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Implementation of GeoGebra-based LMS canvas on conceptual understanding of geometry transformation of grade XI students

Yoga Tegar Santosa[1], Dini Wardani Maulida[2], Budi Murtiyasa[3]

[1,2,3] Master of Mathematics Education, Universitas Muhammadiyah Surakarta
*Corresponding E-mail: a418240010@student.ums.ac.id

Abstrak

Salah satu hal terpenting yang harus dikuasi siswa dalam mempelajari matematika yakni kemampuan pemahaman konsep. Namun pada kenyataannya, kemampuan pemahaman konsep siswa sering kali masih rendah. Salah satu solusi yang dapat diterapkan adalah penggunaan media pembelajaran interaktif berbasis teknologi untuk membantu siswa memahami konsep secara lebih mendalam. Oleh karena itu, tujuan dari penelitian ini adalah untuk menguji perbedaan pemahaman konsep matematika antara siswa yang menggunakan Learning Management System (LMS) Canvas berbasis GeoGebra dan yang tidak menggunakan media tersebut. Penelitian ini menggunakan jenis kuantitatif quasi-eksperimental dengan pretest and posttest non equivalent control group design. Subjek penelitian ini terdiri dari siswa XI MIPA 1 dan MIPA 2 di salah satu SMA di Boyolali, yang masing-masing berjumlah 36 siswa. Tes kemampuan pemahaman konseptual matematika yang telah divalidasi diterapkan sebagai instrumen penelitian. Statistik deskriptif dan inferensial digunakan dalam analisis data. Hasil penelitian menunjukkan bahwa terdapat perbedaan secara signifikan pada kemampuan pemahaman konsep siswa di kelas eksperimen dan kontrol. Selain itu, hasil penelitian menunjukkan bahwa dibandingkan dengan kelompok kontrol, kelompok eksperimen memiliki kemampuan pemahaman konseptual yang lebih unggul. Ini ditunjukkan oleh median dan mean rank nilai post-test siswa pada kelas eksperimen (median = 80; mean rank = 51,25) lebih tinggi daripada kelas kontrol (median = 46; mean rank = 21,75).

Kata kunci: *canvas; geogebra; learning management system; pemahaman konsep; transformasi geometri*

Abstract

One of the most important things students must learn in mathematics is conceptual understanding skills. However, students' conceptual understanding skills are often still low. One solution that can be applied is using technology-based interactive learning media to help students understand concepts more deeply. Therefore, this study aims to test the difference in conceptual understanding between students who use the Geogebra-based Learning Management System (LMS) Canvas and those who do not use the media. This study uses a quasi-experimental quantitative type with a pretest and post-test nonequivalent control group design. The research subjects comprised students in grade XI MIPA 1 and MIPA 2 at one of the high schools in Boyolali, each of which amounted to 36 students. The validated mathematical, conceptual understanding skill test is applied as a research instrument. Descriptive and inferential statistics are used in data analysis. The results showed a significant difference in student's conceptual understanding skills in the experimental and control classes. In addition, the results showed that the experimental group had superior conceptual understanding skills compared to the control group. This is demonstrated by the *median and mean rank of students' post-test scores in the experimental class (median = 80; mean rank = 51.25), higher than in the control class (median = 46; mean rank = 21.75).*

Keywords: *canvas; geogebra; learning management system; conceptual understanding; geometry transformation*

A. Introduction

Conceptually understanding is one of the most essential skills that students must acquire to learn mathematics. This is corroborated by An et al. (2004) opinions, who believe that conceptual understanding, reasoning, connections, representation, communication, and problem-solving are the skills students should possess when learning mathematics. Furthermore, the Regulation of the Minister of Education and Culture of Indonesia Number 58 of 2014 states that the primary objective of learning mathematics is conceptual understanding (Mendikbud RI, 2014).

