

**THE IMPROVEMENT OF JUNIOR HIGH SCHOOL STUDENTS'  
MATHEMATICAL REPRESENTATION ABILITY THROUGH DEEP LEARNING  
ASSISTED BY DESMOS ON THE TOPIC OF TWO-VARIABLE LINEAR  
EQUATION SYSTEMS (SPLDV)**

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**ABSTRAK**


Kemampuan representasi matematis merupakan keterampilan penting yang membantu siswa memahami dan mengomunikasikan konsep matematika. Namun, kemampuan tersebut pada materi Sistem Persamaan Linear Dua Variabel (SPLDV) masih relatif rendah sehingga diperlukan pembelajaran yang lebih inovatif. Penelitian ini bertujuan menganalisis pengaruh pembelajaran *Deep Learning* berbantuan Desmos terhadap kemampuan representasi matematis siswa. Kebaruan penelitian terletak pada integrasi pendekatan *Deep Learning* dan aplikasi Desmos pada pembelajaran SPLDV di tingkat SMP. Penelitian menggunakan metode eksperimen semu dengan desain *pretest-posttest control group*. Subjek penelitian terdiri atas 30 siswa kelas VIII SMP IT Permata Hati Tebing Tinggi yang dibagi ke dalam kelas eksperimen dan kelas kontrol. Data dikumpulkan melalui tes kemampuan representasi matematis sebelum dan sesudah pembelajaran, kemudian dianalisis menggunakan uji normalitas, homogenitas, dan *Independent Samples T-Test*. Hasil penelitian menunjukkan bahwa rata-rata *posttest* kelas eksperimen lebih tinggi dibandingkan kelas kontrol dengan nilai  $t(28) = 16,8$  dan  $p < 0,001$ . Temuan ini menunjukkan bahwa pembelajaran *Deep Learning* berbantuan Desmos berpengaruh positif dan lebih efektif dalam meningkatkan kemampuan representasi matematis siswa pada materi SPLDV.

**Kata Kunci:** *Deep Learning, Desmos, Kemampuan Representasi Matematis, SPLDV.*

**ABSTRACT**

Mathematical representation skills play a crucial role in enabling students to comprehend, express, and communicate mathematical ideas effectively. However, students' representation abilities in the topic of Systems of Linear Equations in Two Variables (SLETV) remain insufficient, indicating the need for more engaging and innovative instructional approaches. This study aimed to examine the effect of a Deep Learning approach supported by Desmos on students' mathematical representation skills. The novelty of this research lies in integrating Deep Learning principles with the Desmos application in SLETV instruction at the junior high school level. A quasi-experimental method employing a pretest–posttest control group design was implemented. The participants were 30 eighth-grade students from SMP IT Permata Hati Tebing Tinggi, divided into an experimental group and a control group. Data were collected through mathematical representation tests administered before and after the intervention and analyzed using normality, homogeneity, and Independent Samples t-tests. The findings revealed that the experimental group achieved a significantly higher posttest mean score than

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the control group, with  $t(28) = 16.8$  and  $p < .001$ . These results indicate that Deep Learning instruction supported by Desmos has a positive and significant impact on enhancing students' mathematical representation skills in learning SLETV.

**Keywords:** *Deep Learning, Desmos, Mathematical Representation Ability, Systems of Linear Equations in Two Variables (SLETV).*

## INTRODUCTION

Mathematical representation skills are one of the essential competencies in mathematics learning because they enable students to express mathematical ideas in various forms, such as symbols, graphs, tables, and verbal explanations (Suningsih & Istiani, 2021). These skills help students connect abstract concepts with concrete mathematical representations, thereby supporting meaningful problem-solving processes (Andriliani et al., 2022). Mathematical representation also plays an important role in helping students interpret, transform, and communicate mathematical information logically and systematically. Therefore, the development of representation skills has become an important focus in mathematics education.

However, students' mathematical representation skills are still relatively low. Many students experience difficulties in transforming contextual problems into mathematical models, interpreting graphs, and explaining mathematical solutions verbally (Suningsih & Istiani, 2021). Similar findings were reported by Damayanti and Prasetyono (2024), who found that students frequently made representation errors when solving Systems of Linear Equations with Two Variables (SPLDV) problems. Preliminary observations conducted at SMP IT Permata Hati Tebing Tinggi also revealed that several eighth-grade students experienced difficulties in drawing graphs correctly and connecting equations with their graphical representations. In addition, approximately 65% of students relied mainly on procedural calculations without being able to explain the meaning of the obtained solutions. These conditions indicate that students' conceptual understanding and mathematical representation skills still need improvement through more meaningful and interactive learning approaches.

