OASE

Proceeding the Overseas Academic Study Exchange Program
ISSN 2686-4312 ☐ 2025 ☐ Volume 7(4), 930–935. ☐ DOI: xxx xxx

Implementing Project-Based Deep Learning to Enhance Reasoning Skills in Mathematical Logic

Aswar[1*]

ABSTRACT
ABSTRACT This study aims to develop and implement a project-based deep learning instructional model within the topic of mathematical logic to enhance students' mathematical reasoning skills. The research employed a developmental approach using the ADDIE model (Analyze, Design, Develop, Implement, Evaluate). The participants were eleventh-grade high school students enrolled in a mathematical logic course. Data were collected through classroom observations, interviews, questionnaires, as well as pre-tests and post-tests of students' logical reasoning abilities. The findings indicate that the project-based deep learning approach significantly enhanced students' active engagement, supported deeper conceptual understanding, and encouraged logical and reflective thinking. Evaluation results showed a notable improvement in students' mathematical reasoning abilities, with the average score increasing from 62.4 to 84.5, and the mastery learning rate rising from 45% to 89%. The study concludes that this approach is effective in teaching mathematical logic, fostering meaningful understanding, and developing higher-order thinking skills.

Keywords: Deep learning, project-based learning, mathematical logic, mathematical reasoning, ADDIE

68 Introduction

Mathematics education in the 21st century demands more than just computational skills. Higher-order thinking abilities such as critical thinking, creativity, and logical reasoning have become essential competencies for students to master. In this context, mathematical reasoning plays a crucial role as it enables students to draw valid conclusions, understand relationships between concepts, and construct coherent and logical arguments. One subject that directly fosters these skills is mathematical logic, which involves processing statements, constructing arguments, and performing deductive reasoning.

However, in practice, the teaching of mathematical logic is often perceived as unengaging by students. The delivery of abstract content, often focused on memorizing logical symbols, makes it difficult for students to grasp the meaning and real-life applications of the concepts. As a result, students not only fail to understand the fundamental concepts of logic but also face obstacles in developing their mathematical reasoning abilities. Most logic instruction still relies on expository approaches, where the teacher serves as the primary source of information while students play a passive role. This approach offers limited opportunities for students to explore, construct, and reflect on their understanding actively. Yet meaningful learning occurs when students are able to connect concepts with real-life experiences, work collaboratively, and engage in deep thinking processes.

[1]Universitas Muhammadiyah Malang
[*]Alamat korespondensi: asw4r80@gmail.com

To address these challenges, a learning approach is needed that promotes student engagement, independence, and depth of thinking. One relevant approach is deep learning. Deep learning is characterized by a strong emphasis on deep conceptual understanding and the critical application of knowledge. Unlike surface learning, which focuses merely on task completion, deep learning encourages students to seek meaning, find connections between concepts, and apply knowledge in new contexts. This approach is grounded in the paradigm that learning should be meaningful, mindful, and joyful, enabling students to understand, apply, and enjoy the learning process.

When combined with Project-Based Learning (PjBL), this approach can create a more contextual, collaborative, and exploratory learning experience. PjBL is a student-centered learning model involving real-world projects designed to solve complex problems. In the context of mathematical logic, such projects may include constructing logic maps, engaging in logical argument debates, or analyzing formal logic-based case studies—all of which aim to actively and reflectively develop students' logical thinking skills. Based on this background, this study aims to implement a deep learning model integrated with project-based learning in the teaching of mathematical logic and to analyze its effect on improving students' mathematical reasoning abilities. Through this approach, it is expected that students will not only understand formal logic but also be able to apply it in critical thinking and logical decision-making within real-life contexts.

69 Literature Review

1. Deep Learning in Education Deep learning in a pedagogical context refers to a learning process that demands deep understanding, meaningful interpretation of information, and the ability to apply concepts in various contexts. This approach differs from surface learning, which relies solely on memorization without genuine understanding.
2. Project-Based Learning (PjBL) Project-Based Learning (PjBL) is a learning model that emphasizes in-depth investigation of a real-world problem or project. According to the George Lucas Educational Foundation, PjBL integrates knowledge and skills through complex projects that involve teamwork and open-ended inquiry.
3. Reasoning in Mathematical Logic Mathematical logic is a subject that deals with reasoning processes. Mathematical reasoning includes the ability to recognize patterns, make generalizations, construct logical arguments, and draw systematic conclusions (NCTM). In mathematical logic, these skills are exercised through the construction and evaluation of logical statements, proofs, and formal arguments.

