Implementation of Deep Learning in Mathematics Learning for Grade IX Students of SMP Negeri 1 Tirtamulya

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Abstrak

Penelitian ini bertujuan untuk menganalisis implementasi pendekatan pembelajaran mendalam dalam pembelajaran matematika untuk meningkatkan pemahaman konseptual siswa pada materi Sistem Persamaan Linear Dua Variabel (SPLDV). Penelitian ini menggunakan pendekatan kualitatif dengan metode studi kasus yang dilakukan pada siswa kelas IX SMP Negeri 1 Tirtamulya, Karawang. Data dikumpulkan melalui observasi kelas, wawancara, dan dokumentasi. Analisis data dilakukan melalui tahapan reduksi data, penyajian data, dan penarikan kesimpulan. Hasil penelitian menunjukkan bahwa penerapan strategi *deep learning* mampu meningkatkan pemahaman konseptual siswa, yang ditunjukkan melalui kemampuan menjelaskan konsep, mengaitkan ide-ide matematika, serta menyelesaikan masalah secara bermakna. Selain itu, siswa menunjukkan peningkatan keterlibatan dan partisipasi aktif selama proses pembelajaran. Penelitian ini memberikan kontribusi terhadap pengembangan praktik pembelajaran matematika yang inovatif, khususnya dalam mengintegrasikan pendekatan *deep learning* untuk mendukung pembelajaran bermakna. Implikasi dari penelitian ini adalah pentingnya guru merancang aktivitas pembelajaran yang mendorong berpikir kritis, pemahaman konseptual, serta pembelajaran yang berpusat pada siswa.

Keyword: Pembelajaran Mendalam, Pemahaman Konsep Matematika, Berpikir Kritis, Kurikulum Merdeka

Abstract

This study aims to analyze the implementation of a deep learning approach in mathematics learning to improve students' conceptual understanding of the System of Linear Equations in Two Variables (SPLDV). This study uses a qualitative approach with a case study method conducted on grade IX students of SMP Negeri 1 Tirtamulya, Karawang. Data were collected through classroom observations, interviews, and documentation. Data analysis was carried out through the stages of data reduction, data presentation, and drawing conclusions. The results of the study indicate that the implementation of a deep learning strategy can improve students' conceptual understanding, as demonstrated by the ability to explain concepts, link mathematical ideas, and solve problems meaningfully. In addition, students showed increased engagement and active participation during the learning process. This study contributes to the development of innovative mathematics learning practices, particularly in integrating a deep learning approach to support meaningful learning. The implication of this study is the importance of teachers designing learning activities that encourage critical thinking, conceptual understanding, and student-centered learning.

Keyword: deep learning, conceptual understanding, mathematics learning, SPLDV, qualitative study

INTRODUCTION

21st-century education faces increasingly complex challenges in developing critical, creative, collaborative, and communicative (4C) thinking skills in response to the acceleration of the Industrial Revolution 4.0 and the development of a knowledge-based society (Lubis et al., 2023). In Indonesia, these challenges are becoming increasingly prominent, as the 2022 Programme for International Student Assessment (PISA) results indicate that Indonesian students' mathematics skills ranked 69th out of 81 countries with an average score of 366, far below the OECD average of 469, and a decline compared to the 2018 PISA (Alfaruqi & Nurwahidah, 2025). Students' weak contextual problem-solving skills and conceptual understanding, still dominated by rote-based learning practices, reflect this condition. This approach limits the development of creativity and exacerbates the impact of learning loss following the COVID-19 pandemic (Ulpa et al., 2021).

In response to these issues, the Ministry of Education, Culture, Research, and Technology launched the Independent Curriculum in 2021, emphasizing deep learning as the primary approach to strengthening

DOI: https://doi.org/10.26486/mma8fz91
W : http://ejurnal.mercubuana-yogya.ac.id/index.php/mercumatika E : mercumatika@mercubuana-yogya.ac.id

students' conceptual understanding, particularly in mathematics (Wafda, 2025). Deep learning is defined as an active process that encourages students to construct knowledge through exploration, reflection, and application of concepts in real-life contexts, rather than merely procedural mastery (Lestari et al., 2025). This approach aligns with Vygotsky's social constructivism theory, which emphasizes the role of social interaction and the zone of proximal development, as well as the mathematical proficiency framework encompassing conceptual understanding, procedural fluency, strategic and adaptive thinking skills, and productive attitudes toward mathematics (Azis et al., 2025).