Mathematical conceptual understanding is a person's skill to understand, internalize, and relate mathematical concepts to be applied in various situations (Perry & Len-Ríos, 2019; Sengkey et al., 2023). A good mathematical conceptual understanding helps students understand the essence of the teaching material in depth and build a strong foundation to achieve mathematics learning goals at a higher level (Nasution & Hafizah, 2020; Yunita et al., 2020). Furthermore, Lisnani (2019) explained that students with a good conceptual understanding can record, understand, apply, and modify a concept to solve various variations of problems and mathematical problems.

Although conceptual understanding has a crucial role in mathematics learning, the reality is that students' mathematical conceptual understanding skills are often at a low level (Kurnia et al., 2024; Ulpah & Zaenurrohman, 2020). This is supported by observations and initial interviews with mathematics teachers and several students at a high school in Boyolali Regency, which shows that students' conceptual understanding skills, especially on geometric transformation, are still relatively low. Students cannot define types of geometric transformations, such as reflection, translation, rotation, and dilation, using their language. In addition, some students often make mistakes in providing examples of the application of geometric transformations in daily life and tend to make mistakes in choosing the correct procedure to solve problems related to geometric transformations. This condition has an impact on students' low mastery of the topic of geometric transformation. Mastery of this topic is essential for studying other mathematical materials, such as functions, vectors, and the equation theorem (Yılmaz, 2015). Consequently, there is an urgent need to address the pupils' inadequate grasp of mathematical concepts, particularly geometric transformation. Furthermore, Figure 1 shows an example of a student's error in applying the procedure for reflection over the line y = −x. The student mistakenly used the concept of reflection over the y-axis instead.

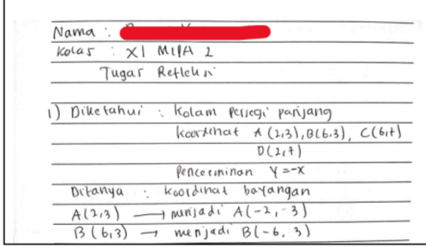
Original Version	Translated Version
	1) Known: Rectangular pool Coordinate: A(2,3), B(6,3), C(6,7), D(2,7) Reflection y = -x Asked: Coordinate image A(2,3) → to A(-2,3) B(6,7) → to B(-6,3)

Figure 1. The Example of Student Conceptual Error Answer

Students' low mathematical conceptual understanding can be remedied by using interactive multimedia (Etyarisky & Marsigit, 2022). One of the digital learning platforms that supports the use of interactive multimedia is Learning Management System (LMS). LMS is a system that allows users to create, organize, and disseminate high-quality educational materials using the Internet (Alia, 2022). An LMS facilitates instruction, assists in organizing course materials within an online learning environment, and grants users unrestricted access to course materials, allowing for easier tracking of students' progress toward course objectives (Ohliati & Abbas, 2019). The use of LMS allows collaboration between teachers and students. Teachers act as platform managers, while students can use it to learn more effectively and efficiently (Shafa, 2024). According to Swerzenski (2021), one of the recommendations for LMS that has good performance in the field of mathematics is Canvas.

LMS Canvas is a web-based platform and application that provides interactive features to support the learning process for teachers, lecturers, students, and parents (Nurjati et al., 2021; Santiana, 2024; Swerzenski, 2021). Each feature on the LMS Canvas is designed to help teachers manage the learning content provided to students. This platform also monitors students' academic progress through assignments, discussions, quizzes, and grade management, as well as providing and receiving feedback (Dang, 2020). LMS Canvas allows teachers to deliver learning in various forms, such as books, modules, videos, images, audio, and collaboration with Geogebra, all automatically connected to students through registered emails (Ataby, 2021). The cooperation between Geogebra and Canvas allows students to be directed directly to the Geogebra application to observe and solve problems to understand the concept of the material conveyed through the application (Hapizah et al., 2022). In addition, Geogebra aids in attaining educational objectives by facilitating students' conceptual understanding, problem-solving abilities, depth of knowledge, and practical and fast visualization of learning materials (Nur et al., 2017). In addition, Geogebra combines geometry, algebra, and calculus so that users can explore mathematical concepts more comprehensively (Hohenwarter et al., 2009; Riska et al., 2023).

