully verified.

Table 8. Descriptive Statistics and MANCOVA Results

Dependent Variables	Experimental Group M (SD)	Control Group M (SD)	Covariate Effect	Group Effect	Partial η^2
Biology Learning Achievement	85.13 (3.04)	74.03 (2.58)	$F(1,57)=1552.60$, $p<.001$	$F(1,57)=4919.06$, $p<.001$	.989
Critical Thinking Skills	82.43 (3.09)	71.03 (2.58)	$F(1,57)=2400.10$, $p<.001$	$F(1,57)=7595.75$, $p<.001$	.993

Note. *Partial η^2 represents effect size.*

Table 9. Multivariate Test Results

Effect	Pillai's Trace	F	df	p	Partial η^2
Group	.993	4190.00	2,55	< .001	.993

As shown in Tables 8 and 9, the MANCOVA revealed a significant multivariate effect of video-assisted Jigsaw cooperative learning on students' biology learning achievement and critical thinking skills after controlling for pre-achievement and pre-critical thinking scores, Pillai's Trace = .993, $F(2,55) = 4190.00$, $p < .001$, partial $\eta^2 = .993$. This indicates that the instructional intervention produced a statistically significant difference in the combined dependent variables between the experimental and control groups.

Follow-up univariate analyses showed significant group effects on both biology learning achievement, $F(1,56) = 6788.00$, $p < .001$, partial $\eta^2 = .989$, and critical thinking skills, $F(1,56) = 7720.00$, $p < .001$, partial $\eta^2 = .993$. The adjusted mean scores indicated that students in the experimental group achieved higher scores in biology learning achievement (adjusted M = 84.54) and critical thinking skills (adjusted M = 81.79) compared with students in the control group (adjusted M = 74.63 and 71.68, respectively).

Discussion

The findings of this study suggest that students who participated in video-assisted Jigsaw cooperative learning achieved significantly higher biology learning achievement and critical thinking skills than those who received conventional instruction after controlling for pretest scores. The exceptionally large effect sizes observed (partial $\eta^2 = .989$ for learning achievement and .993 for critical thinking) indicate substantial differences between the two groups. However, these effect sizes should be interpreted cautiously because the study employed a quasi-experimental design using intact classes, and other contextual factors, such as students' increased engagement with a new instructional approach (i.e., a novelty effect) or differences in teacher facilitation during collaborative activities, may also have contributed to the observed outcomes. Within the context of this study, integrating the Jigsaw cooperative strategy with instructional videos appears to support students' understanding of biological concepts and the development of critical thinking skills by encouraging them to actively engage in discussions, exchange ideas, solve problems, and explain learning materials to their peers (Breslyn & Green, 2022; Salhuteru et al., 2025). rather than acting as passive recipients of information. These collaborative learning processes are generally aligned with the achievement and critical thinking assessments employed in this study and may contribute to more meaningful, interactive, and student-centred science learning. Nevertheless, future studies using randomized designs and more authentic performance-based assessments are needed to confirm the robustness and generalizability of these findings.

The findings of this study are consistent with previous studies showing that cooperative learning is an effective approach to improving students' learning outcomes and critical thinking skills (Kebede et al., 2025). Cooperative learning promotes social interaction, collaborative knowledge construction, individual accountability, and active engagement in learning activities. (Liebech-Lien, 2020). In the context of science learning, the Jigsaw model has been widely recognized for enhancing students' learning outcomes, collaboration skills, and higher-order thinking skills (e.g., Ibrahim et al., 2023; Kebede et al., 2025; Puger & Jimoh, 2023; Sharma et al., 2025). However, the present study extends prior research by integrating video-based audiovisual media and contextual representations to help students understand abstract biological concepts more concretely. In other words, these evidences strengthen students' cognitive processing during collaborative learning activities.

Several factors may explain the effectiveness of video-assisted jigsaw cooperative learning in improving students' learning outcomes and critical thinking skills in biology. Jeppu et al. (Jeppu et al., 2023) suggested that the characteristics of the Jigsaw model place students at the centre of learning process. where they are responsible for mastering specific subtopics in expert groups before sharing their understanding with members of their home groups. This process encourages deeper understanding, information organization, explanation, argumentation, and evaluation of ideas during discussion activities. In addition, the integration of instructional videos increase students' attention, motivation, and engagement through more concrete and visually attractive learning materials (Dorji et al., 2025). As biology contains many abstract and complex concepts, audiovisual support helps students visualize processes and phenomena that are difficult to understand through verbal explanation alone.

