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The Application of Discovery Learning Model with STEM Approach to Improve Critical Thinking Skills and Collaboration Skills of Students at Public Senior High School (SMA Negeri 3 Kupang)

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Abstract: This study aims to determine the application of Discovery Learning model with STEM approach in improving students' critical thinking skills and collaboration skills. This research is a pseudo-experiment with a research design of Randomized Control Group Pretest-Post-test which involved 2 experimental classes. The Discovery Learning model with STEM approach was applied in experimental class 1 while the Discovery Learning model without STEM approach was implemented in experimental class 2. By using t-test, it was found that there was a significant difference in positive critical thinking skills between students in experimental class 1 and 2, as evidenced by 3.042>1. 99346 respectively. Similarly, the critical thinking skills of students who used the Discovery Learning model with the STEM approach were also higher than students who were taught using the discovery learning model without STEM. Meanwhile, the results of students' collaborative skills when implementing the Discovery Learning model with STEM approach had an average percentage of 81% which could be grouped into very collaborative category. These results were higher than the class of Discovery Learning model without STEM approach, which accounted for 73% in collaborative category.

Keywords: Collaborative skill; Critical thinking; Discovery learning; STEM approach

Introduction

In the current era of the Industrial Revolution 5.0, science and technology are developing very quickly and rapidly. Technology is inseparable from various innovations that arise as a result of research and products developed by human. Over time, the need for human resources for routine matters and daily needs have decreased due to the use of machines, robots and the help of information technology tools. Therefore, the skills needed by students to survive in today's developing world are 21st century skills that could answer the demands and challenges of an ever-changing era (Horton, 1997).

Out of several 21st century skills, some skills are regarded as significant such as creative thinking, critical thinking and problem solving, collaboration and communication, or known as the 4Cs (Aulia, 2022; Supena et al., 2021; Zubaidah, 2019). Therefore, education plays an important role in creating a better generation who is able to compete internationally with modern technological advances. Education in the 21st

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century requires different skills that a person must possess to actively participate in future challenges, especially in entering the labor market (Ağaoğlu & Demir, 2020; Narod, 2020).

In Indonesian education system, efforts have been made to develop 21st century skills. Some of these efforts have been implemented since the 2013 Curriculum and Merdeka Curriculum with the main aim to create a critical and confident generation in the era of globalization (Akhiryani, 2023; N. Lestari et al., 2023). This is in accordance with the law of National Education System of the Republic of Indonesia number 20 in 2003, which explains that national education develops skills and forms the character and civilization of the nation that is valuable in order to educate the nation's life. This is also in line with the Ministry of Education and Culture's 2016 policy which explicitly says that competency standards for high school/vocational school graduates must include the ability to think critically, act creatively, productively, and independently, especially in collaborating and communicating with others (Herak & Lamanepa, 2019; Ismayani, 2016).

According to Wartono et al. (2018), critical thinking is defined as an effort to examine ideas to become more specifics, distinguish the ideas neatly, select, connect, study, and develop these ideas towards a more perfect one. Critical thinking is a cognitive aspect that functions to identify a problem in order to find a solution and produce a decision or review that is logically processed in solving the problem. Critical thinking is one of the most important skills that should be owned by every student because this skill makes it easier for them to understand concepts, analyze, and make decisions (Bugg, 1997; Heard et al., 2020). Critical thinking in all aspects of learning, including physics learning is needed to solve a problem so that it can improve students' thinking patterns to become more creative, active and innovative (Ariani, 2020; Wenno et al., 2022).

According to Arnyana (2019), collaboration skill is the ability to work together, establish synergy, adjust to various roles and responsibilities, and appreciate diversity. Students' ability to work together, maintain communication, listen actively, respect each other, and appreciate other points of view is shown by their collaboration skills. The learning process at school also requires collaboration between teachers and students where teachers are responsible for facilitating students to find the right path through the learning process. Furthermore, teachers need to constantly remember that students are in the stage of learning to apply the knowledge they get hence teachers need to trust their students to make their own decisions, which marks the collaboration in the classroom. This proves that the classroom does not belong only to the teacher, instead the classroom and the learning process belong together. This, in turn, makes the students feel valued and trusted. They will be confident in both their educational and personal domains. Therefore, the learning process at school is not only student-centered and teacher-centered but there should be a collaboration between the two in the learning process. Having said so, collaboration is not only about doing tasks together but more about highlighting both roles as joint effort (Ghavifekr, 2020; Sulaiman & Shahrill, 2015; Warsah et al., 2021).

From many learning materials studied by the students at schools, physics is considered to have an important role in the education system. According to Simbolon et al. (2015), physics as a branch of natural science is a subject that is not effective if studied and emphasized only on theory and mathematics, but the emphasis should be placed on building knowledge and its application in everyday life. The goal is to help students to solve a wide variety of physical problems, practice communication skills, work in groups, solve problems given by teachers and faced by students in everyday life (Fraser et al., 2014; Wieman & Perkins, 2008).

STEM (Science, Technology, Engineering, and Mathematics) is currently being talked about a lot, especially in education. One of the reasons is the increasing demands of these integrated skills in this current era. STEM is also believed to be able to train students' thinking skills in depth hence they will be able to see opportunities based on the knowledge they form which arise from meaningful learning activities (Bouchey et al., 2021). Integrating several disciplines into one subject aims to ensure that students are not only knowledgeable, but competent and able to apply these concepts in everyday life holistically.

