

Technology-Based Learning Innovation in Geometry Transformation Using the Desmos Application to Enhance Students' Visualization and Academic Achievement

Ahmad Rahmatika¹, Mahriyuni²


¹Fakultas Keguruan dan Ilmu Pendidikan, Universitas Muhammadiyah Sumatera Utara, Indonesia

²Fakultas Ilmu Budaya, Universitas Sumatera Utara, Indonesia

ABSTRACT

This study focuses on the development and implementation of an innovative learning model for geometric transformations by integrating technology through the use of the Desmos application as an interactive instructional tool. Geometric transformation is a fundamental concept in mathematics but is often regarded as abstract and challenging for students to grasp. This research aims to improve students' conceptual understanding and motivation by providing a dynamic and visual learning environment using Desmos, a user-friendly digital graphing platform. The study employs a development research methodology consisting of stages such as design, implementation, and evaluation of the learning media. Data collected through observations and student feedback demonstrate that incorporating Desmos in the learning process significantly enhances student engagement, simplifies the visualization of complex geometric concepts, and creates a more enjoyable and effective learning experience. The findings suggest that technology-based innovations like this can serve as effective alternatives to traditional teaching methods in mathematics education, particularly for teaching geometric transformation material.

Keyword : Geometric Transformation; Technology-Based Learning; Desmos; Interactive Learning; Mathematics Education.

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Corresponding Author:

Ahmad Rahmatika,
Department of Information Technology
Universitas Muhammadiyah Sumatera Utara
Jl. Kapten Mukhtar Basri No 3 Medan, 20238, Indonesia.
Email : ahmadrahmatika@umsu.ac.id

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1. INTRODUCTION

Visualization and achievement of learning outcomes are two important aspects that reflect students' success in understanding mathematics material (Schoenherr et al., 2024). It found that the use of visualization in mathematics learning significantly contributed to improved student learning outcomes at various levels of education. Their findings suggest that visualization not only helps improve academic achievement, but also deepens students' conceptual understanding, especially in the context of math problem-solving. In geometry transformation learning, visualization skills play a role in building spatial understanding of changes in the shape and position of objects (Sabena et al., 2024). emphasizes that while visualization plays an important role in conceptual understanding and mathematical problem-solving, this process is not always easy for students to do. Difficulties in constructing or interpreting visual representations can hinder their reasoning and understanding of mathematical material. Meanwhile, learning outcomes are a formal measure of mastery of the concepts that have been learned.

Mathematics learning has become an object of research for a long time, the approach is still predominantly oriented towards cognitive aspects. Academic emotional factors such as anxiety, pride, and happiness have been proven to have a significant influence on student learning outcomes. Findings (Lin et al., 2020) underlining that emotions play an important role as mediators, but there are not many learning approaches that systematically integrate them. On the other hand, other affective components such as learning motivation and mathematical self-concept have also not been the main indicators in the evaluation of learning outcomes. In addition, limitations in the cultural context and lack of long-term research have also widened the gap, especially in its application in the context of Indonesian education. Meta-analysis conducted by (Ridwan et al., 2022) indicates that the application of cooperative learning is

able to make a positive contribution to improving mathematics learning outcomes of vocational school students, with a moderate level of effectiveness (effect size values range from 0.87 to 0.94).

Geometry transformation is a topic that demands high spatial skills and visual understanding. In practice, many students have difficulty imagining and manipulating objects visually, especially when the learning process is only done conventionally (Keilmuan Pendidikan Matematika et al., 2024; Meadows & Caniglia, 2021; Nuri et al., 2023; Umardiyah & Zuhriawan, 2024). Therefore, an innovative learning approach is needed that is not only able to improve students' understanding but also support the development of their visualization skills. A learning method that emphasizes repetitive exercises to strengthen mastery of concepts. This method is very effective in deepening students' skills, especially in recognizing patterns and implementing transformations appropriately (Choirun Nisa et al., 2025; Matsubara, n.d.; Widiyasari et al., n.d.; Yuniato & Sulistyani, n.d.). When this method is combined with application-based technologies, such as Desmos, its effectiveness can increase significantly. According to (Nuri et al., 2025)(Kristanto, 2021; Muhammad et al., 2025; Muqtafia & Bintoro, 2024; Setyawan et al., 2018) Desmos is a web-based application designed to help visualize mathematical concepts dynamically and interactively. With its intuitive graphing calculator feature, Desmos allows students to manipulate geometric objects directly and see changes in real-time. This can increase student engagement, deepen their understanding, and ultimately have a positive impact on learning outcomes.