A lot of research has been done on the application of LMS in mathematics learning. Some of them were carried out by (1) Amalia et al. (2021) regarding Problem-Based Learning assisted by Google Classroom on students' conceptual understanding, (2) Wati et al. (2021) about the results of using the Chamilo LMS's basic harmonic motion content in the classroom, (3) Rizqi & Subanji (2021) about mathematics learning using Google Sites with Geogebra, (4) Benita & Kusuma (2022) regarding the analysis of the effectiveness of the implementation of the LMS e-learning platform for students, (5) Ajasa & Adu (2022) regarding the analysis of LMS education platforms in South Africa, and (6) Aziz et al. (2024) regarding the analysis of the use of LMS as a learning medium for students. However, there has been no specific research on applying Geogebra-based LMS Canvas to students' conceptual understanding of geometric transformation materials. Therefore, a study is needed to investigate the application of Geogebra-based LMS Canvas to conceptual understanding in geometric transformation materials. This study can provide empirical evidence that supports the contribution of the application of Geogebra-based LMS Canvas to conceptual understanding in geometric transformation materials.

In light of the description, this study aims to test the difference in conceptual understanding between students who use the Geogebra-based LMS Canvas and students who don't use the media. The hypothesis is that students who obtain mathematics learning using Geogebra-based LMS Canvas have better conceptual understanding skills than students who don't use the media.

B. Research Methods

This research is quantitative. Quantitative research is research based on the positivism philosophy, applied to a specific population or sample by collecting data using research instruments and quantitative data analysis to test hypotheses that have been formulated (Sugiyono, 2019). The quasi-experimental design with pretest and post-test nonequivalent control group was applied to this study (Creswell & Creswell, 2017). Figure 2 shows the quasi-experimental design applied to this study. Two variables are used in this study: Geogebra-based LMS Canvas as an independent variable and students' conceptual understanding skills as a dependent variable.

Experimental Class : P_1 X Q_1
\- - - - - - - - - - - - -
Control Class : P_2 (-) Q_2

Notes:
P_1 and P_2 : Pre-test
Q_1 and Q_2 : Post-test
X : Implementation of Geogebra-Based LMS Canvas
(-) : No treatment
\- - - - - - - - - : Subjects were not selected randomly

Figure 2. Research Design

Six classes of grade XI students from one of the state senior high schools in Boyolali Regency were the population of this study. Because this study uses a pretest and post-test nonequivalent control group design, the sample was not randomly selected (Sutama et al., 2022). Thirty-six students from Class XI MIPA 1 served as the experimental group, and thirty-six students from Class XI MIPA 2 served as the control group. The research sample consisted of students in class XI MIPA 1 as an experimental class and XI MIPA 2 as a control class, with 36 students in each class. The experimental class was given a geometry transformation learning treatment using a Geogebra-based LMS Canvas. Meanwhile, the control class was not given the treatment of learning geometry transformation using the media but obtained geometry transformation learning using textbooks. The research was conducted in the September-November 2024 period.

This study uses a conceptual understanding test in mathematics as its instrument. The test consists of five essay questions adjusted to the conceptual understanding indicators (see Table 1). Before data collection, the instrument was validated by two expert validators in the field of mathematics education. The validation sheet consists of 14 statements grouped into three categories: 1) mathematical conceptual understanding, 2) high school students' characteristics, and 3) good-quality questions. Furthermore, the assessment of the two validators was analyzed using the Cohens Kappa interrater reliability test to measure the agreement rate between the two (McHugh, 2012). If the rate of agreement is high, then the analysis continues to test the validity of the content using the Content Validity Index (CVI) based on the Aiken Coefficient Value (Aiken, 1980). Cohens Kappa's inter-rater reliability test using SPSS 16 showed an agreement rate score of 0.70 for both validators (see Figure 3). Thus, the agreement rate of the two validators is high (Viera & Garrett, 2005) so that it can proceed to the content validation stage. The results of the content validation showed that the CVI values for each question were 0.8, 0.79, 0.82, 0.85, and 0.8. Therefore, the five questions were declared valid.

