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The impact of problem-based learning and inquiry-based learning on analytical thinking

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A B S T R A C T
Mathematical analytic ability is the ability to elaborate facts and thoughts in understanding the parts of a situation to solve mathematical problems. PBL and inquiry-based learning models each have an effect on analytic thinking skills. This research seeks to identify if a difference exists between the use of PBL (x_1) and inquiry (x_2) on analytical thinking (y). The research employed is quasi-experimental. Data analysis used normality test, homogenity test and independent t test. The statistical test show that the implementation of PBL is not better than inquiry-based learning. So in terms of analytical thinking skills, PBL and inquiry are equally effective in improving analytical thinking. The advantages of PBL and inquiry-based learning can be combined in enhancing analytical thinking

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1. INTRODUCTION

Analytic thinking ability is a thinking ability to helps students to solve mathematical problems (Qolfathiriyus, Sujadi, & Indriati, 2019). Analytic thinking ability is a thinking ability that helps students to solve mathematical problems (Amer, 2005). Thus, one can assert that mathematical analytical thinking skills involve the capacity to elaborate facts and ideas while comprehending the components of a condition to solve mathematical problems. Analytical thinking can be further broken down into: (1) pre analytical, (2) partial analytical, (3) semi analytical, and (4) complete analytical (Parta, 2016).

Analytic thinking skills are often associated with critical thinking. Analytic thinking ability is a subset of critical thinking that involves deep understanding and analysis of information (Wang, Mohd Matore, & Rosli, 2025). Some terms of its encompass analytical thinking (Lau, 2024). According to (Suatini, 2019) that critical thinking includes analytical thinking skills, synthesis thinking, and reflective thinking. Furthermore, according to (Facione, 2015) that critical involves the capacity to interpret, analyze, assess, conclude, clarify, and self-manage when encountering different forms of information and conditions

Just like critical thinking skills, analytic thinking is also needed. Someone who thinks analytically has an advantage in learning mathematics because they are able to better understand mathematical concepts and tend to process them in a series of stages (Huincahue, Borromeo-Ferri, Reyes-Santander, & Garrido-Véliz, 2021). Additionally, there is a positive and direct correlation

between analytical reasoning and skills for the 21st century (Abass & Al-Kinani, 2022). The importance of analytical thinking skills encourages mathematics learning for prospective teachers including at Insan Budi Utomo University to be able to adapt. This can be done by applying effective learning methods or models to support students' analytical thinking skills..

Learning models that can be considered are PBL and inquiry-based learning. Problem-based learning is a learning model that uses problems as a starting point for learning, which requires students to solve a problem through the stages of the scientific method so that students can learn knowledge link to the problem (Nugraha, Sinolungan, Nur, Nofirman, & Cahyono, 2023). Acording to (Arends, 2014), PBL can be implemented by introducing students to problems, coordinating student learning, directing individual and group investigations, developing and presenting investigation results, and analyzing and evaluating the problem-solving process. Furthermore, inquiry-based learning is a student-centered approach focused on promoting investigation, the ability to solve problems, and it also makes it possible for learners to actively participate with mathematical ideas and find out about links by doing practical exercises and working together (Doz, Žakelj, & Cotič, 2025). Inqury based learning can be implemented by encouraging students to ask questions, collecting data, analyzing information, and drawing conclusions (Depin, Nurwahid, Sulla, & Barella, 2024).

PBL effectively enhances analytical thinking abilities (Purba & Azis, 2022), as well as inquiry based learning (Sasanti, Hamtasin, & Thongsuk, 2024). In addition, PBL also affects critical thinking skills (Aini, et al., 2018) and also creative (Sari & Stephani, 2024). Inquiry-based learning also has an impact on critical thinking skills (Arifin, Sukarmin, Saputro, & Kamari, 2025) and mathematical reasoning (Şen, AY, & Güler, 2021). Other research states that PBL enhances critical thinking skills (Setiawan & Airlanda, 2023) and problem solving skills (Wijayanti & Anugraheni, 2022) more effectively, when compared to inquiry. According to previous studies, it is revealed that each of the PBL and inquiry models has an impact on analytical skills, meanwhile, PBL is more effective in improving critical thinking skills and problem-solving skills, when compared with inquiry-based learning. This study will examine both PBL and inquiry-based learning to determine whether there are differences between the application of PBL and inquiry-based learning on analytical thinking skills. Considering the significance of implementing learning models that positively influence analytical thinking abilities, this research problem is: Is there a difference between the application of PBL and inquiry-based learning on analytical thinking skills?. The study aim to identify if a difference exists between the use of PBL and inquiry-based learning concerning analytical thinking skills.