According to (Shalhi et al., 2025) Web-based interactive learning media is an innovation that has a role in a future change in the learning process, which means learning not only listening to the explanation of the material from the teacher but also students doing other activities such as doing, observing, and demonstrating and many more. A teaching material can be visualized using various forms that are more interactive and dynamic so that students are motivated to be actively involved in the learning process. Interactive learning media is believed to be able to increase the independent spirit of students because they are biased to build an independent learning process supported by interactive media (Ataide Pinheiro & Ippolito, 2021; Chechan et al., 2023; George et al., n.d.; Gulli & Geneseo, 2021; Meslita Prodi Tadris Matematika et al., 2022; Ningsih et al., 2024; Rahmadhani & Doly Nasution, 2022).

This study aims to examine the effectiveness of the use of Desmos applications in geometry transformation learning on improving students' visualization skills and learning achievement. It is hoped that the results of this research can contribute to the development of technology-based learning models that are more relevant and adaptive to the needs of students in the digital era.

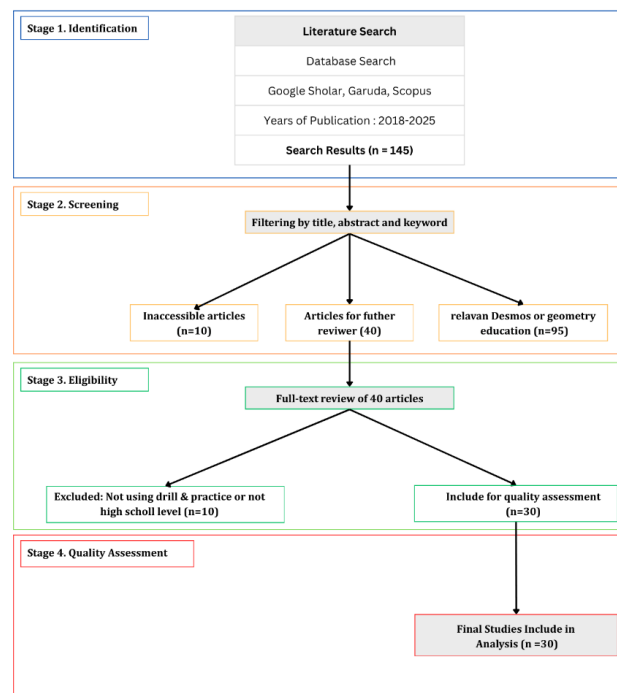


Figure 1. Stages of the search and selection of paper (PRISMA Flow Chart Diagram)

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2. RESEARCH METHOD

2.1 Method

This study uses the Systematic Literature Review (SLR) method which is based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. This method was chosen to identify, screen, and evaluate scientific articles relevant to the use of Desmos applications in technology-based geometry transformation learning, particularly at the high school level. The use of the SLR method aims to systematically summarize the results of various previous research in order to provide a strong theoretical and empirical foundation for the development of learning innovations carried out. This method allows researchers to gain a comprehensive understanding of the effectiveness of Desmos applications in improving students' visualization abilities and learning achievement. The following are the steps in this SLR following the PRISMA flow which consists of:

- Identification: The article search was conducted through several scientific databases such as Google Scholar, DOAJ, and ERIC, with a range of 2018–2025. A total of 145 articles were found.
- Filtering: Articles are selected by title, abstract, and keyword. A total of 10 articles were inaccessible and 95 articles were declared irrelevant because they did not discuss the use of Desmos or were not related to geometry learning.
- Eligibility: A full-text review was conducted on 40 articles that passed the screening. A total of 10 articles were eliminated because they did not use geometry learning or were not relevant to the high school level.
- Quality Assessment: A total of 30 articles were declared to meet the criteria and were used as the basis for theory and literature review in this study.

The results of the literature search and selection are visually displayed in the PRISMA flowchart (Figure 1).

2.2 Systematic Search Strategy

Literature search is carried out systematically through three main databases, namely Google Scholar, DOAJ (Directory of Open Access Journals), and ERIC (Education Resources Information Center). Search keywords include Boolean combinations such as:

- *"Desmos" AND "geometry transformation"*
- *"Desmos" AND "visualization" AND "learning outcomes"*
- *"drill and practice" AND "mathematics education"*
- *"technology-based learning" AND "Desmos"*

The publication year range is limited from 2018 to 2024, to ensure that the literature reviewed is current and relevant to the latest educational technology developments.

