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The Effects of Team Games and Tournament Integrated with STEM 3D Audio-Visual Kit for Enhancing Collaboration Skills and Learning Outcomes

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Abstract: Collaboration is one of the essential skills that students must have in the global era. With collaboration skills, students can interact in groups and take responsibility for solving problems, impacting learning outcomes. However, integrating collaboration skills in learning still challenges teachers and students. Therefore, it is necessary to pilot innovative learning media to promote collaboration skills in learning activities. This study examined the impact of using STEM-based 3D audio-visual protein synthesis kit box learning media on collaboration skills and learning outcomes. The study was conducted on SMA Negeri 1 Tanggul students, Jember Regency, East Java. The study used a pre-test and post-test control group design. The experimental class was treated using the TGT learning model with STEM learning media, while the control class applied traditional learning. This study used two types of groups, namely large groups and small groups, which aimed to determine the effect of the number of members in the group on collaboration skills. Based on the one-way ANOVA test analysis in the control and experimental classes, the research results obtained a sig < 0.05 with the hypothesis Ha rejected, which means there is a difference in collaboration skills between students in large and small groups. The one-way ANOVA test analysis results in the control and experimental classes obtained a sig < 0.05 with the hypothesis H0 rejected, which means there is a difference in student learning outcomes.

Keywords: collaboration skills, learning outcomes, team games and tournaments (TGT).

▪ INTRODUCTION

Several vital skills need to be taught to students in line with the times. The advancement of science and technology in the 21st century necessitates that Indonesia equip its human resources to exhibit excellence in contributing to development (Ulfa et al., 2021). These skills include various abilities such as creativity, communication, critical thinking, and collaboration (Thornhill-Miller et al., 2023; Dilekçi & Karatay, 2023). Collaboration is one of the skills that is the focus of science learning today. Collaboration is a group learning process to discuss different views and knowledge. This activity involves discussion, where group members give each other advice, listen, and respect the various opinions that arise (Astuti et al., 2024; Le et al., 2018). Collaboration skills are critical to optimizing the learning process (Qureshi et al., 2023; Van Leeuwen & Janssen, 2019) because they can increase knowledge, social interaction, self-confidence, and motivation (Liao et al., 2019; Sari et al., 2023).

Collaboration between students can improve the learning process, help distribute tasks, encourage a sense of responsibility for the tasks given, and improve social skills. The research revealed that collaboration impacts learning processes and knowledge retention (Nurwahidah et al., 2021; Zambrano et al., 2019). In addition, learning that emphasizes collaboration has positive impacts, such as increasing the sense of responsibility, experience, creativity, and quality produced by group ideas (Dooley &

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Sexton-Finck, 2017). However, learning involving collaboration skills is still challenging for teachers and students (Hsu, 2018; Scager et al., 2020). Some research results also show that collaboration skills in the learning science process still need to be improved (Baser et al., 2017; Cravens et al., 2022; Ulhusna et al., 2020). The results of some of these studies suggest the implementation of innovative learning that facilitates collaborative activities.

The Team Games and Tournaments (TGT) model is a learning approach that can support STEM-based education because it is a type of cooperative learning where students work together in small groups. The TGT learning model encourages students to help each other complete the assigned tasks (Firdaus et al., 2020; Promwongsai & Poonputta, 2023). The TGT learning model is easy to implement and suitable for promoting collaboration abilities. It demonstrates group collaboration and leadership skills, responsibility for working productively with others, and respect for different perspectives. Erviani et al. (2022) state that the TGT-type cooperative learning model can improve collaboration skills by around 95%. That state also aligns with Nurhidayah (2018), which states that using the TGT model increases student learning outcomes. By applying innovative learning models, collaborative learning activities can facilitate interaction in constructing knowledge to improve learning outcomes.