One way to improve students' critical thinking skills and collaboration skills in the learning process is by applying the STEM-based discovery learning model. According to Anitah (2009) and Sidiq (2020), discovery learning is a learning that involves students in problem solving for the development of knowledge and skills. Using discovery learning can guide students to improve 21st century skills, emphasize critical thinking and analysis processes as well as collaboration skills.

Based on the problems described, the researchers consider that using the discovery learning model with the STEM approach can facilitate students to improve their critical thinking skills and collaboration skills. This motivated the researcher to conduct a study entitled "The application of discovery learning model with STEM approach to improve critical thinking skills and collaboration skills of students at SMA Negeri 3 Kupang."

Method

This research was conducted in the odd semester at SMA Negeri 3 Kupang in the 2022/2023 academic year. This research is a pseudo-experimental design with the form of Randomized Control Group pretest-posttest design. This research used simple random sampling technique. The participants in this study were the students from grade 11 in the Natural Science classes which was divided into experimental class 1 and experimental class 2.

This study was conducted by applying learning using the discovery learning model with a STEM approach to experimental class 1 and applying the discovery learning model without STEM to experimental class 2. The types of data used in this study were quantitative data (pre-test and post-test results) and qualitative data (collaboration skills observation results). The questions in the instrument used to collect critical thinking skills data using pre-test and post-test results were first tested by an expert validators.

The pretest and post-test data obtained were then analyzed using the calculation of the independent sample t-test. Before conducting the t-test, the first step was a prerequisite test, namely the Normality test using the Shapiro-Wilk test and the Homogeneity test using the Levene test to prove whether the data is normally distributed and is on a homogeneous variance. Meanwhile, the collaboration skills observation data were analyzed in the form of descriptive qualitative in percentage by calculating the scores divided by the maximum score and multiplied by 100%. The percentage obtained was then interpreted according to the criteria in table 1.

Table 1. Criteria for Student Collaboration Skills (Widoyoko, 2009)

Value (Percentage)	Category
>80	Very Collaborative
>60-80	Collaborative
>40-60	Collaborative Enough
>20-40	Less Collaborative
≤20	Not Collaborative

The instrument to measure students' collaboration skills consists of 6 indicators that are described in 8 observation items. To measure students' collaboration skills, an observation sheet is used that is observed by two independent observers. The collaboration observation instrument consists of 6 collaboration indicators, namely understanding cooperation, implementing cooperation, adaptation and responsibility, empathy in groups, compromising with group members, and cooperation between groups. The six indicators are then further described into 8 observation instrument items. The eight observation items include observing students' ability to understand the meaning of cooperation in implementing learning activities, applying the principles of cooperation in learning activities, having the ability to cooperate or coordinate group members, implementing the principles of cooperation in group activities, adapting to various roles and responsibilities and working productively with others, having empathy and respecting the different perspectives of others in working in groups, being able to compromise with other members in the group in order to achieve previously set goals, and being able to cooperate well between groups.

Result and Discussion

Research Results

The data used in this study were obtained from samples from two classes, namely grade XI MIPA^{9} as the first experimental class totaling 38 students using the Discovery Learning model with a STEM approach and grade XI MIPA^{7} as the second experimental class totaling 36 students using the Discovery Learning model without STEM. This research was conducted for three meetings for each class and learning was limited to the topic of static fluid.

The data preparation stage was carried out first to prepare pre-test and post-test questions with 5 open ended questions. For the level of difficulty, the average question given was difficult which was adjusted to the level of Bloom's taxonomy, namely cognitive level 4 (C4). This is due to the dependent variable in this research which is about students' critical thinking skills so that the questions given need students to analyze. The data in this study were obtained from giving instruments to both classes in the form of critical thinking skills tests and collaboration skills observation sheets. The critical thinking skills test instrument used consists of 5 items of open-ended questions about static fluid given during the pre-test and post-test, while the observation instrument was carried out by the observer based on the collaboration skills rubric. The research instruments used have passed the validation test assessed by expert validators. The data that has been obtained from giving pretests and posttests as well as observation sheets in experimental and control classes was then analyzed to determine the description of collaboration skills and critical thinking skills of students.

Critical Thinking Skills Test Results

Initial Critical Thinking Skills of Students Before Treatment

The initial critical thinking skills of students are critical thinking skills possessed by students before receiving treatment using the Discovery Learning model

with a STEM approach and with Discovery Learning model learning. The test used is a description test given during the pre-test. The initial critical thinking skills in this study were measured based on five aspects according to R.H. Ennis, namely Basics Support, Advance Clarification, Elementary Clarification, Inference, Strategy and Tactics. As for the results of the student critical thinking skills test for pre-test activities, the results obtained in experimental class 1 had an average score for three indicators higher than that of experimental class 2 and the other two indicators, namely Basics Support and Inference experimental class 1 and experimental class 2 obtained the same average score. The average comparison of each indicator is shown in the following diagram.

