



Drill & practice and modified moore strategies: Inference on students' mathematical deductive reasoning abilities

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Abstract

Background: The effectiveness of learning strategies plays a pivotal role in enhancing the educational experience, engaging students, and ensuring comprehension of the subject matter.

Aim: The primary objective of this research is to evaluate the comparative effectiveness of the modified moore method versus drill & practice strategies in facilitating student understanding and interest in logic and sets material.

Method: Employing a quasi-experimental design, this investigation involved two groups of students enrolled in the 2022.1. Linear Algebra course, with 47 participants in one group and 52 in the other. Selection of participants was conducted purposively. Data collection was achieved through examinations and analyzed utilizing descriptive statistics along with the t-test.

Result: Analysis revealed no significant difference in educational outcomes between students instructed using the modified moore method and those engaging with drill & practice. This lack of disparity was consistent across students with varying levels of proficiency in Logic and Sets, with the exception of the intermediate group. Within this specific cohort, individuals receiving instruction via drill & practice outperformed their counterparts experiencing the modified moore method.

Conclusion: For students of intermediate skill levels, the drill & practice strategy proves to be more advantageous. The findings suggest that while both methods offer comparable benefits for students at different proficiency levels, the drill & practice approach may be more effective for enhancing the learning experience of those with moderate abilities in logic and sets.

INTRODUCTION

Mathematical reasoning is absolutely important in the mathematics teaching-learning process (NCTM, 2000) and must be accomplished by mathematics students. Reasoning is a thought process that can produce a number understanding of a concept (Siregar, 2018), is one part of the ability to think mathematically, part of communication, metacognition and problem solving, for the ability to make decisions by linking various schemes (Rosita, 2014; Susilo et al., 2019). Students who have reasoning abilities will be reflected in their ability to use patterns and properties (Anisah et al., 2011; Rohati et al., 2023), carry out mathematical manipulations in making generalizations and compiling evidence (Kusumawardani & Warmi, 2023; Putra & Ikhsan, 2019), and explain ideas in the form of mathematical statements (Andriani & Wagino, 2021; Zaenal & Heriyana, 2021). This is in line with the objectives of mathematics learning, as stated in the 2007 Decree of the Minister of Education of the Republic of Indonesia that students must be able to generalize and explain the ideas contained

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in mathematics, and this will have an impact on mathematics learning. learning outcomes achieved (Permendiknas, 2007).

It was stated by Sumartini (2015) & Zaenal & Heriyana (2021) that one of the objectives of learning mathematics is for students to use reasoning to determine patterns and properties, carry out mathematical manipulations in making generalizations, compose evidence, or explain mathematical ideas and statements. In connection with this, it is explained five basic mathematical abilities to meet process standards, namely problem-solving, reasoning, communication, connection, and representation (Kurnia et al., 2019; NCTM, 2000). Therefore, reasoning ability is something that needs to be developed in learning mathematics.

One type of mathematical reasoning that is considered important and often used is reasoning deductive (Febrilia & Nissa, 2019). This type of reasoning is related to drawing conclusions that are based on rules, and stages that have been agreed upon, contain truth values that are right or wrong, and not both at the same time (Febrilia & Nissa, 2019; Siregar, 2018). The stages of deductive reasoning include compiling evidence, carrying out calculations, making conclusions (Manurung & Panggabean, 2020).

Several studies on mathematical deductive reasoning have been conducted. Research conducted to compare two groups of students who were taught using Problem Based Learning (PBL) and Inquiry Based Learning (IBL) (Indah & Nuraeni, 2021; Manurung & Panggabean, 2020). The results of this study revealed that students taught with PBL had better deductive reasoning abilities than students taught with IBL. The research results of Retnowati (2017) found that students with high deductive reasoning abilities were able to fulfill all indicators in deductive reasoning. The research results of (Saputra & Zulmaulida, 2020) show that the application of Critical Problem Solving learning on Pythagorean material resulted in 16% of students at a high level of reasoning, 52% of students at a medium level of reasoning, and 32% of students at a low level of reasoning. Several research results that have been presented illustrate that the learning model applied has not been able to maximally improve students' reasoning abilities. So it is necessary to carry out relevant studies related to the application of learning methods or strategies to improve deductive reasoning abilities (Saputra & Zulmaulida, 2020).