One mathematical topic that strongly requires representation skills is Systems of Linear Equations with Two Variables (SPLDV). In this topic, students are expected to integrate symbolic, visual, and verbal representations simultaneously. Students need to understand that the intersection point of two lines represents the solution to the system of equations. Nevertheless, students often struggle to connect equations, tables, and graphs comprehensively (Sulaiman et al., 2024). Muqoddaroh and Maharani (2024) also reported that students still experience difficulties in understanding graphical visualization concepts in SPLDV learning. These findings indicate the need for instructional innovation that can facilitate students in visualizing and connecting mathematical concepts more effectively.

One factor contributing to these difficulties is the learning process, which is still dominated by teacher-centered instruction and procedural problem-solving activities. Such conditions limit students' opportunities to actively construct conceptual understanding. To address this issue, a learning approach emphasizing meaningful and active learning is required. One approach considered relevant is *Deep Learning*, which focuses on conceptual understanding, reflective thinking, and active student engagement during the learning process (Patmaniar et al., 2025). The *Deep Learning* approach encourages students to analyze relationships among concepts, explore various problem-solving strategies, and connect mathematical concepts with real-life situations (Girsang & Rahayu, 2025). This approach is closely related to indicators of mathematical representation skills because students are

encouraged to transform concepts into symbolic, graphical, and verbal forms through reflective and exploratory learning activities.

In addition to instructional approaches, technology integration can support students' understanding of abstract mathematical concepts. One digital platform frequently used in mathematics learning is *Desmos*, which enables students to explore graphs dynamically and interactively (Chorney, 2022). Previous studies have shown that *Desmos* contributes to improving students' mathematical representation abilities by helping them visualize equations, observe graphical changes, and connect symbolic forms with visual representations (Haryani & Harso, 2023; Nurhayati & Gunawan, 2022). Furthermore, *Desmos* allows students to directly identify the relationship between equations and graphs, making abstract concepts easier to understand (Dy, 2024). However, previous studies generally examined *Desmos* separately in relation to mathematical literacy, communication skills, or computational thinking (Nuri et al., 2023; Ramadhan & Setyaningrum, 2024). Research specifically integrating the *Deep Learning* approach with *Desmos* to improve students' mathematical representation skills in SPLDV learning is still very limited. This gap becomes the main novelty and contribution of the present study.

Based on the discussion above, it is necessary to implement learning that facilitates the development of students' mathematical representation skills through meaningful and technology-supported instruction. The integration of the *Deep Learning* approach and *Desmos* is expected to help students understand mathematical concepts more deeply through active exploration and interactive visualization processes. This study not only focuses on improving learning outcomes but also emphasizes strengthening students' abilities to connect symbolic, visual, and verbal representations when solving SPLDV problems. Therefore, this study aims to analyze the improvement of students' mathematical representation skills through *Deep Learning* assisted by *Desmos* on the topic of Systems of Linear Equations with Two Variables (SPLDV).

## RESEARCH METHODOLOGY

This research adopted a quasi-experimental approach with a pretest–posttest control group framework to investigate the effectiveness of a Desmos-supported Deep Learning model in enhancing students' mathematical representation abilities on the topic of Systems of Linear Equations in Two Variables (SLETV). The study was carried out at SMP IT Permata Hati Tebing Tinggi and involved 30 eighth-grade students, equally distributed into an experimental group and a control group. Participants were selected through purposive sampling by considering their comparable academic performance and classroom learning profiles. The experimental group experienced learning activities designed around Deep Learning principles integrated with Desmos, whereas the control group participated in conventional teacher-centered instruction. Data were gathered using a mathematical representation test consisting of five open-ended items that assessed students' visual, symbolic, and verbal representation skills. Prior to implementation, the instrument underwent expert validation and demonstrated a Cronbach's Alpha coefficient of 0.87, indicating a satisfactory level of internal consistency. Detailed test specifications and indicators are provided in the appendix.