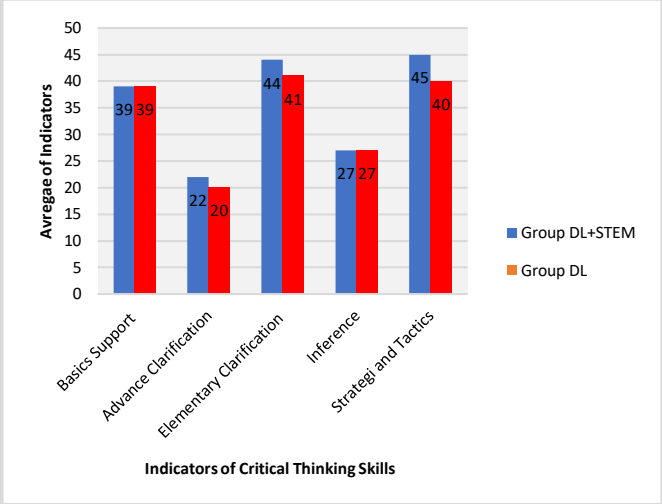


Figure 1. Average score of the sample's initial ability for each indicator

In general, the results of the student critical thinking skills test for pre-test activities, obtained the results that for experimental class 1 had an average critical thinking skills of 34 with a data range of 20-52 and a standard deviation of 8.32. And while the experimental class 2 has an average student critical thinking skills of 32 with a data range of 18-51 and a standard deviation of 8.33.

Critical Thinking Skills of Learners After Treatment

The final results of critical thinking skills are the results obtained by students after getting treatment, namely learning by using the Discovery Learning model with a STEM approach. After conducting a post-test in experimental class 1 and experimental class 2, the researcher then treated the two samples in the form of learning activities in accordance with the syntax of the model and the appropriate learning approach, the final student critical thinking skills test data was collected again through post-test activities. The final critical thinking skills in this study were measured based on five aspects according to R.H. Ennis, namely Basics Support, Advance Clarification, Elementary Clarification, Inference, Strategies and Tactics. Based on the data that has been collected and through data analysis, the results show that after getting learning activities using the Discovery Learning model with the STEM approach in experimental class 1 and the Discovery Learning model in experimental class 2, each indicator of critical thinking skills all increased. Comparison of data improvement for each indicator can be seen in the following diagram.

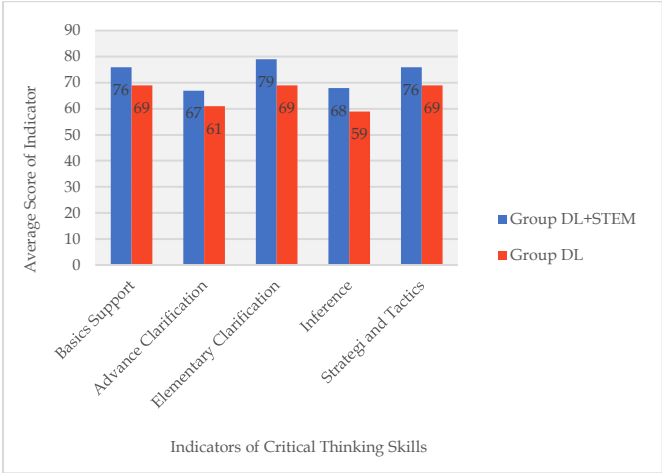


Figure 2. Average score of the sample's final ability for each indicator

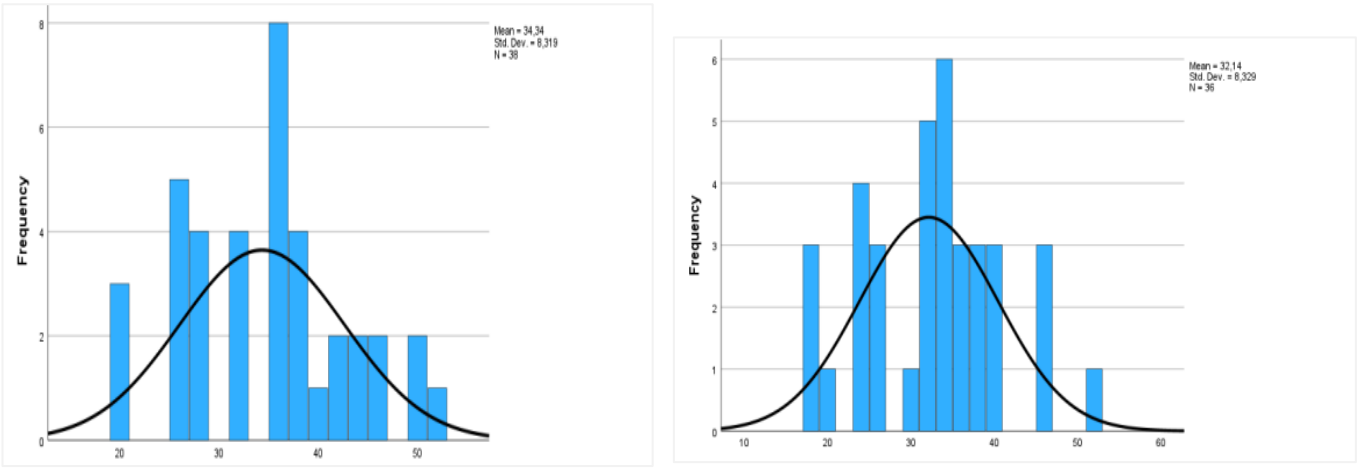
In general, the results of the student critical thinking skills test for post-test activities in experimental class 1 obtained an average student critical thinking skills of 72 with a data range of 54 - 95 and a standard deviation of 11.13, while in experimental class 2 after getting learning activities using the Discovery Learning model with a STEM approach, has an average of 64 with a data range of 45-89 and a standard deviation of 11.60.