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.696	.128	5.831	.000
N of Valid Cases		70			

Figure 3. Cohen's Kappa Test Results

Table 1. Conceptual Understanding Indicators

Student' Skill	Indicators
Conceptual Understanding	Restating a concept
	Classifying objects according to specific properties
	Providing examples and non-examples of concepts
	Presenting concepts in various forms of mathematical representation

	Developing the necessary condition or sufficient condition of a concept
	Using, utilizing, and selecting specific procedures or operations
	Applying a problem-solving concept or algorithm

Source: Sumarmo (2014)

After that, the conceptual understanding test instrument is given at the pretest and post-test stages. The pretest stage is carried out before providing treatment, which aims to determine whether students in the experimental and control classes have balanced conceptual understanding skills. This is the basis for feasibility in determining the research subject. Meanwhile, the post-test stage is carried out after providing treatment to analyze the differences in students' conceptual understanding skills in both classes.

Both descriptive and inferential statistical tests were used to analyze the data. For inferential statistical tests, an independent sample t-test is used. Before implementing the test, a prerequisites test is carried out first, namely a normality and homogeneity test. If one of the prerequisites is unmet, the analysis continues using the Mann-Whitney test (Nikitina & Chernukha, 2022). The independent sample t-test and the Mann-Whitney test were used to analyze whether there was a significant difference in the students' conceptual understanding skills in experimental and control classes. Descriptive statistics will determine which class has better conceptual comprehension skills if there is a significant difference. The data analysis process was carried out with the help of SPSS 16.

C. Result and Discussion

Result

The researcher conducted a pretest in the experimental and control classes before providing treatment (mathematics learning using a Geogebra-based LMS Canvas). The results of this pretest are used to determine whether both classes meet the eligibility as research subjects. This eligibility is determined based on the equivalence of students' conceptual understanding in both classes (there is no significant difference between the two). A parametric independent sample t-test was carried out to test the equivalence. However, it is necessary to carry out statistical prerequisite tests to ensure that the pretest score data from both classes is normally distributed and has homogeneous variances.

The normality test uses the Shapiro-Wilk formula because both classes have many samples of less than 50. To find the variance of the two classes, the test of homogeneity employs Levene test. The significant value of the experimental and control classes is higher than the significance level ($\alpha = 0.05$), according to the normality test findings displayed in Figure 4. Thus, the data of the pretest scores of the two classes is normally distributed.

	Shapiro-Wilk		
	Statistic	**df**	**Sig.**
Experiment	.967	36	.343
Control	.943	36	.063

Figure 4. Result of Normality Test Pretest Score

Figure 5 shows the homogeneity test results of the pretest values of the experimental and control classes. The value of Sig. = 0.626 > α = 0.05 was obtained, so the two classes have homogeneous variances.

	Levene's Test for Equality of Variances			
	Levene Statistics	**df1**	**df2**	**Sig.**
Pre-test Score	0.240	1	70	0.626

Figure 5. Result of Homogeneity Test Pretest Score

An independent sample t-test can be used to continue analyzing the pretest data as the conditions for normality and homogeneity have been satisfied. The test investigates the difference in students' conceptual understanding skills in the experimental and control classes. Below is the hypothesis that was tested using the independent sample t-test.

H_0: There was no significant difference in the pretest results of students' conceptual understanding skills in both classes.

H_a: There was a significant difference in the pretest results of students' conceptual understanding skills in both classes.

If the significance value is less than the significance level α = 0.05, then H_0 is rejected. If the significance value equals or exceeds the significance level α = 0.05, then H_0 is accepted. Figure 6 showed a significant value of 0.689, greater than α = 0.05. This indicates that H_0 is accepted. Thus, the pretest results of students' conceptual understanding skills in the experimental and control classes did not significantly differ. In other words, students in both classes have balanced conceptual understanding skills before being given treatment. This is also supported by the results of descriptive statistics in Figure 7, which show that the average scores of the two classes do not show a sharp difference. Therefore, both classes meet the eligibility requirements for use as research subjects.