Globally, the implementation of immersive learning has shown significant results in countries with high educational performance, such as Singapore and Finland. The integration of project-based learning and the use of digital technology in these countries has contributed to improved PISA scores, which are approximately 30–50 points above the international average (Rosdiana et al., 2024). However, the implementation of immersive learning at the junior high school (SMP) level in Indonesia still faces various obstacles. Several studies indicate that teachers face high administrative burdens, which reduce effective learning time; limited pedagogical readiness due to a lack of ongoing training; and students' learning culture, which remains oriented toward memorization (Nasution, 2021; Junedi et al., 2020).

A recent systematic literature review also revealed a significant research gap. Although the number of publications on the Independent Curriculum (Kurikulum Merdeka) has continued to increase since 2021, only a small number specifically address the application of immersive learning in the context of junior high school mathematics, and very few examine implementation practices in the classroom (Zuhro et al., 2025). Most studies are still descriptive and focus on elementary school or general studies, with limited analysis of supporting factors such as digital technology integration and inhibiting factors such as cultural resistance to active learning, particularly in rural areas (Mudjib et al., 2025). The findings of Rambe et al. (2025) confirm that the implementation of deep learning in Indonesian junior high schools is still hampered by infrastructure gaps and weak policy support at the educational unit level.

This study aims to fill this gap by holistically exploring the implementation of deep learning in ninth-grade mathematics at SMP Negeri 1 Tirtamulya. This study strengthens Vygotsky's (1978) social constructivism theory and Kilpatrick et al.'s (2001) mathematical proficiency framework by providing empirical evidence on how social interaction and critical reflection can develop conceptual understanding of mathematics in the context of the Independent Curriculum. Theoretically, this research contributes to the development of a mathematics learning model that is adaptive to student heterogeneity and infrastructure limitations in Indonesia.

The practical contribution of this research is highly relevant in the current and future context. First, the study results provide concrete guidance for mathematics teachers in implementing effective deep learning despite limited time and facilities. Second, the findings on supporting and inhibiting factors provide valuable input for policymakers in designing teacher training programs and allocating educational resources. Third, this research has the potential to improve national numeracy literacy by providing a replicable learning model in similar schools, particularly in facing the challenges of globalization and the digital transformation of education. Thus, this research not only addresses the urgency of improving the quality of mathematics education in Indonesia but also makes a significant contribution to the development of educational science in the era of independent learning. This study offers novelty by providing empirical classroom-based evidence of deep learning implementation at the junior high school level, which remains underexplored in previous studies.

METHOD

This study employed a descriptive qualitative approach with an exploratory design to gain an in-depth understanding of the implementation of deep learning in ninth-grade mathematics instruction. The qualitative approach was chosen because it allows researchers to comprehensively examine learning phenomena in a natural context and explore participants' subjective meanings and experiences that cannot be measured quantitatively. Through this approach, the reality of education at the junior high school level can be understood contextually, taking into account the surrounding social and cultural characteristics.

The exploratory design was used because the implementation of the Independent Curriculum, particularly deep learning-based mathematics instruction, is still in the adaptation stage in various educational units. This design allows researchers to explore the dynamics of classroom learning and identify naturally occurring issues, such as cultural resistance to active learning, limited facilities and infrastructure, and pedagogical challenges faced by teachers. These aspects tend to be overlooked in quantitative research, yet they play a crucial role in determining the effectiveness of deep learning implementation in schools.

The research was conducted at SMP Negeri 1 Tirtamulya, Karawang Regency, West Java Province, which represents public schools in semi-urban areas with moderate technology access. The location was selected using purposive sampling because this school has consistently implemented the Independent Curriculum since 2022 with a focus on deep learning in mathematics. The research subjects were determined through specific criteria to ensure representativeness: (1) a mathematics teacher with at least 2 years of teaching experience in implementing deep learning; (2) five ninth-grade students selected heterogeneously based on academic ability (two high-ability students, two medium-ability students, and one low-ability student); and (3) elements of school leadership (the principal and vice principal for curriculum) who play a role in policy-making and daily implementation.