Prerequisite Test Analysis

Sample Initial Proficiency

Normality Test

Based on the results of the Shapiro-Wilk normality test using SPSS v.29, it was found that the significance value or p-value (Sig) in the experimental class was 0.403, while for the control class the significance value or p-value (Sig.) was 0.295. Because the results of the Shapiro-Wilk normality test for both the experimental and control classes are greater (>) than 0.05, it can be concluded that the data on the initial critical thinking skills of experimental and control class students are normally distributed. The histogram of the test results is presented in Figure 3.



(a) (b)

Figure 3. Histogram of normality test data of students' initial critical thinking ability (a) DL+STEM Group, (b) DL Group

Homogeneity Test

Based on the results of the homogeneity test shown by Lavene's Test using SPSS v.29, it can be seen in the table 2. Because the results shown are greater (>) than 0.05, it can be concluded that the initial critical thinking ability data of experimental and control class students have homogeneous variance.

Table 2. Homogeneity Test Results of Students' Initial Critical Thinking Skills

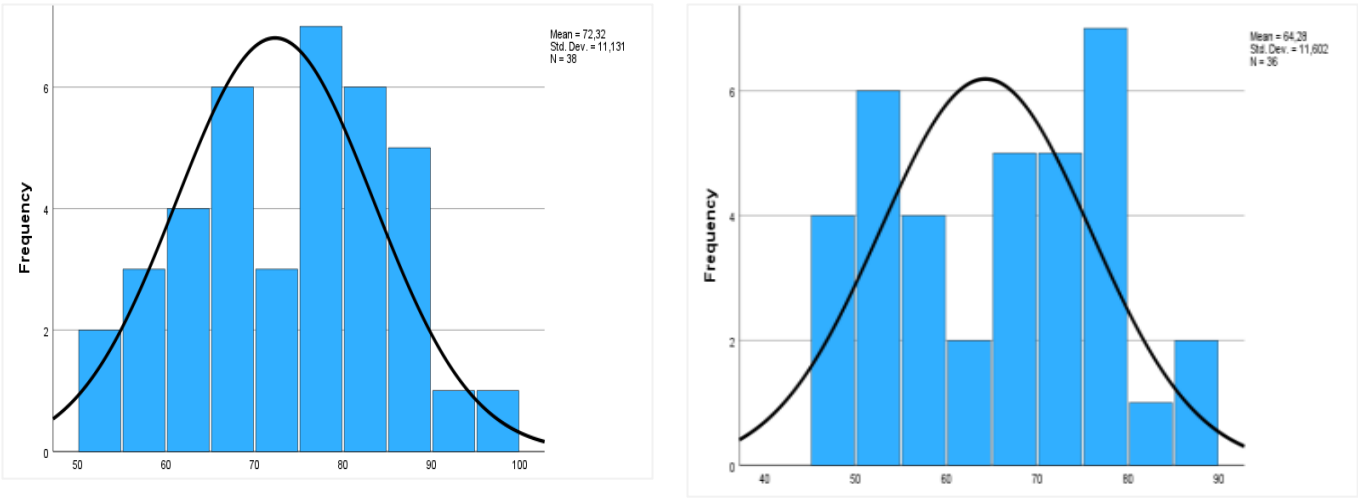
Tests of Homogeneity of Variances *Pre-test*

		Levene Statistic	df1	df2	Sig.
Students' critical thinking skills	Based on Mean	.005	1	72	.943
	Based on Median	.005	1	72	.947
	Based on Median and with adjusted df	.005	1	71.582	.947
	Based on trimmed mean	.006	1	72	.937

Final ability of the sample

Normality Test

Based on the results of the Shapiro-Wilk normality test using SPSS v.29, it was found that the significance value or p-value (Sig) in experimental class 1 was 0.153, while for experimental class 2, the significance value or p-value (Sig.) was 0.88. Because the results of the Shapiro-Wilk normality test for both experimental class 1 and experimental class 2 are greater (>) than 0.05, it can be concluded that the data on the final ability of critical thinking skills of experimental class 1 and experimental class 2 are normally distributed. The histogram of the test results is presented in Figure 4.



(a) (b)

Figure 4. Histogram of Normality Test Data of students' final critical thinking ability (a) DL+STEM Group, (b) DL Group

Homogeneity Test

Based on the homogeneity test results shown by Lavene's Test using SPSS v.29, the complete data results can be seen in the table 3. Because the results shown are greater (>) than 0.05, it can be concluded that the data on the final ability of critical thinking skills of experimental class 1 and experimental class 2 students have a homogeneous variance.

Table 3. Homogeneity Test Results Students' Final Critical Thinking Skills

Tests of Homogeneity of Variances *Post-test*					
		Levene Statistic	df1	df2	Sig.
Students' Critical Thinking Skills	Based on Mean	.203	1	72	.653
	Based on Median	.208	1	72	.650
	Based on Median and with adjusted df	.208	1	71.031	.650
	Based on trimmed mean	.214	1	72	.645

Sample Initial Ability Similarity Test

The sample initial ability test was conducted to determine the similarity of initial abilities between the two research samples. The results analysis of the initial ability of the sample using SPSS V. 29, obtained that the magnitude for students' critical thinking skills was 1.138 with a Sig. (2-sided p) value of 0.259. Because the total sample was 74, the data on students' critical thinking skills has a degree of freedom (df) of 72 which then shows that it is 1.99346 at the 5% level (0.05). Thus<, and the Sig. (2-sided p) value > 0.05. So, the null hypothesis (Ho) is accepted and the alternative hypothesis (Ha) is rejected, which gives the conclusion that there is no significant difference in initial ability between students taught using the Discovery Learning model with a STEM approach and students taught using the Discovery Learning model.