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Low	Upper
Score	Equal variances assumed	-.402	70	.689	-.972	2.419	-5.797	3.852

Figure 6. Results of Independent Sample T-test Pretest Score

Class	N	Mean	Std. Deviation	Std. Error Mean
Experiment	36	37.67	10.762	1.794
Control	36	38.64	9.737	1.623

Figure 7. Descriptive Statistics Pretest Score

Next, the post-test stage was carried out after the researcher provided treatment in mathematics learning using a Geogebra-based LMS Canvas. The post-test results were used to test the difference in student's conceptual understanding skills in the experimental and control classes. Before that, a prerequisite test for normality and homogeneity was first carried out.

	Shapiro-Wilk		
	Statistic	df	Sig.
Experiment	.932	36	.030
Control	.960	36	.211

Figure 8. Result of Normality Test Posttest Score

The control class's significance value (Sig. = 0.211 > α = 0.05) was higher than the significance level, according to the normality test findings shown in Figure 8. Nevertheless, the experimental class's significance value was lower than the significance level (Sig. = 0.03 < α = 0.05), indicating that the class's post-test score data did not follow a normal distribution. Thus, it can be understood that the normality prerequisite test is not met, so the post-test data analysis is continued using the Mann-Whitney test. The hypothesis tested in Mann-Whitney is as follows.

H_0: There was no significant difference in the post-test results of students' conceptual understanding skills in both classes.

H_a: There was a significant difference in the post-test results of students' conceptual understanding skills in both classes.

If the significance value is less than the significance level α = 0.05, then H_0 is rejected. If the significance value equals or exceeds the significance level α = 0.05, then H_0 is accepted. Based on the Mann-Whitney test in Figure 9, the value of Sig. = 0.000 < α = 0.05 was obtained. This indicates that H_0 is rejected. Thus, the post-test results of students' conceptual understanding skill in the experiment and control classes significantly differ. In other words, students in both classes have different conceptual understanding skills after being given treatment.

Test Statistics[a]

	Posttest
Mann-Whitney U	117.000
Wilcoxon W	783.000
Z	-5.984
Asymp. Sig. (2-tailed)	.000

Figure 9. Results of Mann-Whitney Test Post-test Score

Furthermore, a descriptive statistical analysis was conducted on the post-test results to determine a class with better conceptual understanding skills. Table 2 presents the descriptive statistical results of post-test scores, which show that the median post-test score of the experimental class is 80, higher than the median of the control class of 46. Thus, students in the experimental class who received treatment using Geogebra-based LMS Canvas had better conceptual understanding skills than those in the control class who did not. This finding is reinforced by Figure 10, which shows that the mean rank value of the experimental class is higher than that of the control class.

Table 2. Descriptive Statistics Post-test Score

	Experiment	**Control**
N	36	36
Mean	75.0556	45.667
Median	80.00	46.00
Std. Deviation	18.601	7.921
Range	63.00	32.00

Mann-Whitney

Ranks

	Class	N	Mean Rank	Sum of Ranks
Posttest	Experiment	36	51.25	1845.00
	Control	36	21.75	783.00
	Total	72		

Figure 10. Ranks of Post-test Score

Discussion

The skills of grade XI students at one of the Boyolali High Schools to understand mathematical concepts in geometry transformation material are relatively low. The researcher then used LMS Canvas by integrating

Geogebra software in mathematics learning. This integration aims to provide a more interactive and visual learning experience, so it is expected to help students better understand the concept of geometric transformation.

Implementing LMS Canvas integrated with Geogebra in mathematics learning has several stages. At the orientation stage, students access LMS Canvas, which contains general information, concept maps, and introductory videos explaining the application of geometric transformations in everyday life to build initial understanding. Furthermore, at the exploration stage, students study the material through "Modules" equipped with interactive Geogebra activities, where they can manipulate objects dynamically to understand the concept of geometric transformation visually. At the conceptualization stage, students work on practice questions in LMS Canvas and discuss them in forums to deepen their understanding. Then, at the application and evaluation stage, students complete contextual problem-based assignments and take quizzes and final tests through LMS Canvas, providing direct feedback on their learning outcomes. The integration of LMS Canvas with Geogebra in this learning facilitates independent exploration of concepts and provides a systematic and interactive learning structure to improve students' mathematical conceptual understanding.

