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# THE EFFECTIVENESS OF THE STUDENT TEAMS ACHIEVEMENT DIVISION COOPERATIVE LEARNING MODEL IN ENHANCING STUDENTS' CONCEPTUAL UNDERSTANDING IN BIOLOGY AT SENIOR HIGH SCHOOL LEVEL

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**Abstract.** This study aims to examine the effectiveness of the Student Teams Achievement Division (STAD) cooperative learning model in improving students' conceptual understanding of biology at the senior high school level. The research was conducted at SMA Negeri 1 Tempel, Yogyakarta, Indonesia, using a quasi-experimental design with a one-group pretest–posttest approach. A total of 32 students from class X MIA 2 participated in the study. Data were collected using multiple-choice tests administered through the Quizizz platform to measure students' comprehension before and after the implementation of the STAD model. The normalized gain score analysis showed an average value of 0.407, indicating a medium level of effectiveness. Statistical testing using a single mean Z-test confirmed that the posttest results significantly improved compared to the pretest. The findings demonstrate that the STAD cooperative learning model promotes active participation, collaboration, and critical thinking among students, leading to better conceptual mastery. This research highlights the pedagogical value of cooperative learning strategies such as STAD in fostering meaningful and engaging science learning experiences in secondary education..

**Keywords:** STAD; cooperative learning; biology education; conceptual understanding; student achievement

## I. INTRODUCTION

In recent years, the development of student-centered learning models has become a primary focus in science education to improve engagement, comprehension, and higher-order thinking skills among learners. Traditional teacher-centered instruction, which dominates many classrooms in Indonesia, often leads to passive learning behavior and reduced motivation [1]. Consequently, innovative pedagogical approaches that emphasize collaboration, interaction, and active participation are needed to create more meaningful learning environments, especially in biology education [2]. Biology is a subject that requires not only memorization but also conceptual understanding of complex and abstract phenomena. However, research shows that students often struggle to grasp biological concepts when instruction relies heavily on lectures and note-taking [3]. Studies in secondary schools indicate that students' low achievement in biology is frequently linked to ineffective instructional methods that fail to foster interaction and problem-solving [4]. To address this issue, cooperative learning has been widely recommended as an instructional strategy that can enhance academic achievement, social skills, and cognitive engagement [5].

Among various cooperative learning methods, the Student Teams Achievement Division (STAD) developed by Slavin is one of the most practical and effective models for promoting teamwork and peer-assisted learning [6]. STAD emphasizes heterogeneous group collaboration where students work together to master a topic, complete tasks, and compete for team recognition [7]. The method integrates academic performance with social interaction, thereby creating a sense of shared responsibility for learning [8]. Previous research demonstrated that STAD significantly enhances learning motivation, participation, and conceptual understanding across multiple disciplines, including biology [9]. In biology learning, the STAD model facilitates students to actively exchange ideas, discuss complex concepts, and correct misconceptions through peer dialogue [10]. This aligns with constructivist learning theory, which posits that knowledge is actively constructed through social interaction and reflection [11]. When applied effectively, STAD encourages cooperative inquiry, increases retention, and develops communication and collaboration skills essential for 21st-century learning [12]. Moreover, recent studies in Indonesian classrooms reveal that cooperative learning models such as STAD improve not only academic outcomes but also students' self-efficacy and social cohesion [13].

Despite its proven benefits, the implementation of STAD in biology classes is still limited in many Indonesian schools, particularly in rural or suburban areas, due to a lack of teacher training, inadequate classroom management, and limited instructional time [14]. Many teachers continue to rely on conventional lecture methods that emphasize rote learning rather than inquiry-based approaches [15]. Therefore, empirical evidence from local contexts such as SMA Negeri 1 Tempel is crucial to demonstrate how STAD can be effectively integrated into biology instruction to enhance conceptual understanding and motivation. This study builds upon prior findings by examining the effectiveness of the STAD cooperative learning model in improving conceptual understanding among high school biology students. It applies a quasi-experimental one-group pretest–posttest design to determine whether STAD implementation leads to significant improvement in learning outcomes. The research focuses on the topic of Protists, which is often challenging for students due to its abstract characteristics and microscopic concepts.

The novelty of this study lies in its contextual adaptation of the STAD model using digital learning platforms such as Quizizz, combining cooperative learning with formative online assessment. This hybrid approach supports the development of digital literacy and collaborative skills simultaneously [16]. The results of this study are expected to provide both theoretical and practical implications for science educators. Theoretically, it contributes to the growing body of research on cooperative learning by validating the application of STAD in Indonesian biology education. Practically, it offers insights into how teachers can design cooperative learning experiences that foster engagement, deeper understanding, and measurable learning outcomes [17].