Research Hypothesis Test

In this study, there are two hypotheses whose truth would be tested using the independent sample t-test. Based on the results of the prerequisite analysis test, it is known that the data collected are normally distributed and have homogeneous variants, and both samples have the same initial ability through the independent sample t-test two - sided p. Therefore, both hypothesis tests can be continued as parametric tests. Therefore, both hypothesis tests can be continued as parametric tests.

First Hypothesis Test

The first hypothesis uses a two-sided t-test (independent sample t-test two- sided p) to determine whether there is a significant positive difference in students' critical thinking skills between students taught using the Discovery Learning model with a STEM approach and students taught using the Discovery Learning model without STEM. Based on the results of the analysis using SPSS v.29, it was obtained as 3.042 with Sig. (2-sided p) of 0.003. By setting an error rate of 5% (0.05) with a degree of freedom (df) of 72, the t table was obtained at 1.99346. Thus >, and Sig. (2-sided p) value <0.05. So, the null hypothesis (Ho) is rejected and the alternative hypothesis (Ha) is accepted, which gives the conclusion that there is a significant positive difference in students' critical thinking skills between students taught using the Discovery Learning model with the STEM approach and students taught using the Discovery Learning model without STEM.

Second Hypothesis Test

The second hypothesis uses a one-sided t-test (independent sample t-test one tailed), namely the right-sided t-test to determine the higher students' critical thinking skills between students taught using the Discovery Learning model with a STEM approach and students taught using the Discovery Learning model. Based on the results of the analysis using SPSS v.29, obtained 3.042 with Sig. (1-sided p) of 0.002 by setting a significant level of 5% (0.05) with degrees of freedom (df) 72, then obtained one sided p of 1.66629. Thus > , and the Sig (1-sided p) value < 0.05. So the null hypothesis (Ho) is rejected and the alternative hypothesis (Ha) is accepted, which gives the conclusion that the critical thinking skills of students taught using the Discovery Learning model with a STEM approach are higher than students taught using the Discovery Learning model without STEM.

Descriptive Data Analysis of Collaboration Skills

Collaboration skills of experimental class 1 and experimental class 2 students were obtained from the results of observations. Observations were carried out at each meeting by one colleague of the researcher using observation guidelines that had been prepared by the researchers. Data on student collaboration skills was obtained from experimental class 1 with the treatment of applying the discovery learning model with the STEM approach and in experimental class 2 with the treatment of applying the discovery learning model based on a collaboration skills rubric that uses 2 indicators which include contributions and problem solving with a score of 1-4 as the observation criteria. Data on the value of observation of student collaboration skills in the DL +

STEM group and the DL group is displayed in the table 4 and figure 5.

Based on the figure 5, it can be seen that students' collaboration skills in experimental class 1 which was given the treatment of Discovery learning model with STEM approach continued to increase from meeting I to meeting III with the average percentage of students' collaboration skills in experimental class 1 was 81% which could be grouped as very collaborative category. Whereas in experimental class 2 with the treatment of the discovery learning model without STEM, it continued to increase from meeting I to meeting III with an average percentage of student collaboration skills of 73% in the collaborative category. These results show that students in experimental class 1 with the application of the discovery learning model with the STEM approach were much more active than students in experimental class 2 with the application of the discovery learning model without STEM.

Table 4. Data on the Percentage of Collaboration Skills of DL+STEM Group and DL Group

Meeting	DL+STEM Group		DL Group	
	Percentage	Criteria	Percentage	Criteria
I	71%	Collaborative	70%	Collaborative
II	82%	Very Collaborative	74%	Collaborative
III	88%	Very Collaborative	77%	Collaborative
Average	81%	Very Collaborative	73%	Collaborative

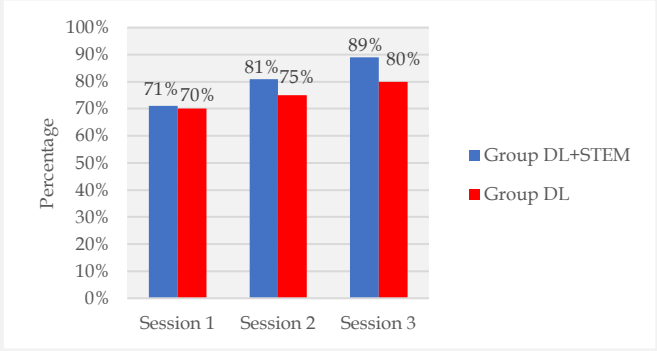


Figure 5. Diagram percentage of collaboration skills

Discussion

Differences in Critical Thinking Skills in Discovery Learning Model with STEM and Discovery Learning Model without STEM

Based on the research that has been conducted, the results obtained was in the form of data on critical thinking skills of students in grade 11 at SMA Negeri 3 Kupang. This quasi-experimental research with Randomized Control Group Pretest-Posttest Design has been conducted for approximately three weeks. This research was conducted by applying Discovery Learning model with STEM approach and Discovery Learning without STEM. The population in this study were all students in grade 11 (Natural Science Class) which consists of 9 classes at SMA Negeri 3 Kupang, with samples taken by simple random sampling to represent the population were students of grade 11 class 9 as experimental class 1 and students of grade 11 class7 as experimental class 2. In the research, there were 5 indicators used to assess students' critical thinking skills in both experimental class 1 and experimental class 2. These indicators are: Basics Support, Advance Clarification, Elementary Clarification, Inference, Strategies and Tactics. Students' critical thinking skills were measured using an instrument in the form of test questions (essay/open-ended questions).