Other research related to reasoning is about mathematical reasoning that is a qualitative research, which qualitatively examines the relationship between mathematics and mathematical language in the learning process in pairs (Wilkinson et al., 2018). One of the last year research found that mathematical disposition and self-concept influence students' mathematical reasoning abilities (Hudria & Zamzaili, 2022). In order to promote mathematical reasoning skills through mathematical modules, some researchers developed a mathematics module to facilitate students' reasoning abilities (Husniah & Azka, 2022). Likewise, learning tools were also have been developed to improve students' mathematical reasoning abilities (Safrida et al., 2016). Research by Pohan & Dewi (2022) suggests that reasoning abilities can be improved through the learning process with NHT assisted by Geogebra.

Previous researches results also found that the application of a problem-based learning model can improve mathematical reasoning abilities better than conventional learning models (Setiawan, 2016; Zaenal & Heriyana, 2021). The mathematical reasoning abilities of students

who receive three-step interview-type cooperative learning are significantly higher than those who receive conventional learning in vocational school students (Aisyah et al., 2017; Nur Afifah et al., 2023). It is also found that improving mathematical reasoning abilities through a guided discovery approach is better than using regular learning for junior high school students (Hermawan & Hidayat, 2018; Salam & Salim, 2020) students taught with the accelerated learning method obtain significantly better adaptive reasoning abilities than students taught with learning (Putra & Ikhsan, 2019).

Drill & practice and modified Moore are part of a learning strategy that has never been compared for its effectiveness in improving mathematical reasoning abilities, especially deductive reasoning. The Drill and Practice strategy provides practice structured for students to increase their interest and learning outcomes in certain subjects (Susanti, 2021; Yusuf et al., 2023), this strategy is carried out through five stages, namely association, explaining the goal, providing motivation, carrying out repeated exercises in stages, and application (Nursehah, 2021; Nursehah et al., 2021). Drill & practice strategy coupled goes along with technology-based learning has a good impact on increasing mathematics learning outcomes (Fahrurrozi et al., 2022; Khoirunisa et al., 2021; Nasution & Prastowo, 2021). Besides, drill & practice alone really improved mathematical learning outcomes (Atiyah et al., 2023; Mare et al., 2021; Rahmawati, 2018). Teacher performance may also be increased by drill & practice strategy (Rachayu et al., 2020).

A number of previous studies have added to the knowledge of mathematical reasoning skills. Meanwhile, the article that the author presents is about student abilities in terms of drill & practice learning strategy compared to the modified Moore learning strategy in terms of student learning outcomes in the Logic and Sets course students already taken. Comparing these two strategies has never been done by previous researchers, especially in relation to improving mathematical deductive reasoning in logic and set material in undergraduate students.

This article aims to compare two extreme learning strategies. Both learning practice in one extreme, drill & practice moderately helps students' learning process and in the other extreme modified Moore does also help students' learning. The hypothesis is that there is a difference in mathematical deductive reasoning abilities between students taught using the drill & practice strategy and the modified Moore strategy, viewed from the grades in the Logic and Sets Course.

METHODS

The research method used in this study is a quasi-experimental design. Research involving two group students of Linear Algebra classes for the first semester of academic year of 2022, at the Department of Mathematics Education university of Halu Oleo Kendari. The first class of 47 students was the class taught by using the drill and practice strategy, and the second class of 52 students was the class with the modified Moore strategy. Samples were purposively chosen, due to the students should be enrolling Linear Algebra course for the semester.