The study was implemented in three consecutive phases: initial assessment, instructional treatment, and final assessment. At the beginning of the research, both groups completed a pretest to identify their baseline understanding of SLETV concepts. During the intervention period, students in the experimental class utilized Desmos to explore and construct graphical representations of linear equations through interactive learning activities aligned with

the Deep Learning approach. In contrast, the control class learned the same material through explanation-based instruction and routine textbook exercises. Following the intervention, a posttest was administered to both groups to evaluate changes in mathematical representation performance. The resulting data were processed using descriptive and inferential statistical techniques. Assumption testing, including normality and homogeneity analyses, was conducted before hypothesis testing. Differences between groups were examined through an independent-samples t-test, while the N-gain analysis was employed to determine the magnitude of students' improvement after the instructional treatment.

## RESULT AND DISCUSSION

### Result

Data processing was carried out using Jamovi software based on responses obtained from 30 participants, comprising 15 students in the experimental group and 15 students in the control group. The dataset was complete, with no missing responses requiring exclusion from the analysis. To address the research objectives, several statistical procedures were employed, including descriptive statistics, assumption testing through normality and homogeneity analyses, and hypothesis testing using the Independent Samples t-test. These procedures were applied to examine whether the integration of Desmos within the Deep Learning approach produced a significant impact on students' mathematical representation abilities in learning Systems of Linear Equations in Two Variables (SLETV).

As an initial step, descriptive statistical analysis was conducted to summarize students' performance before and after the instructional intervention. This analysis provided an overall picture of the distribution, central tendency, and variation of mathematical representation scores in both the experimental and control groups. In addition, the descriptive findings offered preliminary evidence regarding potential differences in learning outcomes between the two groups prior to further inferential testing. A detailed summary of the descriptive statistical results is presented in Table 1.

**Table 1. Descriptive Statistics for the Pretest and Posttest**

Class	N	Mean Pretest	Mean Posttest	SD Pretest	SD Posttest	Min–Max Posttest
Experimental	15	47.1	80.5	2.63	3.25	75–86
Control	15	47.0	63.9	1.69	2.03	60–67

As presented in Table 1, students who participated in the Desmos-supported Deep Learning instruction exhibited a more substantial increase in mathematical representation ability than those in the comparison group. The posttest score pattern further reveals that learners in the experimental class achieved more stable and higher performance levels. These results imply that combining interactive digital tools with meaningful learning experiences can enhance students' comprehension and expression of mathematical ideas. Moreover, the descriptive findings shown in Table 1 provide preliminary evidence that the instructional strategy implemented in the experimental group produced more favorable learning outcomes than the conventional teaching approach.

Prior to conducting inferential statistical analyses, the assumption of normal data distribution was examined using the Shapiro–Wilk normality test. This procedure was carried out to verify whether the pretest and posttest data from both groups satisfied the requirements for subsequent parametric testing. Normality testing was applied separately to the scores of the

experimental and control classes to ensure the validity of further statistical comparisons. A summary of the normality test results is provided in Table 2.

**Table 2. Results of the Shapiro–Wilk Normality Test**

Class	Pretest (p)	Posttest (p)	Description
Experimental	0.829	0.977	Normal
Control	0.874	0.734	Normal

As shown in Table 2, the score distributions in both the experimental and control groups met the criteria for normality. This result indicates that the data were sufficiently normally distributed, allowing the application of parametric statistical procedures in subsequent analyses. Satisfying this assumption enhances the reliability of the inferential tests used to evaluate the research hypothesis. Consequently, the findings reported in Table 2 confirm that the Independent Samples T-Test was suitable for comparing the performance of the two groups.

Besides assessing normality, the equality of variances between groups was examined through Levene's Test. The purpose of this procedure was to verify whether the variability of scores in the experimental and control classes was statistically comparable. Establishing homogeneous variances is a necessary prerequisite for conducting the Independent Samples T-Test under standard assumptions. The outcomes of the homogeneity analysis are summarized in Table 3.

**Table 3. Results of the Test for Homogeneity of Variances (Levene's Test)**

Variable	F	df1	df2	p	Description
Posttest	3.42	1	28	0.075	Homogeneous

Based on Table 3, the variances between the experimental and control groups were relatively equal, indicating that the homogeneity assumption was fulfilled. This condition demonstrates that the two groups possessed comparable variance characteristics, thereby meeting the requirements for conducting parametric hypothesis testing. The fulfillment of this assumption supports the reliability of the comparison between the two groups in the hypothesis testing stage. Consequently, the statistical information presented in Table 3 confirms that the analysis could proceed using the Independent Samples T-Test.