2. METHOD

The research employed a quasi-experimental design, which is a development of true experimental methods when full randomization and control of external variables are difficult to implement in educational settings (Sugiyono, 2016). Although quasi-experimental designs do not fully control all external variables, they remain adequate for examining the comparative effectiveness of instructional models in real classroom contexts. This quasy research aims to determine whether there is a difference between the application of PBL and inqury on analytical thinking skills. The research variables consist of dependent variable (y) which is analytic thinking ability, independent variable x_1 which is PBL model and x_2 which is inquiry based learning.

This research involved two groups: Experimental Class 1, which applied the Problem-Based Learning (PBL) model, and Experimental Class 2, which applied Inquiry-Based Learning. Each group consisted of 33 participants selected using purposive sampling from existing classes. The

sample size reflects the natural classroom structure, however, to minimize bias and improve statistical reliability, prerequisite statistical tests (normality and homogeneity tests) were conducted. Future studies are recommended to involve larger samples to increase generalizability. The material tested is limited to discrete mathematical concepts, namely sets, relations, logic, functions, and combinatorics.

The comparison between the two groups is based solely on posttest performance. To reduce potential bias caused by differences in initial ability, the two experimental classes were selected from the same grade level, had similar academic backgrounds, and were taught within the same curriculum structure.After the treatment, a posttest was administered to measure the improvement in analytical thinking skills following the application of PBL and Inquiry-Based Learning.

Data collection used post-test techniques based on indicators of analytical thinking ability. The instruments were validated through expert judgment and aligned with the learning objectives. Data analysis included prerequisite tests consisting of normality and homogeneity tests, followed by hypothesis testing using the independent samples t-test. The data scale used was a ratio scale. The t-test was applied to determine whether there was a significant difference between the two learning models in terms of students' analytical thinking ability. The hypothesis in this study are: H_0 i.e. the average analytic thinking ability with the application of PBL and inquiry based learning is the same, and H_1 i.e. the average analytic thinking ability with the application of PBL is better than inquiry based learning. The directional hypothesis stating that PBL is more effective than Inquiry-Based Learning is supported by previous studies, such as (Setiawan & Airlanda, 2023), which reported that PBL is more effective in improving critical thinking skills, and (Wijayanti & Anugraheni, 2022), which found that PBL is more effective in enhancing problem-solving skills compared to Inquiry-Based Learning.

3. RESULTS AND DISCUSSION

The findings from the data analysis aimed to establish if there is a distinction between the implementation of PBL and inquiry-based learning regarding analytical thinking abilities. Data analysis was conducted on both the dependent variable y and the independent variables x_1 and x_2. Indicators of analytical thinking, the dependent variable in this research, pertain to (Parta, 2016) namely analytical-complete which consists of: (1) clarity of algorithm, (2) coherence of the logic, and (3) the presence of fundamental assertions supporting the procedure. The application of PBL which is the independent variable x_1 refers to (Arends, 2014) which consist of: (1) directing students towards the issue, (2) structuring students for learning, (3) overseeing individual and team inquiries, (4) creating and showcasing group projects, and (5) assessing and reviewing the problem-solving method. The application of inquiry based learning refers to (Wenning, 2010) which consists of: (1) watching, (2) altering, (3) summarization, (4) confirmation, and (5) implementation.

Data analysis began with normality and homogeneity tests. The Lilliefors test indicates that the data has a normal distribution since the Lilliefors normality test statistic is lower than the quantile value of the Lilliefors test, as demonstrated in Table 1. As for the homogeneity test, the F-count value is 1.238 which is less than the F-table (1.805) so that the data is homogeneous. It can be inferred that the prerequisite test indicates the data is normal and homogeneous.