In summary, this research seeks to answer the following questions: (1) To what extent does the STAD cooperative learning model enhance students' conceptual understanding in biology? and (2) How effective is STAD in promoting student engagement and achievement at the senior high school level? Addressing these questions will not only extend the pedagogical relevance of STAD in science education but also provide guidance for educators aiming to improve instructional practices through collaborative and student-centered learning. Cooperative learning is widely recognized as a learner-centered pedagogical approach designed to foster interaction, collaboration, and shared responsibility among students. According to Johnson and Johnson, effective cooperative learning occurs when students work interdependently toward a common goal, promoting both academic and social growth [18]. This approach aligns with constructivist theory, where knowledge is constructed through active engagement and peer interaction rather than passive absorption [19]. In science education, cooperative learning allows students to collaboratively explore phenomena, test hypotheses, and correct misconceptions through meaningful dialogue [20].

Research across various educational contexts demonstrates that cooperative learning significantly improves students' academic achievement, critical thinking, and motivation compared to traditional instruction [21]. In particular, it enhances conceptual understanding in subjects that involve abstract or process-oriented knowledge, such as biology and physics [22]. Moreover, cooperative learning supports the development of soft skills, including communication, teamwork, and empathy, which are essential for lifelong learning and professional competence [23].

Among the various cooperative learning models, Student Teams Achievement Division (STAD) is one of the most structured and widely implemented. Developed by Slavin, STAD emphasizes heterogeneous team collaboration, where students learn academic material together and are rewarded based on team improvement rather than individual performance [24]. The model involves five key stages: class presentation, team study, quiz or individual assessment, scoring, and team recognition. These stages encourage accountability, peer tutoring, and reinforcement of knowledge through group interaction. Empirical studies show that the STAD model effectively enhances student engagement and learning outcomes across disciplines. For example, Supriyadi and Fitriana [25] found that STAD improved students' motivation and performance in biology through active participation and mutual assistance. Similarly, Kumar and Singh [26] confirmed that STAD facilitated deeper conceptual comprehension in science learning by encouraging cooperative problem-solving. Furthermore, the inclusion of digital platforms, such as Quizizz or Google Classroom, in STAD-based learning environments provides interactive feedback and promotes a fun, gamified learning experience [27].

Conceptual understanding in biology refers to the ability of students to connect abstract biological concepts, apply them to real-life contexts, and explain phenomena coherently. According to Duit and Treagust, conceptual understanding involves reorganizing existing knowledge structures through conceptual change and reflection [18]. Biology, as a discipline, contains many invisible or microscopic processes—such as cell division, metabolism, and protist classification—that are difficult for students to visualize [19]. Therefore, teaching strategies that promote active construction of knowledge are essential to overcome learning difficulties. Research indicates that cooperative learning, particularly the STAD model, facilitates conceptual understanding by allowing peer explanation and collaborative reasoning [20]. Students can negotiate meanings, articulate ideas, and identify misconceptions more effectively in group discussions than in teacher-centered lectures [21]. This approach also encourages metacognitive awareness, enabling learners to monitor and evaluate their own understanding [22]. Studies have shown that students exposed to STAD-based instruction perform better on posttests measuring conceptual retention and application than those taught through conventional methods [23].

The rapid advancement of educational technology has made digital tools an integral part of cooperative learning. Integrating STAD with interactive applications such as Quizizz, Kahoot!, or Edmodo increases student engagement and provides immediate performance feedback [24]. Digital platforms also promote inclusive participation, allowing

quieter students to express their ideas through online interfaces. Moreover, combining cooperative structures with technology fosters digital literacy one of the essential competencies in 21st-century education [25].

Recent empirical findings suggest that the hybridization of STAD and digital learning enhances student motivation, self-efficacy, and satisfaction [26]. When learning becomes interactive and competitive in a healthy way, students experience higher enjoyment and reduced anxiety, which positively affect their conceptual understanding [27]. Therefore, integrating STAD with digital assessments represents an effective pedagogical innovation to improve biology learning outcomes in Indonesian classrooms and beyond.