Before being given treatment, the initial ability test of the sample was carried out both in experimental class 1 and experimental class 2. This was done to determine the initial ability of the selected sample to explore whether they have the same initial ability or not. The data used in testing the similarity of the initial ability of the sample was obtained and analyzed from the results of the pre-test activities. From the results of the analysis using SPSS v.29, it was known that the two sample classes had the same initial ability of the sample. After the two classes were declared to have the same initial ability of the sample, experimental class 1, which amounted to 38 students, was then given treatment by teaching them using the discovery learning model with a STEM approach, while experimental class 2 students totaling 36 students were taught using the discovery learning model without STEM.

The discovery learning model is a learning model that consists of several stages, namely Stimulation, Problem statement, Data collection, Data processing, Verification, and Generalization. This learning model refers to a teaching style where the teacher is actively involved in carrying the content of the lesson to his students by teaching directly. In the Stimulation stage, students are faced with something that causes confusion so that students generate a desire to investigate themselves. The teacher conveys learning objectives, provides motivation and apperception, then students are asked to re-explain concepts and can solve existing problems. At the Problem identification stage (Problem statement), the teacher provides as many opportunities as possible for students to identify existing problems and make hypotheses from existing problems. After that, at the data collection stage, the teacher provides

opportunities for students to find information to prove whether the existing hypothesis is correct or not. Furthermore, students work on the worksheet (in Indonesian, it is called LKPD) distributed by the teacher. At the Data processing stage, students process all the information data obtained based on the literature review. For the proof stage, students conduct a careful examination to prove whether or not the hypothesis is true with alternative findings, connected to the results of the data obtained. The final stage is generalization, the teacher asks students to conclude the material during the learning process.

These two learning models, namely the discovery learning model with the STEM approach and the discovery learning model without STEM, are comparable learning models. Both of the approaches have similarities in terms of linking learning content with real-world situations in everyday life. They also could help students to activate their existing knowledge so that learning concepts or materials can be connected to their prior knowledge as well practice the knowledge and apply it so that it is easy to understand. Applying the knowledge is imperative since students can experience what they learn through simple experiments so that the knowledge and experience they gain can be be applied in students' lives. This could also help the students to understand knowledge where knowledge they learn not just to be memorized but to be understood, believed and become a provision in producing something from the material studied.

However, these two learning models also have a fundamental difference. In Discovery Learning without STEM approach, there is the stage called orientation stage, where teachers provide the apperception. In this stage, the teachers are actively involved in carrying out the content of the lesson to their students by teaching directly to give the stimulation to the students. At this stage, the teacher provides stimuli in the form of problems that cause student confusion and curiosity so that students desire to investigate themselves where the teachers could assist students in leading to problem solving. Whereas in the discovery learning model with the STEM approach, at this stimulation stage, the teachers first need to connect them with the aspects of science and technology where the teacher could show videos of real examples of problems faced by students in everyday life, so that students generate the desire to ask questions and investigate themselves related to the problems that occur. Therefore, students are able to know the concept of science and its relationship with the application of technology in everyday life based on the concept of material from the video that has been shown. Thus, students are able to design a new concept to answer the problems they are facing.

The discovery learning model with a STEM approach consisting stages such as Stimulation-Science and Technology, Problem Statement-science, Data Collection-engineering, Data Processing-mathematics, Verification and Generalization where these stages can help teachers to instill critical reasoning in students. In this learning model, students are invited to discover the concepts they learn by directing students to real problems in students' lives through animated learning videos in the stimulation-science and technology syntax so that students generate a desire to investigate themselves and can restate concepts using their own understanding or language. Then students can carry out activities to identify problems at the problem statement stage with the teacher as a facilitator where at this stage students are given as many opportunities as possible to identify problems that are relevant to the teaching material. Then, they can make a hypothesis based on the problems found during the stimulation. In the next step, the teachers divide the students into several groups to continue working on the worksheet (in Indonesian language it is called LKPD). In the data collection-engineering syntax, the teachers provide an explanation to direct students to conduct a literature review on the hypothesis of the problems students pose which in turn become the topic discussed by the students. Furthermore, students conduct simple experiments or design experiments in solving problems in LKPD where students can design a product to answer the problems in LKPD. In this stage, students also conduct group discussions to solve problems and perform calculations according to the mathematical concept of learning material at the data processing-mathematics stage, after which students conduct careful examinations in proving whether or not the hypothesis is correct, and the product design they do is connected to the results of data processing. Furthermore, students are given the opportunity to present the discussion in front of the class and other groups give opinions and rebuttals actively. After that, in the verification syntax the teacher provides an opportunity for students to dance the conclusions of the learning material that has been learned by students during learning activities. This learning model also directs students to find meaning in learning through activities linking material concepts with everyday life. Each stage in the discovery learning model with the STEM approach always involves students so that students will not quickly feel bored and easily understand the material they will learn.

The application of the STEM-based discovery learning model can improve students' critical thinking skills. The research Fadlina et al. (2021) shows that the application of the STEM-based discovery learning model in learning Motion System topic can improve students' critical thinking skills. The role of the STEM

approach in the learning process is that students independently find and solve problems but the students' thinking process is more active and careful and is based on the thinking process towards critical conclusions to obtain answers to the problems given. Thahir's research (Davidi et al., 2021) also confirms that the STEM approach also has an impact on improving students' scientific attitudes and conceptual understanding of physics material. The integration and deep exploration of STEM aspects (Science, Technology, Engineering and Mathematics) provides learning opportunities and enhances students' learning experience in exploring Physics concepts in a more detailed yet meaningful way.