The TGT learning model emphasizes student cooperation within groups. For the learning process to take place interactively, innovative learning media is needed to help students construct knowledge through an active learning process. It is well-suited for use alongside 3D box learning media, where students actively engage in learning and deepen their understanding of the material. According to Sari et al. (2024), the 3D learning media with the TGT learning model shows that student learning activities are increasing because of student interaction and mutual assistance based on participation and activities in the teaching and learning process. The 3D media presents information in a three-dimensional visual format without projection. This media can be natural objects, both living and dead, and imitations representing the original object (Siregar et al., 2022). According to Husnah et al. (2021), using the TGT learning model with 3D media increases student involvement, makes them more active, and does not feel bored during biology learning. The results of his research show the effect of 3D media with the use of the TGT learning model on student learning outcomes. Therefore, the 3D media in the TGT learning model needs to be tested to determine its impact on collaboration skills and learning outcomes.

Students must have collaboration skills to succeed in the modern era. These skills are not only crucial for learning, but they are also essential for solving problems (Fitriyani et al., 2019; Ilma et al., 2021). Moreover, collaboration skills must be developed because students must often work together in groups to prepare for the globalized era of the 21st century (Aini & Narulita, 2020). According to Sidi (2020), learning media can improve collaboration skills, achievement learning, and completeness. The implementation of the TGT learning model combined with innovative learning media is expected to have an impact on collaboration skills. The learning media tested in this study was the protein synthesis kit box 3D Audio-visual media based on Science, Technology, Engineering, and Mathematics (STEM). This STEM media kit includes work boards, codon table information paper, nitrogenous bases, DNA, mRNA, tRNA, DNA placement boxes, tRNA and amino acid placement boxes, RNA polymerase, ribosomes, RFID cards, and

audio. The media is specifically designed to facilitate students to learn about genetics with protein synthesis submaterial.

▪ METHOD

Participant

The population of this study was 142 class XII students from SMAN 2 Tanggul Jember, East Jawa. The research was conducted in two experimental classes (XII MIPA 4 and MIPA 6) and two control classes (XI MIPA 2 and MIPA 3). Each class was divided into a small group class and a large group class.

Research Design and Procedures

The research used a quasi-experimental method with a pretest-posttest control group design. The scheme of the study involving experimental and control classes is shown in Table 1. Research variables include independent variables and dependent variables. Independent variables include the TGT learning model with protein synthesis kit box 30 audio-visual learning media, while the dependent variables include collaboration skills and student learning outcomes.

Table 1. Research design

Pre-test	Treatment Group	Number of students	Post-test
PR_1	X	36	PO_1
PR_2	X	35	PO_2
PR_3	-	36	PO_3
PR_4	-	35	PO_4

Description:
X: media protein synthesis kit box 3D STEM-based audio-visual model
PR1: Pre-test of large group experimental class PO1: Post-test of large group experimental class
PR2: Pre-test of small group experimental class PO2: Post-test of small group experimental clas
PR3: Pre-test of large group control class PO3: Post-test of large group control class
PR4: Pre-test of small group control class PO4: Post-test of small group control class

The research has a control class and an experimental class, where each class is divided into small and large groups. The application of different numbers of group members aims to determine the effect of the number of group members on collaboration skills and student learning outcomes. The control class used the TGT learning model without 3D media during the learning process, while the experimental class used the TGT learning model and 3D media. Before being given treatment, the control and experimental classes first carried out a pre-test to determine the initial knowledge. Then, in the last week of the meeting, after being given treatment, the control and experimental classes carried out a final test (post-test) to determine student learning outcomes.

Research Instrument

The instruments used include 1) a questionnaire to determine collaboration skills and 2) a test to obtain student learning outcome data. The collaboration skills questionnaire developed in this study consists of self and peer assessments. The questionnaire in this study provides five categories: strongly agree, agree, sufficient, less agree, and strongly disagree. The questionnaire is objective, so students only put a tick

(√) on one of the answers they consider most appropriate to the situation. The questionnaire, assessed in Table 2, has ten aspects and 50 questions. The Google link form questionnaire was given at the end of each class meeting. Meanwhile, the learning outcomes test with 20 questions was conducted at the beginning of the pre-test and the post-test. The results of the up-validation of the collaboration skills questionnaire were declared valid, with an average value of 85% for self-assessment and 86.67% for peer assessment.

