Cooperative learning assisted Desmos in Math: How Does It Affect the Mathematical Communication and Self-Directed Learning?

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Abstract. The existence of learning media, such as Desmos, can make it easier for students to learn mathematics. On the other hand, mathematics communication skills are still low, and students need self-directed learning. The study investigates the impact of a cooperative learning model, aided by Desmos, on students' mathematical communication skills and self-directed learning in financial mathematics. This research is quantitative. The sample for this research is 34 11th-grade vocational students who were selected based on simple random sampling with a one-group pretest-posttest research design. The data collection instrument used a financial mathematics test to determine students' mathematical communication and a questionnaire to determine students' self-directed learning. Hypothesis testing paired t-test was carried out on student communication and questionnaire results. The study's results obtained a p-value of 0.000 <0.05, which indicated a change in the average students' mathematical communication after being given treatment, and for self-directed learning, there was also a difference from an average of 198.41 to 212.79. It is proven that mathematical communication and student self-directed learning can be improved using Desmos..

Keywords: Cooperative Learning, Desmos, Mathematical Communication, Self-directed Learning.

1 Introduction

The concept of information technology is a characteristic of 21st-century learning in the form of online learning, and the study highlights the high prospects and influence of this method in the learning process, particularly in mathematics [1]. Technology effectively aids in enhancing learning potential in mathematics by offering a diverse range of materials to explore [2]. Technological advances have made it easier for students to understand and represent mathematical objects. Taufik reinforces this [3] statement in research that web/technology-based learning media can help visualize abstract information. One of them is Desmos, a program that can display information involving mathematics [4].

Mathematics is important for other scientific disciplines and human life [5][6]. Mathematics is an important tool in developing thinking to solve life problems [7]. This can be seen if mathematics lessons solve cross-topic problems in other subject

P. C. Kuswandi et al. (eds.), *Proceedings of the 6th International Conference on Current Issues in Education (ICCIE) 2023*, Advances in Social Science, Education and Humanities Research 847,
https://doi.org/10.2991/978-2-38476-245-3_40

areas [8]. One of the abilities used in studying mathematics is mathematical communication skills.

Communication can be seen as interactions or activities related to problems, or it can also be interpreted as an exchange of views [9]. Kamid [10] defined mathematical communication skills as the capacity to effectively communicate mathematical concepts using words, symbols, and images and understand, interpret, evaluate, and respond to them. According to the book by Lestari [11] mathematical communication skills involve the ability to express mathematical concepts orally and in writing while fostering a careful, analytical, critical, and evaluative understanding of others' ideas. The higher mathematics conversation (communication) enhances students' understanding of various topics. In addition to increasing their capacity to apply and organize different concepts, students who communicate their thinking during the learning process or assignment will also feel more confident in their mathematical abilities [12].

Therefore, communication is critical to accurately understanding mathematical concepts, and poor communication will result in subpar development of other skills. On the other hand, having effective communication skills will help students to convey messages effectively and solve difficulties. However, most Indonesian students' mathematical communication still needs to improve [13]. The 2019 National Examination results show low communication skills among Indonesian students, with an average of 38.72, with 32% of questions focusing on mathematical communication, indicating a need for improvement [14]. The Program for International Student Assessment (PISA) study reveals that Indonesian students' average mathematical communication skills are below the world average, ranking 72nd out of 78 participating countries [15].

Apart from mathematical communication skills, there is another affective domain related to students' mathematical communication skills, known as self-directed learning, which is equally important in encouraging students' success in mathematics. Self-directed learning is a process individuals or groups use to develop themselves by learning more, developing knowledge and skills, and meeting learning needs [16]. Self-directed learning is a strategy that evaluates students' learning needs, encourages cooperative learning, encourages participation in learning activities, and assesses their subsequent knowledge [17]. However, in field practice, it is still found that students are accustomed to relying on teachers to solve difficult categories of problems when learning mathematics [18], even though self-directed learning is one of the abilities that students must master because self-directed learning can increase students' capacity to think creatively, critically, analytically, and rationally [19].