Data is collected through three main techniques that complement each other to achieve depth and breadth:

a. Participant observations were conducted during 10 learning sessions to document teacher-student interactions, the use of deep learning tools, and the application of mathematical concepts in real-world contexts. Observations used a rubric-based guide with indicators of conceptual understanding from Kilpatrick et al. (2001), covering both verbal and non-verbal aspects in field notes.
b. Semi-structured interviews were conducted with teachers (focusing on implementation strategies), students (personal experiences and understanding), and school leaders (policies and support). Each interview session lasted 45-60 minutes and was audio-recorded for accuracy, using an interview guide with open-ended questions that had been validated through expert review.
c. Documentation studies included analysis of lesson plans (RPPs), learning logs, student portfolios, and school evaluation reports to track the evolution of deep learning implementation over time, corroborating primary data with archival evidence.

Data analysis using the interactive model of Miles, Huberman, & Saldaña (2020) in four cycle stages:

a. Data Collection: Conducted through observation, interviews, and documentation studies, focusing on raw data such as transcripts and field notes.
b. Data Reduction: Filtering and grouping data into key themes (learning implementation, student experiences, conceptual understanding, enabling and inhibiting factors) using initial thematic coding and analytical memos to reduce bias.
c. Data Presentation: Presenting results in the form of thematic tables, implementation process flowcharts, and analytical narratives with network diagrams to illustrate student-teacher interactions.
d. Conclusion Drawing and Verification: Tentative conclusions were verified through member checking (participant feedback), peer discussions with educational experts, and cross-checking field notes to ensure robust and contextual conclusions.

This study uses four data validity criteria according to Lincoln & Guba (1985):

a. Credibility: Achieved through triangulation of sources (teachers, students, documents) and methods (observation, interviews), member checking, and intensive researcher involvement in the field for three months (October-December 2025).
b. Transferability: Through the presentation of a thick description of the school context, teacher and student profiles, and the dynamics of the independent curriculum to enable its application to similar junior high school contexts in Indonesia.
c. Dependability: By compiling an audit trail in the form of complete documentation of the entire research process (daily logs, recordings, transcripts) that can be traced by external auditors.
d. Confirmability: Ensuring that findings are based on empirical data through the researcher's reflective journal, discussions with supervisors to identify bias, and the presentation of direct quotes from informants in the report.

The research process was conducted ethically by obtaining permission from the school, maintaining participant confidentiality, and ensuring voluntary participation without coercion. Data analysis was conducted iteratively using NVivo software for efficient coding and thematic visualization, resulting in comprehensive and in-depth findings regarding the implementation of deep learning in junior high school mathematics learning.

RESULTS AND DISCUSSION

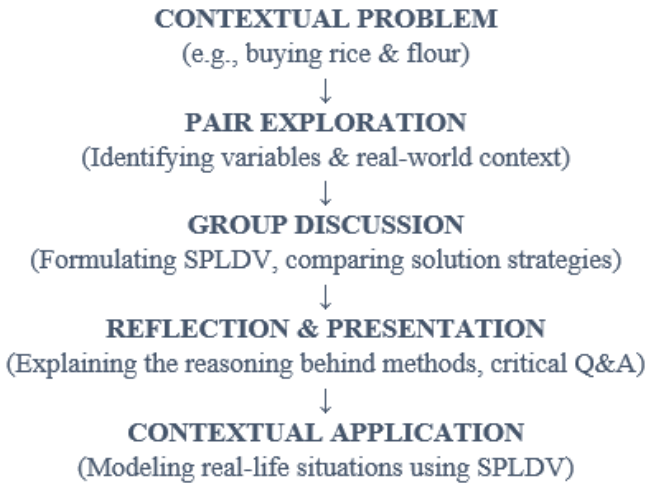
Result

This study yielded comprehensive findings regarding the implementation of immersive learning in mathematics for ninth-grade students at SMP Negeri 1 Tirtamulya. Data were collected through participant

observation during 10 learning sessions; in-depth interviews with two mathematics teachers, 12 students (from grades IX-E and IX-F), the principal, and the vice principal for curriculum; and a documentation study of the lesson plan, student worksheets, and student portfolios.