Comparison of the Improvement of Critical Thinking Skills in Discovery Learning with STEM Approach and Discovery Learning Without STEM

The improvement of students' critical thinking skills on the concept of Static Fluid topic can be seen in each indicator which generally has increased. The comparison of the percentage increase in students' critical thinking skills for each indicator after applying the STEM-based discovery learning model and applying the discovery learning model without STEM, can be seen in the following figure:

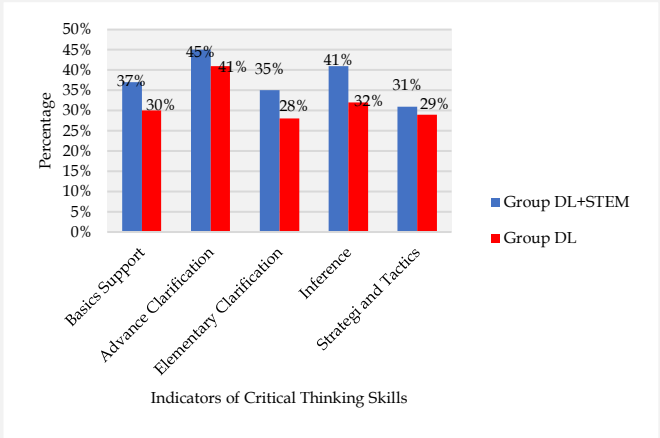


Figure 6. Percentage increase in critical thinking skills per indicator DL + STEM Group and DL Group

When viewed in Figure 6, it is very clear that the difference in critical thinking skills after learning that has taken place in experimental class I and experimental class 2 is due to differences in the treatment given. After being treated, both classes can improve critical thinking skills. In the basic support indicator in which for experimental class 1 was at 37% and experimental class 2 accounted for 30%. It can be seen that the critical thinking skills data in experimental class 1 using the STEM-based discovery learning model was higher than that in experimental class 2 using the discovery learning model without STEM approach. This is because in the STEM-based discovery learning model there is a stage called stimulation-science and technology, where the teacher explains the material and provides examples of real problems in everyday life and provides opportunities for students to use technology in studying and solving existing problems so as to provide opportunities for students to argue actively and practice questioning and answering skills to better understand the material studied. This in line with the discovery learning model itself, where there is a stimulation syntax to enable the teacher to direct the students to the problems that cause confusion so that students are able to investigate them individually.

In the Advance Clarification indicator, experimental class 1 got 45% and experimental class 2 obtained 41%. This difference occurs because in each syntax of experimental class 1 using the STEM-based discovery learning model and discovery learning syntax that always invite the students to analyze a problem they find and are able to solve it and be able to provide further explanation. The STEM-based discovery learning model trains students to engineer a product and use existing procedures from reliable sources (statements, facts) in solving the problem at hand.

In the Elementary Clarification indicator, experimental class 1 obtained 35% and experimental class 2 acquired 28%. It can be seen that the critical thinking skills data in experimental class 1 using the STEM-based discovery learning model was higher than experimental class 2 using the discovery learning model without STE approach. This is because in the STEM-based discovery learning model there are aspects of science and technology where the teacher provides worksheets that emphasize real examples in everyday life that link existing concepts with developed technology so that students review existing problems and are able to find existing facts from a problem that can be used to help answer the problem. According to Fadlina et al. (2021), STEM provides students with the experience of solving real problems with practical activities, so as to increase effectiveness, meaningful learning and support future careers. Meanwhile, the experimental class 2 using the discovery learning model without STEM was only gave a worksheet that directed students in completing a simple practicum based on the existing subject matter.

In the Inference indicator, it was 41% for experimental class 1 and32% for experimental class 2. It can be seen that the percentage data in experimental class 1 was much higher than experimental class 2. This is because the STEM-based discovery learning model is able to train students' thinking skills in analyzing a problem and being able to solve problems based on the technique at hand to draw a conclusion. In addition, students are able to define problems and exportation of problems to be solved. Meanwhile, using the discovery

learning model without STEM approach only directs students to draw a conclusion to be a general principle and applies to all the same problems based on existing evidence.

In the Strategy and Tactics indicator, experimental class 1 accounted for 31% and experimental class 2 obtained 29%. This difference occurs because each syntax of experimental class 1 and experimental class 2 trained students in extrapolating the ability to identify problems from a case and understand it, then determine an action on the problems that occur in the case.

The results of this study are in line with research conducted by Lestari et al. (2021), that the highest increase was in the indicator of giving simple explanations and the lowest increase was in the indicator of organizing strategies and tactics. The results showed that the STEM approach can improve students' critical thinking skills in Static Fluid topic.

Overall, the discovery learning model with the STEM approach and the discovery learning without STEM approach can help students understanding Static Fluid topic well according to what is learned because students construct knowledge with concepts encountered from students' own experiences. However, the results obtained show that critical thinking skills using the discovery learning model with a STEM approach were higher than the discovery learning model without STEM. This happens because the discovery learning model with the STEM approach trains students' skills in engineering products based on existing material concepts so as to improve skills in thinking and reasoning about existing learning concepts.