The research conducted by Kusumah [20] using Geogebra only focused on mathematical communication skills. The research found that digital media can enhance mathematical communication skills in general. This is different from this research; the media used is Desmos, which sees the effect on mathematical communication skills and self-directed learning. Apart from that, Heriyanto's research [21] only described that using Google Classroom assisted by Desmos was more effective on students' mathematical communication skills than conventional learning. To overcome this problem, we have to package the material that will be presented to students and used in financial mathematics. Choosing the right innovation model is crucial for effective learning and preventing students from becoming lazy.

One solution is to package innovative material, namely by using a group investigation (GI) type cooperative model, which is implemented into a scientific learning approach with the help of Desmos. Based on the description above, This research examines the impact of a group investigation (GI) cooperative learning model on students' mathematical communication and self-directed learning skills in financial mathematics. This study investigates the impact of innovative mathematics learning practices using Desmos' scientific approach to the group investigation (GI) cooperative learning model on improving students' mathematical communication and self-directed learning skills in financial mathematics learning.

The benefit of this research is that it can provide an overview and evaluation of innovative learning models for implementing mathematics learning, especially financial mathematics material, to improve students' mathematical communication skills and self-directed learning. Hopefully, this research can make a significant contribution by describing in depth the effects of Desmos media on students' mathematical communication skills and self-directed learning, which can pave the way for developing a more interactive and independent approach to mathematics learning in educational environments.

2 Method

This research is quantitative. The researcher used this type of research because the researcher wanted to use samples to be studied to determine the effect of mathematics learning using a scientific approach, cooperative model type group investigation assisted by Desmos to improve students' mathematical communication and self-directed learning skills. This research employs a one-group pretest-posttest design, as illustrated in by Sugiyono [22] the Table 1.

Table 1. One-group pretest-posttest design.

PreTest	Treatment	PostTest
O_1	X	O_2

Information:
X : Treatment using a scientific approach to the GI-type cooperative model
O1 : Initial test score before treatment (pretest)
O2 : The final test score obtained after receiving treatment (posttest)

This research was carried out in class 11 of SIJA-B SMK Negeri 2 Depok, Sleman Yogyakarta, totaling 34 students for five meetings in the even semester of mathematics, the primary material of financial mathematics. The sampling technique employs a straightforward random sampling method. The class selection was chosen randomly, and one of 9 classes was used as the experimental class. The data collection technique in this research is based on observation sheets, test and non-test results, and documentation. The research instrument employs both test and non-test instruments, with the test being a mathematical ability test consisting of five descriptive questions.

Test of mathematical ability with integrity with mathematical communication skills in problem-solving. The questions are for assessing mathematical communication skills. The non-test instrument is a Self-Directed Learning questionnaire with 60

questions and an observation sheet. Data analysis techniques involve descriptive and inferential methods. Descriptive pretest data analysis describes students' initial conditions, while posttest data evaluates Desmos media's effect on the scientific approach GI-type cooperative learning model in financial mathematics.

Data relating to mathematical communication is described as the score obtained by students from the mathematical communication test before and after the mathematics learning process based on the Minimum Completeness Criteria used by the school, namely 78. Meanwhile, data relating to students' SDL is described as the total questionnaire scores before and after the learning process. Mathematics is obtained by students and categorized based on converted standard scores. Based on Azwar [23], the classification of measurement results is determined by the ideal average (Mi) and ideal standard deviation (Sdi) as shown in Table 2.

Table 2. Mathematical communication skills category.

Interval	Category
$M_i + 1,5Sd_i < X \leq M_i + 3Sd_i$	Very high
$M_i + 0,5Sd_i < X \leq M_i + 1,5Sd_i$	High
$M_i - 0,5Sd_i < X \leq M_i + 0,5Sd_i$	Middle
$M_i - 1,5Sd_i < X \leq M_i - 0,5Sd_i$	Low
$M_i - 3Sd_i < X \leq M_i - 1,5Sd_i$	Very low

Information :

Ideal average : $M_i = \frac{1}{2}$ (ideal maximum score + ideal minimum score) (1)

Ideal standard deviation : $Sd_i = \frac{1}{6}$ (ideal maximum score - ideal minimum score) (2)

X = actual total score

Self-directed learning data obtained by students can be categorized into several categories, including the SDL score category [24], for five criteria consisting of 60 statement items, as seen in Table 3.