Table 1. Normality test results

Dependent variable	Experiment 1	Experiment 2
n	33	33
Average	76,242	74,545
Liliefors normality test number	0,152949366	0,096809
Lilliefors Test Quantile Value	0,154232803	0,154232803

Additionally, the mean difference in the outcomes of the analytical thinking ability assessment for both class 1 and class 2 was analyzed using an t test. The mean analytical thinking ability in experimental class 1 is 76.242 and experimental class 2 is 75.545. According to table 2, the p-value (0.3075) is greater than 0.05 then H_0 is discarded while H_1 is accepted, indicating that there is no significant difference in the average analytical thinking abilities with the application of PBL and inquiry-based learning.

Table 2. The result of t test

Dependent variable	Experiment 1	Experiment 1	p-value
Analytic thinking ability Mean (SD)	76,242 (7,049)	74,545 (6,335)	0,3075*

*Independent t-test; significant if p-value<0.05

Earlier studies indicate that PBL is more successful in enhancing critical thinking abilities (Setiawan & Airlanda, 2023) and problem solving skills (Wijayanti & Anugraheni, 2022), when compared to inquiry-based learning. The analysis of this research state that the aplication of PBL is not better than inquiry-based learning on analytical thinking skills. Whereas there is previous research which states that PBL is effective in improving analytical thinking skills (Purba & Azis, 2022), as well as inquiry-based learning is effective in improving analytical thinking skills (Sasanti, Hamtasin, & Thongsuk, 2024). So in terms of analytic thinking, both PBL and inquiry-based learning are equally effective in enhancing analytic thinking skills.

The application of PBL is able to support analytical thinking skills because through PBL students are required to analyze and evaluate the problem solving process (Arends, 2014). Just like PBL, pupils are also directed to carry out the verification process in inquiry-based learning (Wenning, 2010). Through the generalization and verification stages, students conclude and test by using concepts derived from the previous stage through other problems regarding the same thing to be discussed again (Meika, Suciati, & Karyanto, 2016). This stage will form students to have a sequence in reasoning which is one of the parameters of analytical thinking skills. Both, PBL and inquiry models, have advantages that can support learners analytical thinking skills.

This research is limited and tested on mathematics learning about discrete mathematics concepts. Discrete mathematics is a branch of mathematics that focuses on discrete or separate structures, such as sets, relations, logic, functions, and combinatorics. These concepts are abstract, but are still represented through symbols, relations, and logical arguments (Rosen, 2019). Discrete mathematics concepts require analytical thinking skills because, according to (Anderson & Krathwohl, 2001), analytical thinking skills are to break down a problem into smaller parts, understand the relationships between those parts, and draw logical conclusions based on available data or premises.

Based on this research, both PBL and inquiry models have significant contributions to the development of analytical thinking skills in learning discrete mathematics concepts. PBL emphasizes problem analysis and evaluation of logical solutions (deductive approach), while inquiry emphasizes pattern discovery and concept formation (inductive approach). This is in line

with (Arends, 2014) that PBL is designed primarily to help students develop their thinking, problem-solving, and intellectual skills through various real-life situations or situations. Learning with inquiry is also able to improve analytical thinking skills through activities to build connections between theoretical concepts and real-life challenges, and empower them to generate potential solutions to these problems (Sasanti, Hamtasin, & Thongsuk, 2024), as well as actively seeking and investigating knowledge, instilling confidence in their abilities (Kusdiastuti, Harjono, Sahidu, & Gunawan, 2016). Furthermore, when combined, the two can provide a holistic learning experience, where students not only understand concepts abstractly, but are also able to apply them analytically in real contexts.

4. CONCLUSION

The analysis show that utilizing PBL does not surpass inquiry-based learning in improving analytical thinking skills. This is evident from the hypothesis test indicating that the p-value (0.3075) exceeds 0.05 so that H_0 is discarded while H_1 is accepted indicating that there is no significant difference in the average analytica-PL,l thinking abilities with the implementation of PBL and inquiry. In terms of analytical thinking, both PBL and inquiry-based learning are similarly effective at enhancing analytical skills. The use of PBL can enhance analytical thinking skills as it guides students in analyzing and assessing the problem-solving process. The application of inquiry-based learning is also able to support analytical thinking skills through the process of concluding and testing solutions using previously learned concepts. The advantages of PBL and inquiry-based learning models can be used as suggestions for further research to combine the two models in improving analytical thinking skills. Further research can also be applied to other mathematical concepts.

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