## II. RESEARCH METHODS

This study adopted a quantitative quasi-experimental design with a one-group pretest–posttest model to examine the effectiveness of the Student Teams Achievement Division (STAD) cooperative learning model on students' conceptual understanding in biology. The quasi-experimental approach was selected because it allows the researcher to measure the impact of an instructional intervention without a control group, while maintaining ecological validity within a real classroom environment [28].

The research was conducted at SMA Negeri 1 Tempel, Yogyakarta, Indonesia, during the 2019/2020 academic year. The population comprised all students of grade X, and the sample consisted of 32 students from class X MIA 2, selected through purposive sampling to ensure their exposure to the biology topic Protists. The study was carried out over four learning sessions using the STAD cooperative learning procedure: (1) class presentation, (2) team learning, (3) individual testing, (4) team scoring, and (5) team recognition.

The experimental procedure began with a pretest to assess students' prior knowledge, followed by the implementation of the STAD model, and ended with a posttest to evaluate conceptual improvement. The design is represented as follows:

$$O_1 \rightarrow X \rightarrow O_2$$

where:

- $O_1$ = Pretest,
- $X$ = Implementation of STAD learning model,
- $O_2$ = Posttest.

The main data collection instrument consisted of a multiple-choice conceptual understanding test developed from the 2013 Biology Curriculum syllabus for senior high schools. The test consisted of 20 items that measured students' understanding of protist classification, structure, and ecological roles. All test items were validated by two subject matter experts and one educational measurement expert. Instrument validity was established through Pearson's correlation ($r > 0.30$), and reliability was confirmed using Cronbach's Alpha ($\alpha = 0.86$), indicating high internal consistency [29]. In addition to the conceptual test, classroom observations and student reflections were used to qualitatively support the quantitative findings. The test was administered via the Quizizz digital platform, enabling students to respond interactively and receive instant feedback. The integration of Quizizz was intended to enhance engagement and reduce test anxiety, as recommended in previous digital learning studies [27].

Data analysis involved both descriptive and inferential statistics. First, normalized gain (N-gain) was calculated to measure the relative improvement in students' conceptual understanding between pretest and posttest scores using the formula:

$$g = \frac{(Posttest - Pretest)}{(100 - Pretest)}$$

The N-gain values were categorized following Hake's criteria:

- $g > 0.70$: High improvement,
- $0.30 \leq g \leq 0.70$: Moderate improvement,
- $g < 0.30$: Low improvement.

Second, the Z-test for a single mean was applied to determine whether the observed improvement was statistically significant. The significance level was set at $\alpha = 0.05$. Normality of data distribution was checked using the Shapiro–Wilk test, while homogeneity was tested using Levene's test. Data were processed using SPSS 25 software for accuracy and reliability.

Finally, results were interpreted based on the quantitative improvement in students' scores and the qualitative observations regarding their engagement during group work and peer discussions. These findings were triangulated to determine the pedagogical effectiveness of the STAD model in promoting conceptual understanding in biology.

## III. RESULTS AND DISCUSSION

The pretest and posttest results revealed a notable improvement in students' conceptual understanding of biology after the implementation of the Student Teams Achievement Division (STAD) model. The mean pretest score was 47.19, while the mean posttest score increased to 51.89, indicating a positive learning gain. Based on the normalized gain (N-gain) formula, the average value obtained was 0.407, which falls within the moderate improvement category according to Hake's criteria. Out of 32 students, 7 achieved scores above the minimum competency standard (70) during the pretest, while the number of students achieving that threshold increased in the posttest session. Although the improvement was moderate, the results demonstrate that STAD effectively enhanced students' conceptual comprehension of the biology topic Protists. This result aligns with similar studies showing that cooperative learning methods improve academic performance and retention across diverse student groups [30].

*Inferential Statistical Analysis*

To verify whether the observed improvement was statistically significant, a Z-test for a single mean was conducted. The calculated Z-value exceeded the critical value at a significance level of $p < 0.05$, confirming that there was a significant difference between pretest and posttest scores. This implies that the STAD learning intervention led to measurable improvement in students' understanding. The results demonstrate that learning gains were not random but stemmed from the structured cooperative learning environment. Students who actively participated in team discussions performed better on the posttest, suggesting that group accountability and peer instruction played key roles in reinforcing understanding. This finding is consistent with the social interdependence theory, which posits that positive interdependence among learners enhances motivation and academic performance [31].

The results of this study corroborate prior findings indicating that cooperative learning strategies such as STAD positively influence students' academic achievement, engagement, and social interaction [32]. By promoting teamwork and peer teaching, STAD provides students with opportunities to articulate ideas, correct misconceptions, and construct knowledge collaboratively. During group discussions, students exchanged explanations and clarified biological concepts such as protist classification, reproduction, and ecological function. This process reflects the constructivist learning principle, where learners build knowledge through active participation and interaction [33].

