The improvement of students’ mathematical understanding ability influenced from argument-driven inquiry learning

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Abstract. The aim of this study was to examine the role of Argument-Driven Inquiry (ADI) learning toward the improvement of the mathematical understanding ability of mathematics teacher candidate students. The population of this study is students of mathematics teacher candidate in Cimahi City, while the sample is 270 students of mathematics teacher candidate determined purposively and then randomly to be included in experiment and control class. The results show that (1) the mathematical understanding ability improvement of students who received Argument-Driven Inquiry (ADI) learning is better than those who studied using direct learning viewed on the whole; (2) There is a difference in the improvement of mathematical understanding ability of students with Argument-Driven Inquiry (ADI) learning which is better than those who learn by direct learning in terms of PAM (High, Moderate and Low) factors; (3) There is no interaction effect of Learning Factor and PAM on improving students' mathematical understanding ability.

1. Introduction
Mathematics is a discipline of science that plays important role in everyday life, because it can help people solve problems that are faced. This is in line with the opinion of Quigley [1] who suggests that mathematics is a discipline that begins through the method of practical problem-solving analysis.

The ability of mathematical understanding becomes an important factor for the learners. This is in line with what Kilpatrick, Swafford, & Findell [2] have suggested that one's ability to solve a problem is the components of the mathematical skill, namely: (1) conceptual understanding; (2) procedural fluency; (3) strategic competence; (4) adaptive reasoning; and (5) productive disposition.

Learners with the ability to understand mathematically can know more facts and solve a problem by using diverse methods. They can better understand why mathematical ideas are important. Learners with comprehensive ability can also understand a problem which can be solved through operations and relationships in mathematics. Kilpatrick et al [2] argues that conceptual understanding is concerned with understanding comprehensive and functional mathematical ideas. In addition, Fauziah & Sukasno [3] reveal that mathematical understanding is a person's ability to include knowing, understanding and applying concepts, procedures, principles and ideas of mathematics. This implies that learners with good mathematical understanding skills are able to explain the concepts and facts of mathematics by making logical connections between concepts, as well as identifying problems accurately.

Meaningful learning in producing learners’ achievement needs to pay attention to educators’ knowledge about subject matter and pedagogical content factors. Both factors are also called the
domain of knowledge of mathematics teaching that should be a reference that must be considered by an educator.

Educator's knowledge of subject matters has caused the achievement of mathematical understanding of learners is influenced by the ability of the educator's understanding in mathematics. This is because, if an educator has good mathematical understanding ability, then he or she can know better the facts and solve a problem with variety of methods through practical problem-solving analysis [4,5]. Development of mathematics learning should also consider that mathematics is one of the means of forming students' mindset that can be measured from the ability. Thus it is clear that for students (learners) to have good mathematical skills, the teacher of mathematics as a supporting factor must also have good math skills.

Based on problems in field, Bardini, Pierce, Vincent, & King [6] found that mathematicians have mastered skills without any conceptual understanding. In addition, the results of research on high school math teachers show that they tend to not have the ability to ask in mathematics completely. Teacher's mathematical questioning ability is still not well achieved on indicators of problem solving in the form of non-routine questions and open questions [7,8]. Therefore, a teacher candidate student needs to be equipped with mathematical understanding as his or her basic ability, so that he or she can teach students later after he or she becomes a teacher.

One of the most popular learning for teachers is direct learning [9]. It is a learning model that begins with the teacher's explanation of concepts, and then the students are asked to test their understanding through the execution of training tasks under the guidance of their teacher [10]. Direct learning is a method where for content, learning materials, recommended ways to engage with the material, and the speed is determined by the teacher. If direct learning is used appropriately, it will provide effective and efficient results in helping students improve their math skills [11,12].

Kilpatrick et al [2] suggests that the quality of learning is influenced by the level of learner's active involvement during the process of teaching and learning. The influence of learning without the guidance process is very small, while the learning process with the guidance process can increase the learner's activity in constructing his or her knowledge to be optimal [13]. One of the learnings through the guidance process is Argument Driven Inquiry [14].

The stages of Argument Driven Inquiry (ADI) learning according to Sampson et al [14] are: (1) Problem identification; (2) Designing methods and data collection; (3) Analyze data and develop initial arguments; (4) Argumentation; (5) Write a report; (6) The process of blind peer-review; (7) Revise and submit reports. These steps can have a positive impact on developing the learners' mathematical understanding ability [15].

Concerning Prior Mathematics Knowledge (PAM), Castle, Arends, & Rockwood [16] explains that learning new knowledge depends on one's initial and cognitive abilities. This is because the nature of mathematics is a well-organized structure, it is necessary to know the initial knowledge that is a condition in the development of further knowledge.

Based on the issues that have been revealed, the purpose of this research is to know and examine in more depth about: (1) the improvement of students' mathematical understanding ability who receive Argument-Driven Inquiry (ADI) learning and direct learning reviewed in whole and by factor PAM (High, Moderate and Low); (2) the interaction effect of Learning Factors and PAM on improving students' mathematical understanding ability.

2. Experimental method
This study is designed in the form of experiments with a pretest-posttest control group design that aims to examine the role of Argument Driven Inquiry (ADI) learning on improving the mathematical understanding of mathematics teacher candidate students. The population is student of mathematics teacher candidate in Cimahi City, while the sample is 270 students of mathematics teacher candidate which determined purposively and then randomly to be included into experiment and control class. The test of mathematical understanding ability in this research is arranged based on the characteristic of mathematical understanding ability and good test preparation guideline. The data were analyzed by
using Two-Way Annova statistic test to see the difference and interaction effect between Mathematical Prior Knowledge (PAM) learning and type in improving students' mathematical understanding ability.