Table 2. The Assessment of collaboration skills aspects

Aspects of Skills	Statement of Commitment
Readiness	I discuss, prepare, and bring the necessary materials
Problem-solving and feedback	Each group member as a group member begins to convey their respective information and ideas.
Information Sharing	I never share or provide reference information, ideas, suggestions, solutions, or opinions in group discussions.
Listening, questioning, and discussing	Each group member always shares and contributes reference information, ideas, suggestions, solutions, and opinions in group discussions.
Quality of work	I sincerely give my energy, time, and ability to work with the best quality.
Working productively	Each group member feels awkward when working in a group with various types of people.
Compromise to the group	I tend to impose opinions and do not accept group members' views.
Task-focused and engagement	I can manage tasks by making detailed work details.
Responsibility: All members contribute	Each group member obeys orders about what is sent and does not depend on others to complete it.
Respect for opinions	Each group member cannot accept decisions that group members have agreed upon.

Data Analysis

The research data were analyzed using the One-way ANOVA statistical test. Data were normalized and homogeneity tested before being analyzed. The normality test was carried out with One Sample Kolmogorov-Smimov at a significance level of >0.05. At the same time, the homogeneity test was carried out using Levine's test. One-way ANOVA was carried out when the data had been declared normal and homogeneous so that it could determine the difference in the effectiveness of learning media on collaboration skills and student learning outcomes. Duncan's test was then conducted to provide more information on class differences. Learning outcome data was tested n-gain to determine how the treatment could improve student understanding. The n-gain criteria are interpreted according to Hake (1998) criteria.

▪ RESULT AND DISSCUSSION

Collaboration Skills

The data on collaboration skills were tested for normality and homogeneity as prerequisites for performing the one-way ANOVA and Duncan's post hoc test. The analysis results indicate that the data are normally distributed and homogeneous, with a

significance value of> 0.05. Thus, the one-way ANOVA test can be performed to assess the differences in the effectiveness of various learning media on collaboration skills.

Table 3. One-way ANOVA test results for collaboration skills of control class (A_2B_1) and experimental class (A_1B_1) (large group)

	Df	Mean Square	F	Sig.
Between Groups	3	3.500	4.698	.064

Based on Table 3 above, the results of the one-way ANOVA test on collaboration skills obtained a sig > 0.05, so H0 is accepted. That result means there is no difference in collaboration skills between large group students without media and large group collaboration skills with media. The statement means that the one-way ANOVA test results showed no significant difference in collaboration skills between the two groups of students. In other words, the use of media in learning has a similar impact on the collaboration skills of the two groups. The collaboration skills of class A2B1 students showed that several group members did not actively participate in group activities when completing the assigned tasks, such as students often playing on cellphones, chatting, and playing. Moreover, class A2B1 does not use learning media during the learning process, making students feel bored. While the collaboration skills of class A1B1 students who use learning media, some students still need to play an active role in group activities. The amount of media used still needs to be increased, while the number of members in each group is 8-10, thus causing the collaboration skills of both classes to be the same. Duncan then further tested the results of the one-way ANOVA test in Table 4.

Table 4. Duncan's advanced test results for collaboration skills of control class (A_2B_1) and experimental class (A_1B_1) (large group**)**

	Class	N	1	2	3
Duncan	PA A_2B_1	36	21.050		
	SA A_2B_1	36		21.575	
	PA A_1B_1	36		21.914	21.914
	SA A_1B_1	36			22.294
	Sig.		1.000	.113	.075

PA : *Peer Assessment* SA : *Self Assessment*

The results of the Duncan test showed that the average self-assessment of class A1B1 was 22.294, significantly different from the self-assessment of class A2B1 of 21.575. The average peer assessment of class A1B1 was 21.914, significantly different from the peer assessment of class A2B1 of 21.050. Thus, the average value of extensive group collaboration skills of class A1B1 students is better than that of class A2B1. Overall, these results indicate that the collaboration skills of A1B1 students were better than those of A2B1 students, both in self-assessment and peer assessment. In class A1B1, self-assessment and peer assessment are still better than in class A2B1 because the group activities are more active, such as students discussing, collaborating, and helping group members. Learning media affects collaboration skills, and students feel more enthusiastic when using it because it is new. Meanwhile, in class A2B1, which did not use learning

media, students were less active in discussions; only the group members who stood out were active. So, the use of learning media has a positive impact on collaboration skills.