The implementation of immersive learning proceeded through four systematic phases: (1) contextual problem exploration, (2) collaborative group discussions, (3) reflection-presentation, and (4) contextual application. Based on observations, approximately 80-85% of students were actively engaged in the discussions, with the classroom atmosphere being collaborative and communicative. The teacher acted as a facilitator by asking reflective questions such as "Why is that method more efficient here?" rather than providing direct solutions.

Figure 1. In-depth Learning Flow in SPLDV Material



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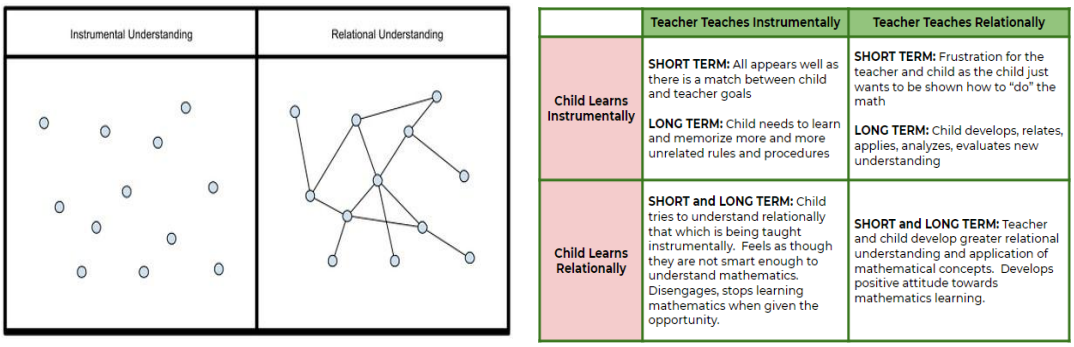

Figure 2. Comparison of Relational Understanding and Instrumental Understanding (Skemp, 1976) in (Anggraini et al., 2024)

Table 1. Level of Students' Conceptual Understanding after In-Depth Learning

No	Name Student	Ability to Explain Variable Relationships	Ability to Relate to Real-Life Situations	Ability to Select a Resolution Strategy	Comprehension Category
1	Student A	Very Good	Good	Very Good	High
2	Student B	Good	Very Good	Good	High
3	Student C	Good	Good	Fair	Medium-High
4	Student D	Fair	Fair	Fair	Medium
5	Student E	Very Good	Good	Fair	High
---	Average	83%	78%	Very Good	High

Of the five students sampled in depth, four (80%) demonstrated significant improvement in their

conceptual understanding of the Two-Variable System of Linear Equations (SLSE). All four students were able to logically explain the relationships between variables, relate concepts to real-life situations (such as modeling grocery shopping), and select appropriate solution strategies for the context.

Table 2. Supporting and Inhibiting Factors for the Implementation of Deep Learning

Factors	Types	Percentage	Description
School Policy Support	Supporters	95%	Ample space for innovation, collaboration between teachers, and regular reflective monitoring.
Teacher Readiness	Supporters	90%	Teachers are open to Independent Curriculum training and skilled at facilitating reflective inquiry.
Student Enthusiasm	Supporters	85%	Students actively discuss and boldly propose alternative ideas.
Digital Facilities	Supporters	80%	LCDs, interactive digital boards, and contextual learning modules are used.
Time Constraints	Obstacles	95%	Discussion and reflection phases are often cut short due to the busy schedule (45-60 minutes per session).
Ability Heterogeneity	Obstacles	85%	Students with weak foundations are slow to model verbal problems using SPLDV.
Old Learning Habits	Obstacles	75%	Students are still accustomed to memorizing formulas and lack independent reflective thinking practice.

The main supporting factors included school policies that provide space for innovation (95%), teacher readiness, having participated in independent curriculum training (90%), student enthusiasm (85%), and adequate digital facilities (80%). Meanwhile, the main obstacles were limited time (95%), heterogeneity in student abilities (85%), and traditional learning habits oriented toward memorization (75%).

Based on interviews, teachers stated that the deep learning approach was chosen to shift the paradigm from procedural memorization to in-depth conceptual understanding. The majority of students (85%) stated that the learning experience was more meaningful than the conventional approach, with statements such as the following:

"At first, I was confused about formulating the equation for the story of rice and flour, but after discussing it with my friends, I understood why the substitution method was faster in this case."