So based on this, it will be clear that although the Discovery Learning (DL) learning model can also improve students' critical thinking skills, the physics critical thinking skills of students taught using the Discovery Learning model with a STEM approach are higher than students taught using the Discovery learning model without STEM. Understanding this learning model helps teachers to encourage students to find material concepts based on existing problems they learn and meaningful learning occurs which can make it easier for students. Furthermore, it can also make students more active, independent, and work on their own initiative in understanding physics concepts.

Based on relevant research conducted by Khoiriyah (2018), it shows that learning with the STEM approach is proven to improve the critical thinking skills of high school students on Sound Wave topic. The results showed that the average value of N-gain in the experimental class was 0.63 and the control class was 0.35 with a moderate category. This shows that learning Sound Waves in the experimental class treated with the STEM approach was much more effective in showing an increase in critical thinking skills than the experimental class 2 which used a conventional approach.

Collaboration skills in STEM-based Discovery Learning and Discovery Learning without STEM

Based on the results of the study, it shows that the collaboration skills of the experimental class were higher than the control class. This was obtained from the percentage increase in collaboration skills from meeting I to meeting III. The researchers obtained data on the increase in student collaboration skills in experimental class 1 with the application of the discovery learning model with the STEM approach and experimental class 2 with the application of the discovery learning model without STEM.

In experimental class 1, in meeting I, students' collaboration skills reached 71%, and increased in meeting II to 82%. Then again experienced an increased at meeting III, namely 88%. While in the experimental class 2, the first meeting of students' collaboration skills reached 70%, and increased in meeting II to 74% and also increased in meeting III to 77%. The final average result of student collaboration skills for experimental class 1 was 81% with a very collaborative category and experimental class 2 was 73% in the collaborative category. This shows that applying the discovery learning model with the STEM approach can facilitate students to collaborate more. On the other hand, the discovery learning model without STEM also facilitated students to collaborate but this learning model does not emphasize students to work actively in teams to solve the problems at hand. In addition, when looking at the increase in each indicator of collaboration skills in general has increased every meeting both experimental class 1 and experimental class 2. However, the indicator that greatly improved in collaboration skills was the contribution indicator in experimental class 1.

The difference in achievement in the collaboration skills of students in experimental class 1 and experimental class 2 is because in the learning process of STEM-based discovery learning, students are trained to be able to solve a problem using the steps in the STEM-based discovery learning model. Learners must compromise with their group members so that they are able to make temporary answers regarding several pictures in the form of pollution problems in the LKPD. Learners are also trained to identify problems based on real problems that students find in everyday life, collect data collaborate in teams to complete the design of the products they will work on to answer the problems they face, and process data to conclude characteristics in collaboration. It will build their spirit to be more responsive and active, careful in solving problems. While the application of the discovery learning model

without STEM, students work in groups to answer the hypothesis that has been set and search for a lot of literature to answer problems on LKPD without being required to collaborate actively in designing a concept to answer problems faced by students in everyday life.

This shows that using the STEM-based discovery learning model trains students to work together in teams and exchange ideas that can provide critical input and ideas and are willing to accept input from other team members to create optimal solutions. This is also very influential with the syntax of the STEM-based discovery learning model, namely data collection-engineering where students are encouraged to take an active role in the learning process, and this syntax provides opportunities for students to work independently or in small groups. In small groups, students learn to collaborate with their peers and develop skills to work together to achieve a common goal. By working together in groups, students can also learn to respect differences of opinion, seek mutually beneficial solutions, and develop social skills that are important in everyday life. In conclusion, providing opportunities for students to work independently or in small groups, while still supervising and providing guidance if needed, is a very important syntax and has a great influence in improving students' collaboration skills in the discovery learning model. In STEM (Science, Technology, Engineering, and Mathematics), technology and engineering is a very influential or prominent part in improving students' collaboration skills. In technology and engineering, students are often given tasks that involve problem solving or product design, which require collaboration and cooperation in groups to achieve a common goal. In this case, students learn to listen to and understand each other's perspectives, develop ideas together, divide tasks and responsibilities fairly, and work together to complete assigned tasks. In conclusion, technology and engineering are very influential in improving students' collaboration skills. In technology and engineering, students often work in groups to complete assignments or practicums, and learn to cooperate and respect different opinions in achieving a common goal. This helps students build social skills and develop solid team relationships (Balqist et al., 2019; Fitriyani et al., 2019).

Furthermore, during the research, more challenges were encountered when researchers measured the collaboration aspects compared to when measuring the critical thinking aspects. This happened because when observing the collaboration aspect of each individual (student), activities were very dynamic so that every moment that appeared according to the indicators must be assessed by the observer as soon as possible on the spot. Making decisions regarding students' collaboration abilities requires a fast and precise assessment according to the existing observation rubrics.

Conclusion

This research has brought about some conclusions. First, it can be seen from this study that there is a significant positive difference between the thinking skills of students taught using the discovery learning model with a STEM approach and the discovery learning model without STEM as evidenced by tcount 3.042 > ttable 1.99346 at a significant level α = 0.05. Second, critical thinking skills between students taught using the discovery learning model with a STEM approach are significantly higher than students taught using the discovery learning model without STEM as evidenced by tcount 3.042 > ttable 1.66629 with a significant 0.002 > 0.05. Third, Students' collaborative skills on static fluid material with the application of the Discovery learning model with the STEM approach has an average percentage value of 81% with a very collaborative category. These results are higher than the class with the discovery learning model without STEM which obtained an average percentage value of 73% in the collaborative category.

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