Table 5. Results of one-way ANOVA test of collaboration skills of control class (A_2B_2) and experimental class (A_1B_2) (small groups)

	Df	Mean Square	F	Sig.
Between Groups	3	32.800	55.868	.000

Table 5 shows that the one-way ANOVA test results on collaboration skills obtained a sig <0.05, so H0 is rejected, which means there is a difference in collaboration skills between small-group students without media and small-group collaboration skills with media. Overall, these results show that using media in learning positively affects collaboration skills in small groups. Examples include collaboration skills in class A1B2 during the learning process when each group member showed suitable collaborative activities. As each member gets a task/responsibility, communicate with each other if there are obstacles so that all group members focus on completing the task. Using exciting learning media makes students more enthusiastic in groups of 4-6 people. So that students can operate learning media optimally. The collaboration skills appear pretty good in class A2B2. However, some students must be more active in group discussions when completing assignments because they depend on more prominent students. So, using learning media is efficacious in improving collaboration skills. Duncan further tested the one-way ANOVA test results in Table 6.

Table 6. Duncan's advanced test results for collaboration skills of control class (A_2B_2) and experimental class (A_1B_2) (small groups)

	Class	N	1	2
Duncan	PA A_2B_2	35	21.523	
	SA A_2B_2	35	21.583	
	SA A_1B_2	35		23.040
	PA A_1B_2	35		23.383
	Sig.		.744	.063

PA : *Peer Assessment* SA : *Self Assessment*

The results of the Duncan test showed that the average value obtained by the peer assessment of class A1B2 was 23.383, significantly different from the peer assessment of class A2B2 of 21.583. The self-assessment of class A1B2 was 23.040, substantially different from the self-assessment of class A2B2 of 21.583. As a result, the average collaboration skills of the small group in the experimental class are higher than those in the control class. These results show that small-group collaboration skills in the experimental class (A1B2) were better than those in the control class (A2B2), both from self-assessment and peer assessment. The use of media in the experimental class contributed positively to collaboration skills. Collaboration skills, self-assessment, and peer assessment in class A1B2 are better than in class A2B2. Learning media in class, A1B2, positively impacts student collaboration activities, where students are more active and enthusiastic when completing assignments. Each group member discusses, works together, and divides tasks according to the abilities of the group members. The 3D

learning media is new for them, increasing enthusiasm for learning and collaboration skills. Meanwhile, collaboration skills are pretty good in class A2B2 without learning media. However, some students still need to be more responsible when given assignments and complete them better, depending on the students who stand out more. That result proves that using learning media positively impacts collaboration skills.

Table 7. One-way ANOVA test of collaboration skills of large media group (A_1B_1) and small media group (A_1B_2)

	Df	Mean Square	F	Sig.
Between Groups	3	16.060	29.655	.000

Based on Table 7, it can be seen that the results of the one-way ANOVA test on collaboration skills obtained a sig. A value of 0.000 <0.05, so H0 is rejected, which means there is a difference in collaboration skills between students in the large media group and students in the small media group. The grouping (large or small) can impact student collaboration outcomes. Both classes, A1B1 and A1B2, use 3D learning media, and collaboration skills are significantly different. These differences are primarily due to varying group sizes.nClass A1B1 has 8-10 students per group. Although the collaboration skills in this class are considered good, the large group size can decrease individual student engagement in activities. With so many members, students may feel less confident in actively contributing, which can reduce collaborative dynamics.

In contrast, class A1B2 consists of 4-6 students per group. This smaller group size encourages students to participate more actively in group activities. With a limited number of members, each student has a more incredible opportunity to contribute and interact, making learning media more effective in improving collaboration skills in class A1B2. A Duncan test was conducted to understand these differences better, as described in Table 9. This test aims to provide additional insights into the relationship between group size and collaboration outcomes, helping to identify how variations in group structure can influence collaboration skills.