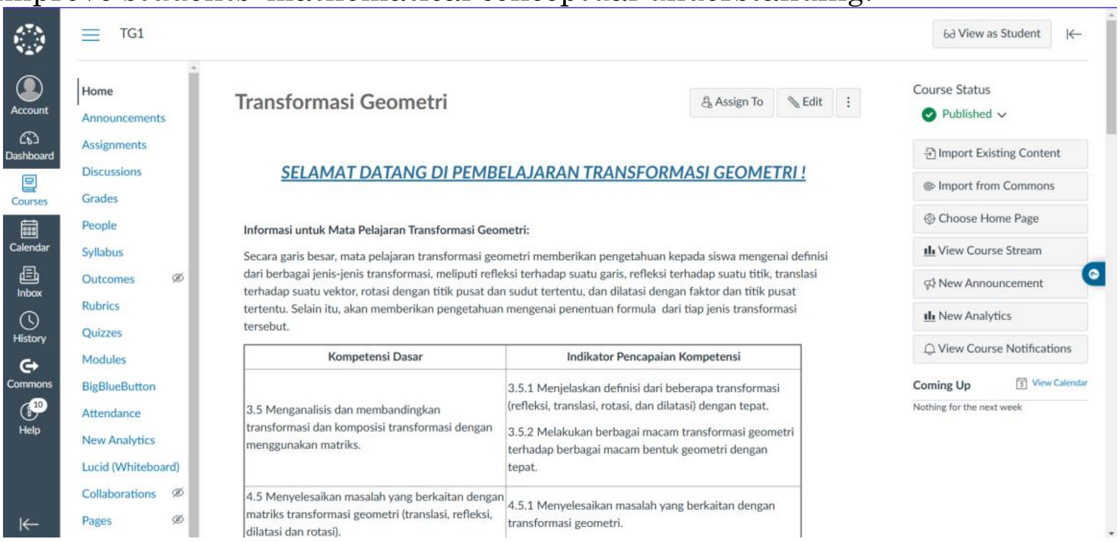


Figure 11. Geometry Transformation Canvas LMS Initial View (1)

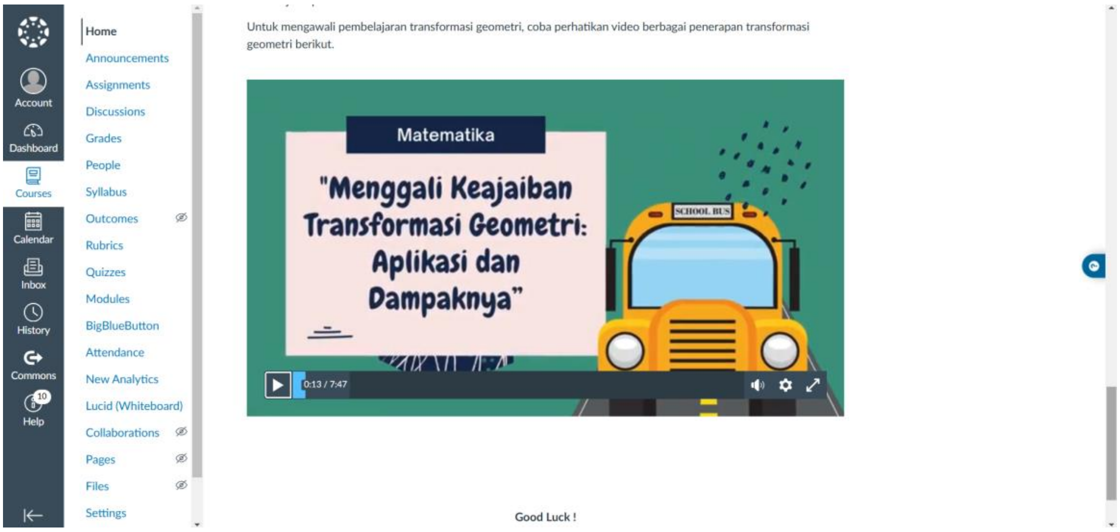


Figure 12. Geometry Transformation Canvas LMS Initial View (2)