3. Result and discussion

Findings on students' mathematical understanding abilities based on PAM learning and types are presented in Table 1.

| Type of PAM | Improvement of Mathematical Understanding Ability |
|-------------|--------------------------------------------------|
|             | ADI Class (n = 135) | Direct Class (n = 135) |
|             | Mean | SD  | Mean | SD  |
| High        | 0.78 | 0.07| 0.69 | 0.08|
| Moderate    | 0.64 | 0.11| 0.57 | 0.11|
| Low         | 0.48 | 0.10| 0.40 | 0.11|
| Total       | 0.64 | 0.14| 0.56 | 0.14|

Notes: Ideal Score 1.00

Based on the above description, it can be seen that the mathematical comprehension of students with ADI learning is better than those with direct learning, whether reviewed in whole or by PAM type (High, Moderate and Low). However, the increase for ADI class with PAM type (High) belongs to high category, while ADI class in PAM type (Moderate and Low) and direct learning class on PAM type (High, Moderate and Low) are categorized into moderate.

In addition, reviewed from factors that affect the improvement of the ability of mathematical understanding; then, based on Table 1 it looks that the learning factors and the type of PAM each affects the improvement of students' mathematical understanding ability. However, when viewed simultaneously, the learning and PAM factors do not affect the improvement of students' mathematical understanding ability.

To support the description of the students' mathematical understanding abilities described above, a data analysis test on students' mathematical understanding is performed through statistical test of mean difference. After the normality test of data distribution of students' mathematical understanding ability is conducted; then, it is clear that the data is normally distributed. Based on these findings, the mean difference test is performed using Two-Way Annova test presented in Table 2.

| Source          | JK  | Df | RJK | F    | Sig |
|-----------------|-----|----|-----|------|-----|
| Learning Approach (A) | 0.311 | 1  | 0.311 | 27.878 | 0.000 |
| PAM (B)         | 2.182 | 2  | 1.091 | 97.911 | 0.000 |
| A x B           | 0.007 | 2  | 0.003 | 0.298 | 0.743 |
| Inter           | 2.941 | 264| 0.011 |      |      |

In relation to the learning factor presented in Table 2, the sig = 0.000; It can be concluded that, at 5% significance level, there is a significant difference in the improvement of students' mathematical understanding ability who learn by using Argument Driven Inquiry learning with those who learn by using direct learning.

Based on Table 2 it is also obtained the value of sig for PAM factor to the ability of mathematical understanding of 0.000; It can be concluded that, at 5% significance level, there is a significant difference in the improvement of students' mathematical understanding ability who learn by using Argument Driven Inquiry learning with those who learn by using direct learning.

However, when seen from the interaction effect of learning and PAM factors on the improvement of students' mathematical comprehension ability; then, based on Table 2, at 5% significance level, it is found that there is no significant interaction effect of the learning approach (ADI and Direct) with
PAM (High, Moderate and Low) type to the improvement of mathematical understanding ability of students.

Based on the result of research, it can be seen that basically student of mathematics teacher candidate can understand well through process of solving of problem given. This is because someone who has the ability to understand mathematics, then he can explain the relationship between concepts and relevance based on mathematical concepts that have been understood before and apply the concept or algorithm in a flexible, accurate, efficient and appropriate in solving problems [17–19].

In relation to the role of learning factors, Argument-Driven Inquiry affects the improvement of students' mathematical understanding skills. This is because they gain experience with the right learning experience in developing mathematical understanding skills. Thus, they can optimally utilize various learning resources and engage in communication relations between individuals. The Argument Driven Inquiry (ADI) learning also has four important aspects developed: (1) constructing and producing argumentative skills in supporting mathematical explanations; (2) the ability to use mathematical explanations in problem solving; (3) participating in the discussion process; (4) writing conclusions based on his or her own opinion as well as input from the opinions of others [2,14,15,20–23].

ADI learning can help learners to argue, especially when they get a solution to the problem. Their argumentation is the individual's thought in contributing to the collective thoughts and actions and shared experiences adopted by each individual in the group [14,15,24–28]. In addition, learners can provide creative ideas that can be understood by others who read it; so, the creative ideas they have generated can be acknowledged by others who are in a social group by paying attention to something new and meaningful and can contribute to the mathematical knowledge in the group [26,29].

Thus, Argument Driven Inquiry (ADI) learning is a model that gives positive influence to the achievement and improvement of mathematical understanding ability of prospective teacher students. Thus, they are also able to understand alternative models and strategies to help learners ask the right questions and enable them to diagnose the problem-solving process that the learners will do later [30–33].

4. Conclusion
Based on the results and discussion, it can be concluded that: (1) Improving students' mathematical understanding ability using Argument-Driven Inquiry (ADI) learning is better than using direct learning reviewed in whole; (2) There is a difference in the improvement of students' mathematical understanding ability who learn by using Argument-Driven Inquiry (ADI) learning is better than those who learn by direct learning in terms of PAM factors (High, Moderate and Low); (3) There is no interaction effect of Learning Factors and PAM on improving students' mathematical understanding ability.

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