Following the confirmation that all statistical assumptions had been satisfied, an Independent Samples T-Test was performed to compare the posttest scores of the experimental and control groups. The analysis was designed to investigate whether the implementation of the Desmos-supported Deep Learning approach produced a meaningful effect on students' mathematical representation abilities. A significance threshold of 0.05 was adopted in evaluating the research hypothesis. The detailed outcomes of the t-test analysis are reported in Table 4.

**Table 4. Results of the Independent Samples T-Test**

Variable	t	df	p	Decision
Posttest	16.8	28	< 0.001	Ho Rejected

Based on Table 4, the hypothesis testing results demonstrate that there was a statistically significant difference between students who learned through Deep Learning assisted by Desmos and those who learned through conventional instruction. The experimental class showed better

mathematical representation performance after receiving the treatment. These findings indicate that integrating Deep Learning with interactive visualization technology can positively influence students' conceptual understanding and mathematical representation abilities. Therefore, the results summarized in Table 4 confirm that the use of Desmos-supported Deep Learning can be considered an effective instructional alternative for mathematics learning, particularly in the topic of SPLDV.

## Discussion

Thus, the integration of *Deep Learning* instruction using *Desmos* can be recommended as an effective learning strategy for improving students' mathematical representation skills. The findings of this study indicate that students who learned through *Deep Learning* assisted by *Desmos* achieved better representation abilities than those who learned through conventional instruction. The higher posttest scores in the experimental class demonstrate that the integration of interactive technology with meaningful learning approaches can support students in understanding mathematical concepts more effectively. This finding supports the view that mathematical representation skills are essential for helping students connect symbolic, graphical, and verbal forms of mathematics (Suningsih & Istiani, 2021). The improvement was reflected in students' ability to interpret graphs visually, express mathematical relationships symbolically through equations, and explain problem-solving processes verbally in a more systematic manner. These results indicate that mathematics learning should not only emphasize procedural mastery but also prioritize conceptual understanding and the ability to communicate mathematical ideas in multiple forms.

The effectiveness of *Deep Learning* assisted by *Desmos* can be explained through the characteristics of the learning process implemented in the experimental class. Students were encouraged to actively explore mathematical concepts, analyze relationships between equations and graphs, and discuss problem-solving strategies collaboratively. This learning process aligns with constructivist learning theory, which emphasizes that knowledge is actively constructed through interaction and learning experiences. Patmaniar et al. (2025) explained that the *Deep Learning* approach promotes meaningful learning through reflective thinking, conceptual analysis, and problem-solving activities. In addition, *Deep Learning* enables students to connect prior knowledge with newly acquired concepts, resulting in deeper conceptual understanding (Girsang & Rahayu, 2025). Compared with conventional learning, which tends to focus on memorization and procedural exercises, students in the experimental class demonstrated stronger abilities in transforming and interpreting mathematical representations. This finding confirms that the *Deep Learning* approach is closely associated with the development of visual, symbolic, and verbal representation indicators because students are encouraged to construct meaning through active exploration and reflection.

The use of *Desmos* also contributed significantly to students' understanding of SPLDV concepts because the application provides dynamic and interactive graphical visualizations. Students were able to directly observe how changes in equation coefficients affected the position and intersection of lines on graphs. This visual experience helped students understand abstract concepts more concretely and meaningfully. Similar findings were reported by Dhani et al. (2022), who found that *Desmos* facilitated students' understanding of mathematical concepts through interactive graph exploration. This finding is also consistent with Nisa et al. (2025), who explained that *Desmos* supports interactive mathematics learning environments by encouraging students' active participation, visualization, and conceptual exploration during the learning process. Furthermore, Chorney (2022) emphasized that the use of *Desmos* in

mathematics classrooms can create more exploratory and student-centered learning environments. Dy (2024) also stated that *Desmos* improves students' engagement and understanding in graphing activities because learners can instantly observe the results of mathematical manipulations. Therefore, the integration of *Desmos* into mathematics learning supports the simultaneous development of students' visual and symbolic representation skills.