Figures 11 and 12 show the LMS Canvas homepage view for the geometry transformation material created. The homepage contains general information about geometry transformation materials, essential competencies, instructions for students to use LMS Canvas, learning concept maps, and introductory videos showing various examples of applying geometric transformations in daily life. This kind of video presentation is intended as a first step to help students understand mathematical concepts better (Rohmah & Setyaningrum, 2022; Sitepu & Siregar, 2023).

Geogebra integration in LMS Canvas is found in the Modules section, which contains topics on geometry transformation (see Figures 13 and 14). Interactive Geogebra activities accompany each topic to help students understand concepts visually and practically. Hayati & Ulya (2022) explained that using Geogebra has proven effective in improving students' conceptual understanding of various geometric topics, especially transformation geometry because it provides a dynamic and interactive picture that makes it easier for students to explore geometric properties.

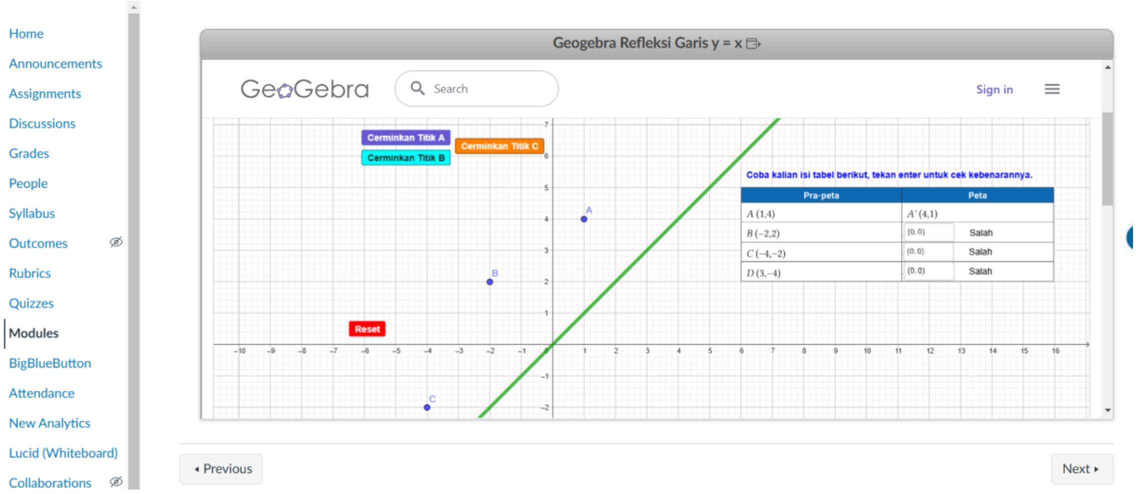


Figure 13. Example of GeoGebra in LMS Canvas Reflection Topic

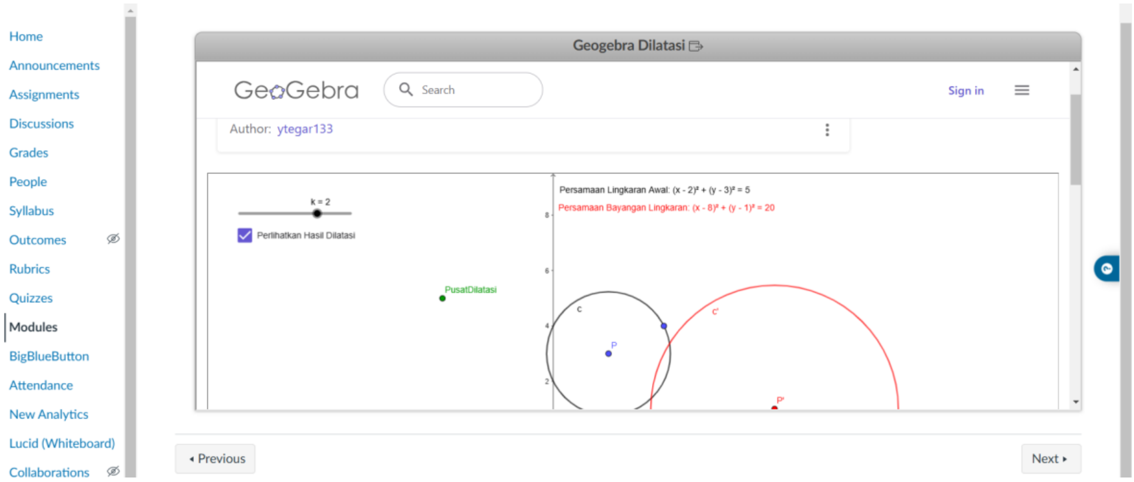


Figure 14. Example of Geogebra in LMS Canvas Dilatation Topic

In this study, the application of Geogebra-based LMS Canvas is proven to have a positive effect on students' mathematical conceptual understanding, especially on the topic of geometric transformation. This is shown by the results of the Mann-Whitney test on the mathematical conceptual understanding post-test score, which obtained a significance value of $0.000 < \alpha = 0.05$. These results show a significant difference in student's conceptual understanding skills in the experimental and control classes. Furthermore, descriptive statistical analysis revealed that the median and mean rank of the post-test scores of students in the experimental class were higher than those of students in the control class. Thus, students in the experimental class had better mathematical conceptual understanding than those in the control class.

This finding is relevant to the research of Febriani et al. (2024), which shown that students' conceptual understanding and problem-solving skills in mathematics may be enhanced by including the Geogebra application in mathematics learning models and media. Another relevant research study was conducted by Lisnawati et al. (2024), which showed that integrating Geogebra on the Google Meet platform had positively impacted students' conceptual understanding of mathematics learning. Then, another study by Wibowo et al. (2025) showed that developing a specific platform-based