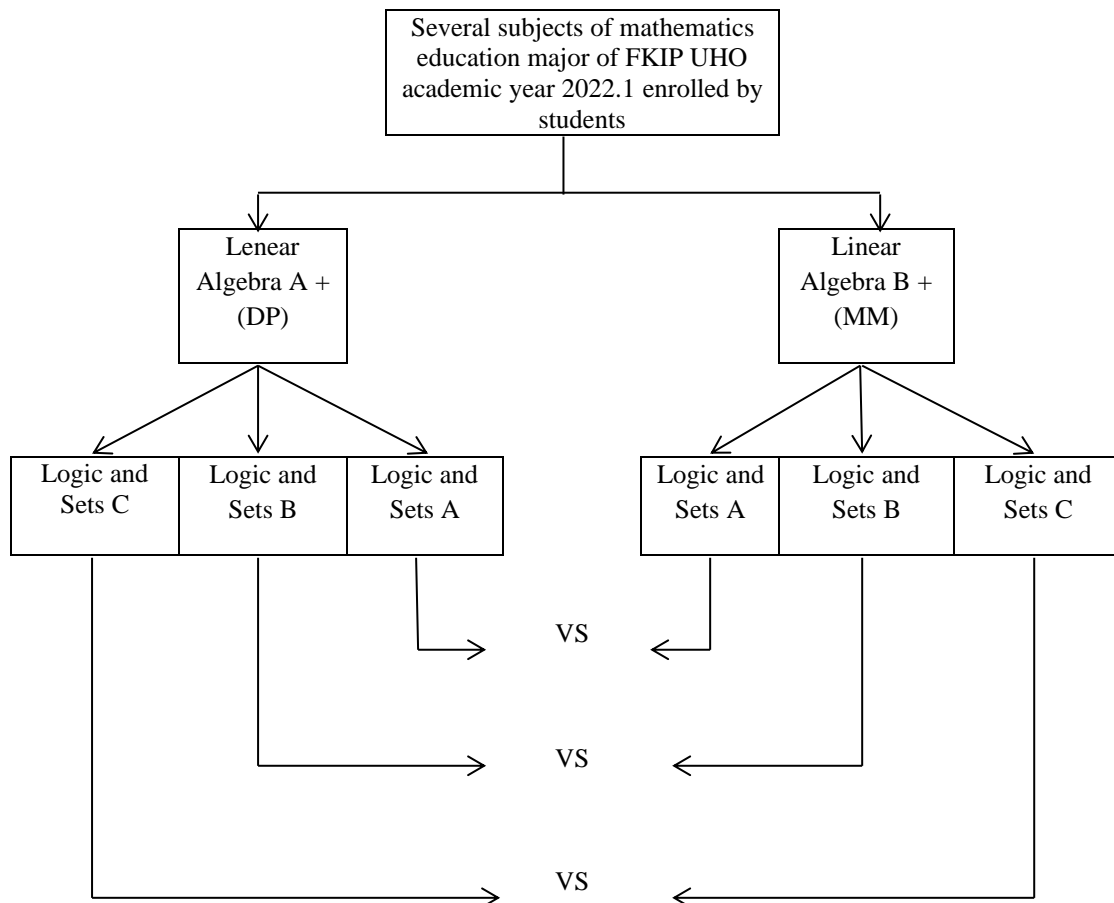


Figure 1. Flowchart of choosing research subjects

After learning process for the first half of the semester (7 times class-room meeting), a test was given to students containing two mathematical deductive reasoning questions incorporated with other questions (five questions) in the first mid-semester exam. It was also being done in the middle of the second semester. This method is used to disguise mathematical deductive reasoning questions during the exam.

Statistical t-test was being applied to reveal the different between the two groups. Each group was divided into three competency level: high level, middle level, and low level of Logic and Sets score. These test were to show students' mean different score between Logic and Sets high level, middle level, and low level of the Logic and Sets category, after the students being taught by applying modified Moore or drill & practice strategy.

RESULTS AND DISCUSSION

Result

Table 1 shows the number of students involved in the study grouped by final score of the mathematical subject Logic and Sets. This score was available at the Department of Mathematics Education UHO academic year of 2022.1.

Table 1. Students' Logic and Sets Score

#	Strategy of teaching-learning process	Logic & Sets Score		
		A	B	C
1	Drill & Practice	5	10	32
2	Modified Moore	8	14	30

Table 2 provides quantitative information that the mathematical deductive reasoning abilities of students taught using the drill & practice strategy are better than the deductive reasoning abilities of students taught using the modified Moore strategy. This provides an indication that the reasoning abilities of students who are the subject of this research can generally be improved by providing many case examples or exercises repeatedly and gradually according to the material being taught. Students in secondary school are in a transition phase, namely from the level of thinking in concrete operations to formal operations. In this phase, students must be given lots of practice and examples that are appropriate to their environmental conditions (Prayogo, 2022). In this case, the drill & practice strategy is more suitable to be applied in learning when students are still in secondary level, where students are given many case examples and practice in stages so that students can more easily understand, accept and internalize the information provided.