Table 8. Duncan's Advanced test results for large media group (A_1B_1) and small media group (A_1B_2) collaboration skills

	Class	N	1	2	3
Duncan	SA A_1B_1	36	21.914		
	PA A_1B_1	36		22.294	
	SA A_1B_2	35			23.040
	PA A_1B_2	35			23.383
	Sig.		1.000	1.000	0.52

Description:
PA : *Peer Assessment* SA : *Self Assessment*

Based on Table 8, the average value of the A1B2 peer assessment, 23.383, significantly differs from the A1B1 peer assessment, 22.294. Similarly, the average value of the A1B2 self-assessment, 23.040, substantially differs from the A1B1 self-assessment, 21.914. Thus, the average value of A1B2 collaboration skills is better than A1B1. These results show that collaboration skills in class A1B2 are better than those in class A1B1, both from the self-assessment and peer-assessment perspectives. The results

of the collaboration skills questionnaire, both self- and peer-assessment, showed that class A1B2 had the highest/best score compared to class A1B1. Groups with a few members are more active in discussions, distribute tasks more evenly, work together, and help each other if members have difficulties. Students can make maximum use of learning media, and all members can operate it so that all group members work together. Meanwhile, even though class A1B1 also uses learning media, collaboration skills still need to improve compared to class A1B2. Many group members need to maximize learning media properly. Some group members were still seen playing on cell phones, joking, not participating in discussions, etc. So, only some students operate learning media well.

The results of the study showed that there were differences in collaboration skills between the control class and the experimental class. In this study, we also wanted to determine the effect of the number of members in a group on collaboration skills. The table of hypothesis test results above shows that there are differences between large-group classes and small-group classes. So, the number of members in a group affects collaboration skills. Most students in large groups are less active in group activities, as some students are busy playing with their cellphones, lack communication between group members, and group assignments are assigned to students who contribute highly. In addition, there are differences between students in the large media group class (A1B1) and the small media group class (A1B2) when using or utilizing learning media. In the small media group class (A1B2), students are more enthusiastic or active when using the learning media. STEM-based learning media is new to them, so it becomes a unique attraction and increases interest in learning. In the large media group class (A1B1), it can be seen that only a few students are active in using the learning media, while the other students are less active.

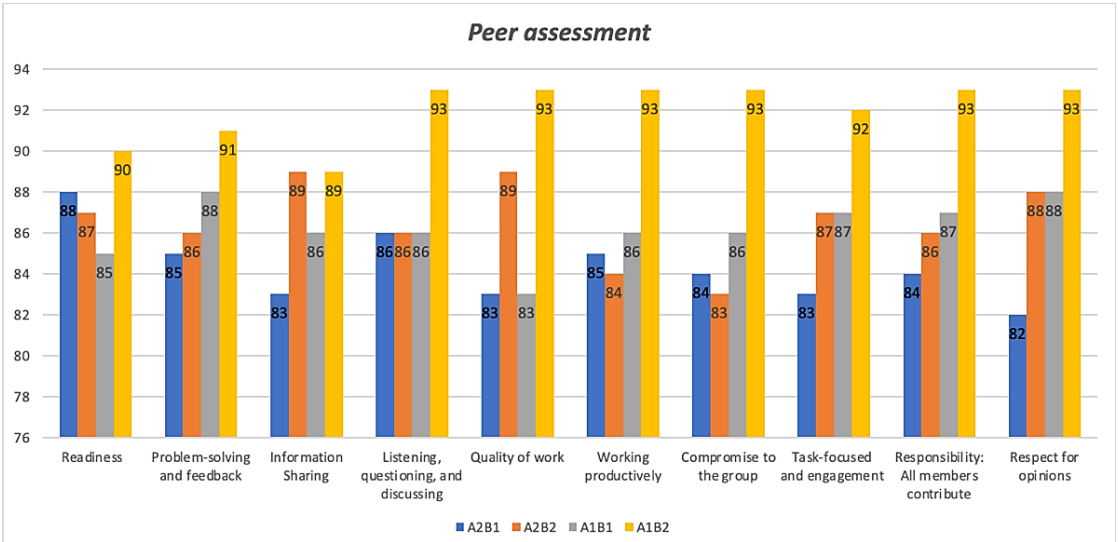

Figure 2. Collaboration skills of peer assessment

The collaboration skills are based on peer assessment and self-assessment. The achievement of each aspect of collaboration is shown in Figure 2 and Figure 3. It can be seen that the results of the experimental class collaboration skills questionnaire (A2B1 and A2B2) are better than those of the control class (A1B1 and A1B2). The 3D learning