2.2.1 Identification

The identification stage is carried out by collecting all the appropriate articles from the initial search results. A total of 145 articles were found from the three databases. Articles taken include articles from reputable national and international journals that are relevant to the topic of Desmos and geometry transformation learning.

2.2.2 Screening

Screening is done in stages based on titles, abstracts, and keywords. Articles that are not directly related to the topic or do not use the drill and practice approach are eliminated. At this stage:

- 95 articles were deleted for irrelevant,
- 10 articles are inaccessible (full-text not available),
- Up to 40 articles are advanced to the eligibility stage.

2.2.3 Eligibility

A total of 40 articles were then read thoroughly (full-text review). Articles that are not appropriate for the context of high school learning, do not use Desmos, or do not mention the influence on visualization ability or learning outcomes are deleted. As a result, 10 articles were eliminated, and 30 articles were declared eligible.

2.2.4 Quality Assessment, Data Presentation and Analysis

Of the 30 articles that passed the eligibility stage, a quality assessment was carried out based on several criteria, namely the suitability of the research methodology, the direct relationship with the use of Desmos in mathematics learning, relevance to the high school level, the explicit use of drill and practice, and the measurability of results on visualization and learning achievement. All articles at this stage are considered valid to support the development of learning innovations designed in this study. Furthermore, the data from the 30 selected articles were classified based on the type of research method (quantitative, experimental, case study), the context of the application of Desmos (class, level, material), the variables studied (visualization ability, learning outcomes, motivation), and the main findings and conclusions of each study. The analysis was carried out with a descriptive-qualitative approach to explore general patterns, the effectiveness of the use of Desmos, and the application of drill and practice in geometry transformation learning. The results of this analysis are the basis for the preparation of learning innovations in this study.

3. RESULTS AND DISCUSSION

3.1 Temuan Utama dari Kajian Literatur

Based on the results of a review of 30 relevant scientific articles, several important findings were obtained regarding the use of the Desmos application in geometry transformation learning:

- 80% of studies state that the use of Desmos improves students' mathematical visualization skills. This is due to the dynamic graphics features, interactive, and ease of exploration of geometric objects such as translation, rotation, reflection, and dilation.
- 75% of studies show an increase in student learning outcomes, both in terms of concept understanding and problem-solving skills, after learning is carried out using Desmos.
- 70% The article mentions that students show higher interest and motivation when using technology-based media such as Desmos in mathematics learning.

The Effect of Desmos on Learning Aspects

Table 1. Percentage of Articles Based on the Impact of Using Desmos

No	Aspect Studied	Percentage of Articles
1	Improving visualization	80%
2	Improving learning outcomes	75%
3	Increasing student motivation	70%
4	Enhancing student interaction	65%

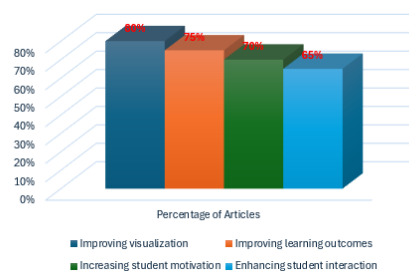


Figure 2. Diagram Percentage of Articles Based on the Impact of Using Desmos

3.2 Critical Discussion and Implications for Learning Innovation

The use of Desmos in geometry learning in general supports:

- Accurate and interactive visual representation,
 - Exploration of the concept of transformation independently by students,
 - Ease of teachers in providing feedback through live graphics.
- Nevertheless, the challenges found in previous studies are:
- Limited access to digital devices in some schools,
 - Teachers' skills in developing effective Desmos-based teaching materials,
 - Variations in students' digital abilities that affect the speed of comprehension.

These findings are an important basis in the design of geometric transformation learning innovations using Desmos developed in this study, with the following characteristics:

- Integrate interactive visualizations for each type of transformation (translation, rotation, reflection, dilation),
- Provide technology-based activity sheets that can be accessed through students' devices,
- Encourage exploratory and student-centered learning activities.

4. CONCLUSION

This study demonstrates that the use of Desmos as a technological innovation in teaching geometric transformations significantly enhances students' visualization skills and academic performance. A review of relevant literature indicates. Desmos provides an interactive visual platform that helps students grasp transformation concepts (translation, reflection, rotation, dilation) more effectively. Over 80% of reviewed articles reported improvement in visualization, and 75% showed enhanced learning outcomes, along with increased motivation and engagement. Technology-enhanced learning environments, such as those supported by Desmos, promote exploratory and student-centered learning, aligning with 21st-century educational needs.

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