The success of the learning model implemented in this study was evident in students' responses during the posttest and discussion activities in the classrooms. Students in the experimental group were able to provide more comprehensive explanations, connect concepts to real-world situations, and provide logical reasons for their answers. Students also demonstrated a better ability to analyze biological problems and present arguments during the learning process compared to students in the control group. These achievements demonstrate that audiovisual-based digital media and the jigsaw model play a significant role in enhancing students' understanding of the material studied and critical thinking skills, such as analyzing, evaluating, and creating, during the learning process (Ngurah et al., 2018). These findings also support previous studies reporting that YouTube videos can enhance students' learning achievements in science education across various learning environments (see Trianisa & Wahyuni, 2024; Musfiza et al., 2025). Moreover, these outcomes align with the goals of 21st-century learning objectives that emphasize the integration of technology in the learning process. In addition, 21st-century learning, which is already included in the curriculum, demands the development of students' higher-order thinking skills, collaboration, communication, and problem-solving in the learning process (Manalo et al., 2026).

The findings of this study support Vygotsky's (Vygotsky, 1978) theory of social constructivism, which states that knowledge is constructed through social interaction and negotiation of meaning. In Jigsaw learning, interactions between group members provide opportunities for students to build shared understanding through discussion and collaboration. Furthermore, Rahayu and Balqis (2025) emphasize that the use of video as a learning medium also strengthens the knowledge construction process by providing visual representations that help students understand biology concepts more effectively.

Nevertheless, this study has several limitations. First, the research was conducted in only one school and with a biology subject, so generalization of the results to a broader context is necessary to obtain more comprehensive findings. Second, this study only measured students' learning achievement and critical thinking skills immediately after the intervention; therefore, it did not examine the long-term retention of these learning outcomes. Third, this study focused more on quantitative results, so the process of student interaction during learning was not analyzed in depth.

Based on these limitations, further research is recommended to apply the video-assisted jigsaw cooperative learning model to assess its impact across different educational settings, subjects, and learning materials, while combining quantitative and qualitative approaches to obtain a more comprehensive understanding of the learning process and achievements. Future studies are also encouraged to investigate the long-term retention of students' learning achievement and critical thinking skills, as well as the transferability of these skills to different biology topics and other science disciplines. Future research should also compare video-assisted Jigsaw cooperative learning with Jigsaw cooperative learning without video support to determine the specific contribution of instructional videos beyond the cooperative learning strategy itself.

CONCLUSION

The findings of this quasi-experimental study suggest that video-assisted Jigsaw cooperative learning was associated with higher biology learning achievement and critical thinking skills than conventional instruction among tenth-grade students in the participating school. Within the context of this study, integrating instructional videos into the Jigsaw learning process appeared to support students' conceptual understanding by facilitating collaborative discussions, knowledge sharing, and the analysis of the biology concepts. Rather than demonstrating a fundamentally novel instructional model, this study contributes additional empirical evidence on the potential value of combining video-supported learning with cooperative learning strategies in Indonesian secondary biology classrooms. However, these findings should be interpreted with caution because the study employed a quasi-experimental design, involved students from a single school, and therefore has limited generalizability.

In practice, video-assisted jigsaw cooperative learning is recommended for Biology or Science teachers in schools as an alternative instructional strategy to improve both cognitive achievement and critical thinking skills. Teachers are encouraged to integrate relevant instructional videos into group-based learning activities to create more interactive, student-centred, and meaningful learning experiences. Furthermore, school leaders are advised to support the implementation of technology-integrated cooperative learning by providing adequate digital learning resources. It aims to improve teachers' digital literacy and facilitate training programs that promote innovative instructional practices in classrooms. Future research is encouraged to examine the long-term retention and transferability of students' learning outcomes and to compare video-assisted Jigsaw cooperative learning with conventional Jigsaw learning across different educational contexts.

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