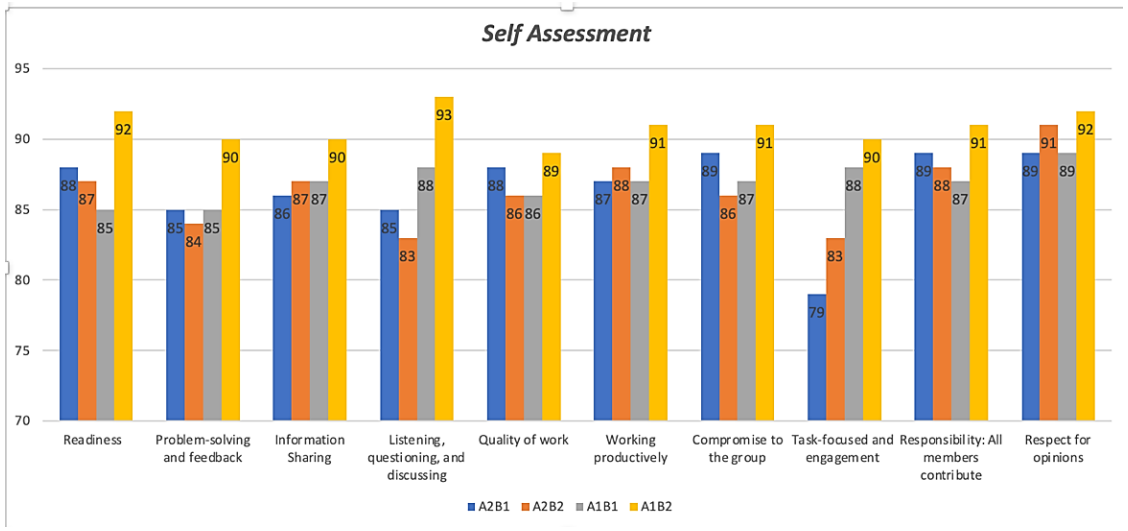

Figure 3. Collaboration skills of self-assessment

media integrated with TGT learning is suitable for improving collaboration skills and student learning outcomes. Students are actively involved in the learning process, deepening their understanding of the material and fostering a spirit of cooperation and mutual assistance between students. These results align with the research conducted by Husnah et al. (2021), which states that learning media combined with the TGT learning model increases student learning activities because of interaction and mutual assistance between students. Using 3D media with the TGT learning model can improve collaboration skills; differences in group members also affect collaboration skills.

The TGT learning model emphasizes student cooperation, making it suitable for pairing with 3D box learning media. This approach promotes active student engagement in the learning process and enhances their comprehension of the material. Thus, 3D learning media and the TGT learning model can synergistically improve collaboration skills, creating an interactive, practical, and fun learning environment. The 3D media helps students convert natural objects into visual objects, such as real objects (Tarial et al., 2022). Students can learn the phenomenon of a science event based on the events seen in the learning media.

There were varying activities between the control and experimental classes throughout the learning process. In the experimental class, students look more active and enthusiastic about listening to the material when the learning process uses learning media. Learning media is formed with an attractive appearance and easy to use so that students can operate the media freely. Students can understand the material efficiently and improve learning outcomes. Students who feel connected to the material are more motivated to learn. In addition, using learning media with the TGT learning model also affects the atmosphere during learning. During the learning process, they were seen interspersed with games, making the classroom atmosphere more fun and preventing students from feeling bored. Collaboration skills also improve because students must discuss, communicate, negotiate, and be responsible for completing the challenges the teacher gives to each group.