70 Research Methods

Research Approach and Type

This study employs a developmental research approach using the ADDIE development model, which consists of five stages: Analyze, Design, Develop, Implement, and Evaluate. This model is used to design and implement a project-based deep learning instructional design on the topic of mathematical logic, as well as to evaluate its impact on students' reasoning abilities.

Research Subjects

The research subjects are Grade XI students of SMA Negeri 1 Gapura who are taking mathematical logic during the even semester of the 2024/2025 academic year. The mathematics teacher of the class is also involved in the validation and implementation processes of the learning design.

Research Procedure

1. Analyze: This stage aims to identify learning needs, student characteristics, and difficulties in understanding mathematical logic. Data are collected through classroom observation, analysis of prior learning outcomes, and interviews with the teacher.
2. Design: Based on the analysis results, a learning scenario is designed that integrates the principles of deep learning and the Project-Based Learning model. This design includes project planning, activity flow, reasoning assessment instruments, and instructional media.
3. Develop: At this stage, instructional tools are developed, including logic project modules, student worksheets (LKPD), reasoning assessment rubrics, and teacher guides. These tools are then validated by subject matter experts and instructional design experts.
4. Implement: The instructional design is implemented over two main sessions. Students engage in project-based learning activities aimed at building logical reasoning, such as argument construction and logic debates. Observations and documentation are carried out to record the learning process.
5. Evaluate: Evaluation is conducted both formatively and summatively. Formative evaluation involves reflecting on the learning process and gathering feedback from students and the teacher. Summative evaluation is conducted through logical reasoning tests and a comparative analysis of students' learning outcomes before and after the implementation.

Data Collection Techniques

1. Mathematical reasoning tests (pretest and posttest) are used to measure students' improvement.
2. Observation is used to monitor student activity and participation during the project.
3. Questionnaires and interviews are used to gather students' perceptions of the learning experience.
4. Expert validation is conducted to assess the feasibility of the instructional tools.

Data Analysis Techniques

1. Quantitative data are analyzed using descriptive statistics (mean scores, percentage of improvement, and learning mastery).
2. Qualitative data are analyzed through reduction, categorization, and interpretation of observation, questionnaire, and interview results.

71 Result and Discussion

The research and development process for project-based deep learning in the topic of mathematical logic was conducted through the five stages of the ADDIE model: Analyze, Design, Develop, Implement, and Evaluate. The following describes the results at each stage:

Analyze Stage (Needs Analysis)

Initial observations revealed that students had difficulty understanding mathematical logic concepts, particularly in distinguishing types of logical statements (implication, converse, contrapositive) and constructing coherent arguments. Interviews with the teacher confirmed that instruction was still predominantly theoretical and lacked contextual application. Analysis of student characteristics also indicated that most students were more motivated when involved in project-based activities or discussions. Therefore, an instructional approach that integrates deep learning and project-based learning was deemed relevant to address these issues.

Design Stage (Instructional Design)

Based on the findings from the analysis stage, a learning scenario was designed that integrates deep learning and Project-Based Learning (PjBL). The developed project was titled "Logic in the Real World," in which students were asked to analyze logical arguments from advertisements, news articles, or public statements, then construct logical counterarguments. The instructional design included:

1. Learning objectives based on logical reasoning competencies,
2. A sequence of learning activities that facilitates concept exploration, discussion, and reflection,
3. Assessment instruments such as reasoning rubrics and pre/post-tests,
4. Student worksheets (LKPD) and supporting reading materials.

Develop Stage (Product Development)

Instructional tools were then developed based on the initial design and validated by two experts: one in mathematical logic and the other in instructional design. The validation results indicated that the tools were feasible for use, with suggestions for improving the flow of group discussions and project timing. Development also included the creation of visual media (examples of logical arguments from social media) and logic debate simulations as a means of strengthening critical thinking.

Implement Stage (Instructional Implementation)

The implementation was carried out over two sessions (each lasting 2 × 45 minutes). In the first session, students were introduced to basic logic concepts and divided into groups to begin analyzing logical arguments from real-life sources. In the second session, students constructed and presented their logical arguments, followed by class discussion and reflection. Observations showed that students became more actively engaged in discussions, enthusiastic in expressing opinions, and able to identify and correct flawed arguments. Some previously passive students began contributing to the group's logical conclusions.