Table 3. Self-directed learning category.

Interval	Category
$221 < X \leq 300$	Very high
$141 < X \leq 220$	Middle
$60 < X \leq 140$	Low

The inferential analysis aims to conclude the hypotheses. The analysis is used to statistically prove the research hypothesis and answer the problem formulation, involving an assumption test consisting of a homogeneity and normality test conducted before doing the MANOVA test for the hypothesis. The Kolmogorov-Smirnov test is utilized in the normality test, assisted by IBM SPSS Statistics 26 software. The data is considered to have a univariate normal distribution if the significance value is greater than 0.05. The homogeneity test utilizes the Levene

statistical test, assisted by IBM SPSS Statistics 26 software. If the Test of Homogeneity of Variance table shows a significance value greater than 0.05, it indicates that the data is from a homogeneous population. The t-test with a paired sample t-test is used to test the hypothesis after normality and homogeneity tests have been performed on the data. The statistical hypothesis in the t test is: H_(0): μ_1=μ_2;⟦H⟧_1:μ_1>μ_2.
Informatioan :
μ_1 : posttest average
μ_2 : pretest average

3 Findings and Discussion

The research uses a scientific approach to investigate the impact of Desmos' group investigation (GI) cooperative learning model on students' mathematical communication and self-directed learning skills in financial mathematics learning. The t-test with paired sample t-test is used to test the hypothesis after normality and homogeneity tests have been performed on the data.

3.1 Findings

Test Assumptions Before and After Learning
The assumption test in this research consists of the normality and homogeneity tests. A normality test was carried out to determine whether the pretest and posttest data were normally distributed. At the same time, the homogeneity test aims to determine whether the pretest and posttest data come from a homogeneous population.

Normality Test
The study utilized the Shapiro-Wilk normality test with SPSS version 26 software, with a significance level of α = 0.05, and the results are presented in a table.

Table 4. Normality test results.

Shapiro-wilk	Written test		Questionnaire	
	Pretest	Posttest	Pretest	Posttest
α = 0.05	0.215	0.464	0.384	0.445
Decision	Norma l	Normal	Norma l	Normal

Based on the data in the Table 4, it was found that the normality test results related to the pretest questions obtained sig. 0.215 > 0.05, then the pretest questions have a normal distribution, and the posttest questions get big results. 0.464 > 0.05, and then the posttest questions are normally distributed. So, the pretest and posttest questions are normally distributed. Meanwhile, the pretest questionnaire obtained sig. 0.384 > 0.05, and the posttest questionnaire obtained sig. 0.445 > 0.05 means the pretest and posttest questionnaires are normally distributed.

Homogeneity Test

The homogeneity assumption test was conducted using SPSS version 26, using the Levene assumption test, and the results are presented in Table 5, indicating that the homogeneity assumption is met when the p-value is > α = 0.05.

Table 5. Homogeneity test results.

Levene Statictics	Pretest	Posttest	α	Information
7.736	0.215	0.464	0.07	Written test
0.42	0.384	0.445	0.83 9	questionnaire
Information		Homogeneous		

Based on the data in the Table 5, obtain sig. 0.07 > 0.05 for mathematical communication questions and 0.839 > 0.05 for the self-directed learning questionnaire results indicate that the pretest and post-test questions and questionnaires are from a homogeneous population at a significance level 0.05.

Effectiveness of Learning on Written Tests

The researcher analyzed pretest and post-test results to determine student averages, standard deviations, maximum and minimum observation scores, and maximum theory scores and then calculated the percentage of these results. The pretest and post-test will provide detailed results on mathematical communication skills as they integrate into the overall assessment process. The following table presents a table related to the written test after and before learning financial mathematics using the group investigation type cooperative model assisted by Desmos.

Table 6. Effectiveness of learning in written tests.