Meanwhile, the Modified Moore strategy offers a learning approach that motivates students to study mathematical proofs actively. Students are motivated to think independently, starting from simple problems to improve a solution accompanied by supporting reasons and communicating their ideas in writing or orally so that other students can understand them. It seems that this process has not been able to be internalized by students so that in this research it did not provide better results. The drill & practice method was more dominantly applied in learning when these students were still studying at the secondary level, while the Moore and modified Moore methods were certainly not applied at all at the secondary school level.

Likewise, we can see from Table 2 that students in groups A, B, and C in drill & practice learning have a higher average score compared to their counterparts in the group taught with the modified Moore strategy. These two groups actually have the same opportunity to study together, because there was no restriction that they could not study together. This can be seen in the t-test which provides information that groups B and C from the two treatment groups did not show any differences in their deductive reasoning scores.

Table 3. Descriptive Statistic of The Two Treatment Groups

#	Experimental group	Logic and Sets score	N	Statistics			
				Mean score	Deviation Standard	Mean total	Deviation Standard Total
1	Drill & Practice	A	5	14,400	0,548	11,278	1,365
		B	10	12,500	1,433		
		C	32	10,406	1,266		
2	Modified Moore	A	8	13,875	1,642	10,617	1,208
		B	14	10,857	1,292		
		C	30	10,333	0,994		

Discussion

This research involved two groups students of Linear Algebra classes. One class was taught by using the drill & practice strategy and the other was taught by using the modified Moore strategy. Each class was divided into three groups high (A), medium (B), and low (C) based on their grades in the Logic and Sets course. Table 1 provides a more compact picture of the data for this experimental class.

Mathematical deductive reasoning scores were scored based on a scoring rubric. A score of 4 was given to a completely correct answer. The student answer also uses correct symbol, the statements were logically sequenced with each other, and clearly indicated the hypothesis and conclusion of the reasoning process. A score of 3 was given to student's answer whose reasoning process follows the correct logical flow, but one of the main elements is wrong or does not appear. Also, there are elements of symbols that are used incorrectly or errors in important logical processes. Overall the argument or reasoning process is written correctly. A score of 2 was given to answers whose reasoning process has correct hypotheses and conclusions. However, the process contains errors in the use of symbols or the logical flow is flawed. Meanwhile, a score of 1 was given to answers whose reasoning process has important errors that make the logical flow flawed. This error can occur in the use of symbols, in initial assumptions, so that it contains damage to the logic of thinking. The reasoning process is failure to follow the logical flow of reasoning.

Students from the drill & practice strategy group benefited quite a bit from the learning process in class. The mathematical deductive reasoning process is taught well by lecturers, and students benefit from this process. The results obtained show that students' deductive reasoning abilities can be developed through repeated practice activities based on the stages that have been determined through the learning plan. However, the impact of the changes mostly occurred on students with high and medium abilities, while students with low abilities does not have an impact on changing reasoning abilities in solving the given problem. Five students from group A were able to carry out the mathematical deductive reasoning process with the help of drill & practice strategy done during the class session. There were some students from group B who can even achieve the maximum score in this deductive reasoning process. Group C students do not seem to benefit much from the learning process using the drill & practice strategy.

In line with previous research, it was found that deductive reasoning can be improved through repeated practice (Barkl et al., 2012; García-Madruga et al., 2022; Stephens et al., 2020), providing repeated training with practical examples stimulates reasoning power in carrying out calculations based on certain rules or formulas (Van den & Drijvers, 2020), drill & practice with practical examples can equip students to make generalizations and conclusions in mathematical problems (Lehtinen et al., 2017). Learning by doing lots of practical exercises and repeating them gradually in solving example problems can improve students' reasoning such as understanding patterns and properties and drawing conclusions (Mulnix, 2012), repeated practice in solving examples of mathematical problems can also improve students' reasoning in compiling direct proofs (Koedinger et al., 2012). These findings enrich the research results found from this research that learning with drill & practice strategies can improve deductive reasoning abilities in mathematics learning in logic and set material.