LMS can improve students' understanding of mathematical concepts. In addition, in their research, Suratno & Waliyanti (2023) incorporating Geogebra into mathematics lessons has been shown to assist students in selecting and implementing efficient methods for solving mathematical problems. Furthermore, the ability to choose and apply the right strategies and concepts in solving mathematical problems is one of the characteristics of a good understanding of students' mathematical concepts (Febriani & Sidik, 2020).

This finding is important because mathematics learning in the modern era urgently needs technology support (Pagau & Mytra, 2023). As a form of technology, LMS Canvas is essential in supporting students' mathematical conceptual understanding by providing a structured, interactive, and flexible learning environment (Furqon et al., 2023). Students can access materials systematically through the learning module feature, from fundamental theories to examples of geometric transformation applications. Discussion and forum features allow students to collaborate, exchange understanding, and get feedback from teachers and peers. In addition, interactive assignment and quiz features help students test their knowledge independently with direct feedback. Integrating Geogebra in LMS Canvas further strengthens learning with dynamic concept visualizations so students can intuitively explore the relationships between geometric transformation elements (Ali & Anwar, 2021). With its ability to adaptively present materials and support various learning styles, LMS Canvas increases student engagement and deepens mathematical conceptual understanding.

D. Conclusion

The significant value of the Mann-Whitney test on the data from the post-test scores was $0.000 < \alpha = 0.05$. Therefore, students in the experimental and control classes significantly differ in conceptual understanding skills. Furthermore, the descriptive statistical test results showed that the experimental class got a median post-test score of conceptual understanding of 80 and the control class 46. This indicates that students in the experimental class who participated in learning geometric transformation using the GeoGebra-based LMS Canvas had better conceptual understanding skills than those in the control class who did not know the media. Thus, the application of GeoGebra-based LMS Canvas has proven effective in helping students understand the concept of geometric transformation. The results of this research can be used as an alternative solution to the problem of students' low skill in understanding mathematical concepts, especially on the topic of geometric transformation.

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