Variation	Achievement of Basic Competencies		Mathematical Communication	
	Pretest	Posttest	Pretest	Posttest
Many students	34	34	34	34
Average score	1.89	4.35	39.56	74.74
Standard deviation	0.512	0.544	10.133	6.707
Observation max score	3	4	65	89
Min observation score	1	3	22	57
Theory max score	100	100	100	100
Theory min score	0	0	0	0

Effectiveness of Learning on Non-Tests

Based on the learning results using a scientific approach with a group investigation type cooperative learning model, researchers searched for the average score obtained by students, standard deviation, maximum observation score, minimum observation score, and maximum theory score. Then, they looked for the percentage of the questionnaire results. The following table presents a table related to self-directed learning using the group investigation type cooperative learning model.

Table 7. Effectiveness of learning on non-tests.

Variation	Self-Directed Learning Questionnaire	
	Pretest	Posttest
Many students	34	34
Average score	198.41	212.79
Standard deviation	14.941	13.930
Observation max score	240	245
Observation min score	171	190
Theory max score	300	300
Criteria	Middle	Middle

3.2 Discussion

After obtaining regular and homogeneous distributed data, the study used a t-test with paired sample t-test to test the hypothesis that students' mathematics tests after learning using a scientific approach using the group investigation type cooperative learning model assisted by Desmos were better than before. The P-value of 0.000 was obtained, rejecting hypothesis H0, indicating that the study results were statistically significant.

Mathematical Communication Skills

Based on the results of the calculation analysis on mathematical communication ability, the questions were taken from a written test, considering that the test given has a relationship with mathematical communication. Students obtained an average of 74.74 for the posttest and 39.56 for the pretest, which showed that the posttest results were better than the pretest results. Reinforced by the results of the t-test with paired sample t-test, it was found that the significance value or p-value was 0.000. So, it can be concluded that H0 is rejected, meaning that applying a scientific approach to cooperative learning type group investigation assisted by Desmos on financial mathematics material improves mathematical communication skills and learning independence of class XI students of SMKN 2 Depok.

This is in line with the research of Wahyono et al. [25], who said that learning with a scientific approach has a good effect on students and even teachers because learning refers to a scientific thinking process that trains systematic thinking and is reinforced by research [2] which says that technology is a good tool to support the development of learning potential in mathematics learning. This research aligns with Rahmawati's research [26], which shows that students who use the Group Investigation type cooperative learning model show superior mathematical communication skills compared to conventional learning models.

Self-directed Learning

Based on the results of learning using a scientific approach to cooperative learning type group investigation assisted by Desmos in financial mathematics material, self-directed learning for class learning after applying the scientific approach to group investigation type cooperative learning assisted by Desmos. This is in line with

Pujianti's research [27], which states that students' level of self-directed learning is in line with their cognitive ability level, which is in line with the students' mathematical communication skills. This is strengthened by Millah's research [12], which states that students' level of self-directed learning is in line with indicators of the cognitive abilities they have mastered.

4 Conclusion

Based on the results obtained and the discussion described, the conclusions of this study are as follows: (1) This study found that the use of the scientific approach and the Desmos Group Investigation type cooperative learning model significantly improved students' mathematical communication skills and learning independence through statistical tests using the paired sample t-test; (2) This study showed the effect of the scientific approach in the Desmos-assisted cooperative learning model on improving the basic competencies of grade XI students in financial mathematics at SMKN 2 Depok; (3) The group investigation type cooperative learning model assisted by Desmos significantly improves mathematical communication skills through a scientific approach; and (4) The effect of innovative mathematics learning practices with a scientific approach in group investigation type cooperative learning assisted by Desmos to improve self-directed learning of class XI SIJA-B students at SMK Negeri 2 Depok and self-directed learning in accordance with their cognitive ability level. Based on the conclusions that have been described, some suggestions can be made as follows: (1) Future researchers are expected to look at other mathematical abilities possessed by students by applying various approaches, models, and methods using different learning media from this study; (2) Mathematics teachers are expected to design learning tools for innovative mathematics learning practices in order to improve student competencies and support skills that are important for students to have in the 21st century.

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