Students who were taught using the modified Moore strategy become students whose reasoning processes are very independent. The reasoning process is deeply embedded in students' minds. In the previous study was also found that students with high cognitive abilities were able to follow the learning process using the modified Moore strategy (Maya & Sumarmo, 2011). In line with other Saefudin (2017) findings, reasoning abilities, in this case students' ability to prove, increased after students were taught using the modified Moore method. His stance was firm in maintaining his opinion in his reasoning process. The modified Moore method could not help groups B and C. In these two groups, their logical thinking processes were hampered by their ability to regulate their previously possessed cognitive rhythms.

In learning with the modified Moore strategy, it is more likely to entrust students' independence in solving problems, with the assumption that students have basic abilities so that they are given the freedom to determine how to solve the problem, after that they are then given guidance by the teacher. This characteristic is what differentiates the modified Moore strategy from the drill & practice strategy. In the drill & practice strategy, students are seen as still at a transition stage which requires a lot of practice and practice repeatedly so that they can instill a broader understanding, improve analytical and evaluation skills related to deductive reasoning.

Implication

Students of mathematics education or (pure mathematics) should be encouraged to active in learning, and as a consequent self-confidence and self-directedness is established and builds within the individual (McLoughlin, 2008). Because of the very minimum lectures in class session, lectures should adopt an approach such that inquiry is ongoing. A demand for understanding what is and why it is, what does not know and an understanding of why it is not known, the difference between the two, and a confidence that if enough effort is exerted, then a solution can be reasoned (Saefudin et al., 2021). Seven steps in doing teaching-learning process by using modified Moore method should be considered important to do (Wicaksana & Rachman, 2018).

Drill and practice is a behaviorist aligned technique in which students are given the same materials repeatedly until mastery is achieved. In each iteration, students are given similar questions to answer or activities to perform, with a certain percentage of correct responses or actions moving the student to the next level of difficulty. One of the most common practices for drill & practice strategy is in the area of Mathematics and this practice has been resulted in increasing students' performance and ability in solving problems (Hendriana et al., 2018).

This drill & practice strategy was really good for the middle group of students who enrolled Logic and Sets course. They are scored B. These students group scored in mathematical reasoning ability surpassed the score of that of group of modified Moore strategy. So, there is no doubt to implement drill and practice in to class-room teaching strategy.

To develop deductive reasoning abilities which include the ability to carry out calculations based on certain formulas or rules, make logical reasoning based on certain rules, compose direct proof, indirect proof, and proof by mathematical induction, compose analysis

and synthesis of several cases, as well as the ability to think procedurally mathematically, you can carried out through the application of the drill & practice strategy, especially in the learning of students at secondary level who are still at the transitional thinking process stage.

Limitation and Suggestion for Further Research

This study was conducted in the Department of Mathematics Education UHO Kendari city, a small city in South-east Sulawesi. The subject is comprised with multi-ethnics community. Both group of lecturers involved and those students were indicated newly applying modified Moore and Drill & Practice strategy of teaching-learning process. So, for the future study researchers and lecturers should be familiarized with both teaching strategies. Both strategies were extreme towards students and the other was extreme towards lecturers. These two strategies should be applied more correctly, precisely, and brilliantly.

The limitations of this research are the relatively small number of tests and no empirical validation. The quality of the test is based solely on experience and expert judgment in the class where it is taught. Apart from that, there is no checking of students' initial abilities. Therefore, it is recommended in further research to apply the two methods used in this research to different samples by paying attention to students' initial abilities.

CONCLUSIONS

The conclusion that can be drawn is that firstly, there is no significant difference between students taught using the drill & practice strategy and students taught using the modified Moore strategy. Second, the high Logic and Sets student group with drill & practice and modified Moore showed that their deductive reasoning abilities were not significantly different, as did the low Logic and Sets group. The group of students with moderate Logic and Sets showed differences in deductive reasoning abilities.

With the findings of this research, the researcher suggests that the drill & practice strategy still needs to be utilized in the learning process by looking at students' initial abilities which are relatively the same as the abilities of students with moderate levels. The modified Moore strategy can also be used in the learning process for students who have a high level of academic ability.

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AUTHOR CONTRIBUTIONS STATEMENT

KD and BN both played crucial roles in the project, with KD focusing on administration, manuscript development, technical support, data interpretation, literature review, and funding. BN, on the other hand, concentrated on the study's conceptualization and design, statistical and data analysis, data acquisition, literature review, and also contributed to securing funding. Their combined expertise ensured a robust and thorough approach to the research.

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