Discussion

The findings of this study indicate that the implementation of in-depth learning in ninth-grade mathematics at SMP Negeri 1 Tirtamulya successfully created student-centered learning and developed deeper conceptual understanding. These results align with the research objectives of describing the implementation, describing students' learning experiences, explaining the level of conceptual understanding, and identifying supporting and inhibiting factors.

Theoretically, these findings reinforce the mathematical proficiency framework of Kilpatrick et al. (2001) in Triyana & Kusno (2025), which places conceptual understanding as a core mathematical competency. Four out of five students studied demonstrated the ability to not only memorize procedures but also understand "why" a concept or method works—a strong indicator of relational understanding, according to Skemp (1976) in Anggraini et al. (2024). This contrasts with the instrumental understanding dominant in conventional learning in Indonesia, where students simply memorize formulas without understanding the underlying principles.

The 80-85% participation rate of students in active discussions supports the findings of Isnayanti et al. (2025), who found that deep learning is effective in developing 21st-century skills such as collaboration and communication. However, student ability heterogeneity poses a significant challenge, with 15-20% of students initially having difficulty modeling verbal problems into mathematical equations. This finding is consistent

with research by Rambe et al. (2025), which found that ability disparity is a major barrier to implementing deep learning in Indonesian junior high schools.

Supporting factors such as school policy support (95%) and teacher readiness (90%) confirm the importance of institutional support for the success of curricular reform, as noted by Nafi'uddin (2022). Conversely, time constraints (95%) were the primary obstacle reducing the effectiveness of the critical reflection phase of deep learning. This aligns with the findings of Pebriani et al. (2025) that administrative burdens and limited time allocation reduce teachers' opportunities to develop deep learning.

Comparison with previous research indicates congruence. Natsir (2025) found that implementing the Independent Curriculum (Kurikulum Merdeka) with a deep learning approach improved conceptual understanding of mathematics in pilot schools, despite similar challenges related to time management and student heterogeneity. However, this study makes a unique contribution by holistically exploring the dynamics of implementation at the junior high school level, filling the research gap identified by Andriyanita & Maftuh (2025), where less than 5% of Independent Curriculum publications examine deep learning in junior high school mathematics in depth.

Practically, these findings demonstrate that deep learning is effective in increasing student engagement and conceptual understanding in mathematics, although it requires differentiation strategies and optimal time management. Important policy implications include the need to strengthen teacher training in facilitation techniques and learning differentiation, as well as revising learning time allocations to allow adequate space for reflection and contextual application.

Limitations of this study include the limited scope of subjects in a single school and the relatively short duration (3 months). For future research, longitudinal studies are recommended to measure the long-term impact of deep learning on academic performance, as well as comparisons between schools with different characteristics to examine the influence of socio-cultural context and infrastructure on implementation.

CONCLUSION

This study examines the implementation of deep learning in ninth-grade mathematics at SMP Negeri 1 Tirtamulya within the Merdeka Curriculum framework. Using a descriptive qualitative approach through participant observation during 10 learning sessions, in-depth interviews with teachers, students, and school leaders, and documentation studies, this study explores four phases of implementation: contextual problem exploration, collaborative group discussions, reflection-presentation, and contextual application. The study subjects included a mathematics teacher, five ninth-grade students selected heterogeneously based on academic ability, and school leaders, focusing on the topic of two-variable linear equation systems (SLSV) relevant to everyday life.

The results showed that approximately 80% of students actively participated in the discussions, with four out of five students demonstrating significant improvement in their conceptual understanding of SLSV, including their ability to explain relationships between variables and relate them to real-life situations. Key supporting factors included school policy support (95%), teacher readiness (90%), and digital facilities (80%), while key barriers were time constraints (95%) and heterogeneity in student abilities (85%). Deep learning has been shown to be effective in increasing student engagement and conceptual understanding but requires differentiation strategies and optimal time management. These findings reinforce Kilpatrick et al.'s (2001) mathematical proficiency framework and Skemp's (1976) concept of relational understanding, while also filling a research gap on the implementation of deep learning in Indonesian junior high school mathematics, with important implications for developing mathematics education policy in the Merdeka Belajar era.

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