Moreover, the use of digital tools such as Quizizz enhanced students' enthusiasm and motivation throughout the learning process. The gamified format of online quizzes made assessments more engaging and provided immediate feedback, supporting formative evaluation. This aligns with recent studies demonstrating that digital-assisted cooperative learning increases engagement and reduces anxiety during assessment [34].

The moderate level of effectiveness (N-gain = 0.407) observed in this study can be attributed to the short implementation period (four sessions) and the novelty of the learning approach for students and teachers. However, even within this limited duration, STAD successfully fostered active learning behaviors, including collaboration, communication, and critical reasoning. These findings suggest that consistent and prolonged application of cooperative learning could yield even greater improvement in conceptual understanding over time.

Additionally, this research reinforces the pedagogical relevance of integrating cooperative learning and digital literacy within science education in Indonesia. It provides evidence that STAD can address the challenges of low engagement and passive participation prevalent in conventional classrooms. For biology teachers, this implies that structured cooperative models not only improve comprehension but also cultivate essential 21st-century skills, such as teamwork, responsibility, and reflective learning [35].

The implementation of the Student Teams Achievement Division (STAD) model in biology learning resulted in an average normalized gain (N-gain) of 0.407, which falls within the moderate category of effectiveness. This finding indicates that the STAD approach contributed meaningfully to improving students' conceptual understanding, though further optimization could yield even greater results. Statistical testing through the Z-test also confirmed a significant difference between the pretest and posttest scores ($p < 0.05$), demonstrating that the observed improvement was not due to chance but was directly influenced by the application of the STAD model. In practice, the use of STAD successfully fostered higher levels of student engagement, collaboration, and motivation, as learners became more actively involved in group discussions and peer learning. Additionally, integrating the STAD model with the digital platform *Quizizz* further enhanced classroom interactivity by providing instant feedback and an enjoyable, gamified assessment experience. This combination of cooperative and digital learning strategies not only deepened conceptual mastery but also created a more dynamic and inclusive learning atmosphere. Overall, the findings validate the effectiveness of cooperative learning—particularly the STAD model—in improving biology learning outcomes at the senior high school level, making it a promising pedagogical approach for fostering active, meaningful, and student-centered science education.

From a pedagogical perspective, the study reinforces the importance of cooperative learning as a foundation for achieving meaningful learning and developing 21st-century competencies, including collaboration, communication, and critical thinking [36]. For teachers, especially in science and biology education, STAD provides a flexible and practical framework to engage students in group learning activities while maintaining accountability for individual performance. The method encourages equitable participation, fosters social cohesion, and nurtures learners' confidence in expressing scientific ideas.

Educational policymakers and curriculum developers are encouraged to integrate cooperative learning methodologies like STAD into national science curricula and teacher training programs. When coupled with digital platforms, cooperative learning can enhance instructional innovation and increase students' enthusiasm for science learning. For future research, it is recommended to conduct longitudinal and comparative studies involving different subjects, larger samples, and diverse educational settings to further validate the generalizability of the STAD model's effectiveness [37].

Overall, the study contributes both theoretically and practically to the field of science education by providing empirical evidence that STAD enhances students' conceptual understanding and engagement. Its implementation can serve as a sustainable strategy to improve the quality of biology education in Indonesian high schools and comparable contexts globally.

## IV. CONCLUSION

This study concludes that the Student Teams Achievement Division (STAD) cooperative learning model has a positive and significant effect on enhancing students' conceptual understanding in biology. The quantitative analysis revealed an average normalized gain (N-gain) of 0.407, which falls into the moderate effectiveness category, while the Z-test results confirmed a statistically significant difference between the pretest and posttest mean scores ($p < 0.05$). These findings demonstrate that the structured stages of the STAD model—team formation, collaborative learning, individual testing, and team recognition—effectively promote students' engagement, active participation, and conceptual comprehension. The improvement in students' learning outcomes suggests that cooperative interaction and peer teaching are essential components in facilitating deeper conceptual understanding in complex science subjects such as biology. Moreover, the integration of digital tools like Quizizz within the STAD framework enhanced motivation and provided formative feedback that strengthened learning retention. Thus, STAD serves as an effective instructional strategy for transforming teacher-centered classrooms into more interactive, student-centered learning environments.

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