Evaluate Stage (Evaluation and Reflection)

Summative evaluation was conducted by comparing students' logical reasoning test results before and after implementation:

Table 14: Average Score and Learning Mastery Before and After Implementation

Stage	Average Score	Learning Mastery
Pretest	62,4	45%
Posttest	84,5	89%

There was a significant improvement in both average scores and mastery level.Formative evaluation was carried out through questionnaires and interviews. The results showed that most students found the learning more meaningful. They felt challenged yet enjoyed the experience, as they could relate logic to real-life situations. These findings align with previous studies showing that project-based learning and deep learning foster active engagement, deep understanding, and enhanced critical thinking skills. Integrating real-world contexts into the project helped students grasp abstract concepts like mathematical logic, while collaborative work encouraged them to construct and critique arguments reflectively. The ADDIE model proved effective as a systematic framework for designing and developing innovative instruction focused on meaningful learning outcomes.

72 Conclusion

This study demonstrates that the development approach using the ADDIE model successfully designed and implemented an effective project-based deep learning strategy to enhance reasoning skills in mathematical logic. Each stage of ADDIE contributed significantly:

1. The Analyze stage effectively identified students' difficulties in understanding logic as well as the need for meaningful and contextual learning approaches.
2. The Design stage produced a project-based learning plan aligned with deep learning principles.
3. The Develop stage resulted in valid and feasible instructional tools.
4. The Implement stage showed that project-based learning in mathematical logic can stimulate active participation and cognitive engagement.
5. The Evaluate stage confirmed a significant improvement in students' logical reasoning abilities and a positive response toward the learning process.

Overall, this approach encouraged students to think deeply, logically, and reflectively in understanding and applying concepts of mathematical logic in real-life situations.

Suggestions

1. For teachers and educational practitioners, project-based deep learning can serve as an innovative alternative strategy for teaching abstract subjects like mathematical logic, in order to enhance students' higher-order thinking skills.
2. For curriculum developers and policymakers, it is recommended to support the integration of deep and project-based learning approaches into curricula and teacher training programs.
3. For future researchers, this study can be extended to other educational levels or mathematical topics requiring high-level reasoning, such as proof or calculus, with a larger sample size to enable broader generalization of the results.

References

1. Akbar, W. D. (2025). The effect of deep learning on mathematical reasoning and self-confidence of high school students at Dharma Pancasila Medan. Journal of Pedagogical Education Innovation, 1(1), 9–16.
2. Biggs, J., & Tang, C. (2011). Teaching for Quality Learning at University (4th ed.). Open University Press.
3. Branch, R. M. (2009). Instructional Design: The ADDIE Approach. Springer.
4. Danuri, & Sukma, C. A. (2022). Development of a flipped classroom mathematics e-module to improve mathematical communication skills. Elementary Teacher Education Journal, 9(1), 197.
5. Dole, S., Bloom, L., & Doss, K. K. (2017). Project-Based Learning in the Mathematics Classroom. Routledge.
6. Hidayat, A. (2019). The implementation of a project-based learning model to improve students' critical thinking and reasoning skills. Journal of Mathematics Education, 7(2),

113–123.
7. Kusumawardani, R. D., Wardono, & Kartono. (2018). The importance of mathematical reasoning in improving mathematical literacy skills. journal.unnes.ac.id, 588–594.
8. Mahindra, D. A. (2024). Understanding the concept of the deep learning approach in early childhood education that is meaningful, mindful, and joyful: A philosophical review of education. Golden Age Anthology Journal, 10(1), 108–120.
9. Maulidiya, N. S., Septiani, M., & Asrin. (2025). A deep learning approach for meaningful science learning in elementary schools. Elementary Education Journal, 2(1), 9–18.
10. Mutmainnah, N., Adrias, & Putri, Z. A. (2025). Implementation of the deep learning approach in mathematics learning at elementary schools. Scientific Journal of Elementary Education, 10(1), 858–871.
11. Rahman, H., & Dwi, O. (2021). Adaptive reasoning skills in solving mathematical logic problems based on learning creativity. Journal of Mathematics Education Study Program, 491–500.
12. Rahmawati, L., & Pramudya, I. (2021). The effect of the PjBL learning model on students' mathematical reasoning ability. Journal of Mathematics Education, 10(1), 56–65.
13. Rusman. (2012). Learning Models: Developing Teacher Professionalism. RajaGrafindo Persada.
14. Setyowati, N., & Mawardi. (2018). The synergy of Project-Based Learning and meaningful learning to improve mathematics learning outcomes. Artikel Info, 253–263.
15. Thomas, J. W. (2000). A Review of Research on Project-Based Learning. The Autodesk Foundation.
16. Widodo, S., & Wahyudin. (2018). Selection of mathematics learning media for junior school students. Turkish Online Journal of Educational Technology, 17(1), 154–160.

CITATION:

Aswar (2025). Implementing Project-Based Deep Learning to Enhance Reasoning Skills in Mathematical Logic. *OASE, 7*(4), 930–935.