According to Le et al. (2018), collaboration skills have several obstacles, such as coordinating an action to negotiate, receive, and give assistance. Students who contribute

highly do not use their time to help other members, so students who contribute less feel marginalized. Group formation in the learning process can improve collaboration skills. Students get more opportunities to express their opinions, take the initiative in making decisions, develop social interaction habits, and train students to have a sense of responsibility. According to Putri et al. (2024), groups of 4-6 students (small groups) can maximize group learning. In addition, according to Michaelsen et al. (2023), small groups of 4-5 allow students to work together optimally to solve a problem and achieve success in the group. The hypothesis test results in this study were reinforced by previous research conducted by Al Mulhim & Eldokhny (2020), which stated that the value of collaboration skills in smaller groups resulted in higher collaboration skill values than in large groups. Small groups have more effective communication, more explicit division of tasks, and a more even level of participation. In addition, according to Li et al. (2020), learning that uses small groups will result in more optimal learning conditions to achieve learning goals.

Learning Outcomes

Data from the pre-test and post-test results of all control classes (A1B1 and A1B2) and experimental classes (A2B1 and A2B2) were tested for normality and homogeneity as a requirement for further testing. The learning outcome data of students in the control and experimental classes are normally distributed and homogeneous because of the sig. Value > 0.05, then the data can be tested further. The n-gain test determines how much the increase in student learning outcomes is between the pre-test and post-test. Figure 4 shows the improvement in learning outcomes due to the learning process conducted in the two classes.

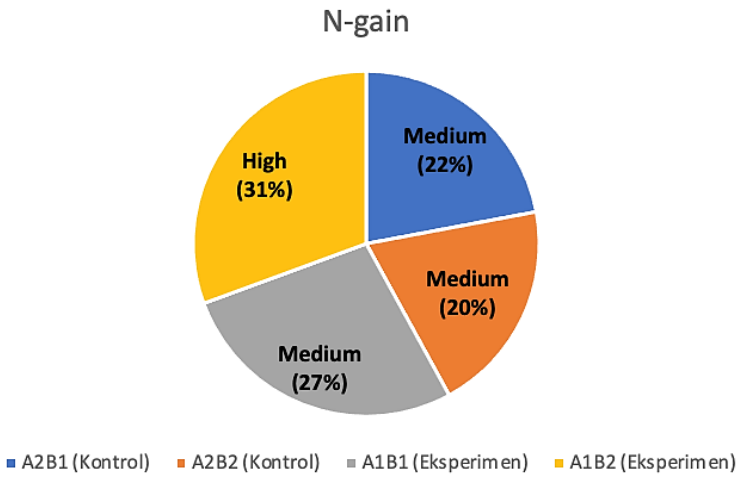

Figure 4. N-Gain of learning outcomes

Based on the research analysis results, the STEM-based 3D audio-visual protein synthesis kit box learning media integrated with the team games tournament model has proven effective in improving student learning outcomes. The use of easy-to-operate 3D media helps students utilize the media during learning. Learning media helps students understand the material better because students are directly involved during learning activities. In addition, it was seen in the experimental class (A2B1 and A2B2) that

students were more active and enthusiastic and did not feel bored because STEM-based 3D learning media was new to them. It positively impacts students, arouses interest in learning, motivates and stimulates learning activities, and has a good psychological effect on students. These results align with research conducted by Tussadiah & Febriyana (2021), which showed that student learning outcomes increase after using learning media with the TGT model. In addition, Wang et al. (2022) also stated that applying STEM-based learning media can improve student learning outcomes. Students learn through collaborative activities by utilizing learning media.

▪ CONCLUSION

The protein synthesis kit box 3D audio-visual learning media and the TGT learning model effectively enhanced collaboration skills and learning outcomes in this study. Additionally, the number of members in the group also affects collaboration skills. Smaller groups encourage active participation and interaction, allowing members to contribute more effectively. Smaller groups provide more opportunities for students to interact with the media and other students during the learning process. Collaboration skills and cognitive learning outcomes are crucial competencies for students. Collaboration skills must be internalized in the learning and teaching process as part of the groundwork related to the era of globalization in the 21st century. Using innovative learning media can facilitate the development of various skills, including collaboration. Teachers must be able to design and implement innovative learning media to improve learning quality and develop teacher professionalism.

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