The findings of this study are also consistent with previous studies showing that technology-assisted learning can improve students' mathematical abilities. Astuti et al. (2024) reported that *Desmos*-assisted learning media effectively improved students' mathematical representation abilities and learning resilience. Similarly, Nurhayati and Gunawan (2022) found that the use of the *Desmos Graphing Calculator* enhanced students' representational understanding in solving mathematical problems. Research conducted by Nuri et al. (2023) further revealed that integrating *Desmos* with project-based learning positively influenced students' mathematical literacy skills. In addition, Ramadhan and Setyaningrum (2024) demonstrated that *Desmos*-assisted learning contributed to improving students' mathematical communication skills because students became more capable of explaining mathematical ideas logically and systematically. AbdulAmeer and Hassan (2025) also confirmed that learning supported by *Desmos* and other digital technologies significantly enhanced students' higher-order thinking skills. Lestari (2025) further explained that digital learning media positively affect mathematics learning outcomes because interactive technology can increase students' motivation, engagement, and conceptual understanding during the learning process.

From the perspective of mathematical visualization, the findings of this study indicate that visual learning experiences help students build stronger conceptual understanding. Visualization enables students to connect abstract mathematical symbols with concrete graphical representations, making learning more meaningful. Koyunkaya and Dede (2024) explained that digital tools in mathematics learning support students in solving modelling problems through visual exploration and interactive reasoning processes. Similarly, Simsek and Clark-Wilson (2025) emphasized that technology-integrated classroom practices encourage active participation and conceptual engagement among students. Moreover, Ningsih et al. (2024) found that *Desmos*-assisted instructional materials support higher-order thinking skills because students are encouraged to analyze patterns, relationships, and mathematical structures critically. Chien et al. (2026) also demonstrated that instructional lessons incorporating *Desmos* improved students' conceptual understanding and mathematical reasoning abilities through interactive visualization activities.

Overall, the findings demonstrate that the integration of *Deep Learning* and *Desmos* creates a more interactive, meaningful, and student-centered learning environment. Students not only learned procedural problem-solving techniques but also developed deeper conceptual understanding regarding relationships among equations, graphs, and mathematical concepts. The novelty of this study lies in the integration of the *Deep Learning* approach with *Desmos* specifically to strengthen students' mathematical representation skills in SPLDV learning, particularly across visual, symbolic, and verbal representation dimensions. Compared with previous studies that generally examined *Desmos* or learning models separately, this study provides a more comprehensive perspective on how meaningful learning approaches combined with interactive digital technology can optimize conceptual understanding and mathematical representation abilities simultaneously. The findings of this study theoretically reinforce constructivist learning principles in technology-assisted mathematics instruction, while practically providing recommendations for mathematics teachers to design innovative learning

environments that encourage active participation, conceptual exploration, and higher-order mathematical thinking skills.

## CONCLUSION

Based on the results of the study, it can be concluded that the implementation of *Deep Learning* instruction assisted by *Desmos* positively contributes to improving students' mathematical representation skills in the topic of Systems of Linear Equations with Two Variables (SPLDV). Students who participated in technology-assisted learning demonstrated better abilities in representing mathematical ideas visually through graphs, symbolically through equations, and verbally through systematic explanations compared to students who learned through conventional instruction. The integration of interactive digital media into mathematics learning not only improves students' academic achievement but also strengthens conceptual understanding and active knowledge construction. The use of *Desmos* enables students to visualize abstract mathematical concepts more concretely, while the *Deep Learning* approach encourages active exploration, discussion, and reflective problem-solving processes. The novelty of this study lies in the integration of the *Deep Learning* approach with *Desmos* specifically to strengthen students' visual, symbolic, and verbal mathematical representation skills in SPLDV learning. The findings also reinforce the theoretical perspective that meaningful and technology-assisted learning supports deeper conceptual understanding, while practically providing mathematics teachers with an innovative and student-centered instructional alternative.

The findings of this study provide practical implications for the development of technology-based mathematics instruction in creating more interactive and meaningful classroom environments. Schools and educators are encouraged to optimize digital learning media to improve students' engagement and conceptual understanding during mathematics learning. Furthermore, future studies may expand the implementation of this approach to other mathematical topics, such as geometry or calculus, and across different educational levels to examine its broader effectiveness. Further research is also recommended to investigate additional variables, including students' motivation, critical thinking skills, and problem-solving abilities, in order to enrich the understanding of the impact of *Deep Learning* assisted by *Desmos* in mathematics education.

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