The effectivness of test instrument to improve mathematical reasoning ability of mathematics student

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Abstract. Mathematical reasoning ability is one of the most important abilities mastered by students. Students must be accustomed to working on high order thinking skills to hone their reasoning skill in solving problems. Therefore, this study aims to develop a standardized test that has undergone a qualitative and quantitative analysis process. As for the specific purpose of this paper is to determine the effectiveness of standard test developed. The test development used The Thiagarajan, Semmel, and Semmel models, namely the 4-D model (define, design, develop, disseminate) with 29 first semester mathematics students as the research subject and the test instrument to improve students’ mathematical reasoning ability as the object. The instruments used were tests and questionnaires. The legibility test results by distributing questionnaires obtained that students gave a positive response to the questions tested. From field trial, it can be seen that the average student is in the “quite well” category. The results of questionnaires and tests show that the tests developed are effective to measure students’ mathematical reasoning ability on the topics of Linear Equation System (LES) and matrix. Thus, this test is standard and suitable for use by lecturers in classroom learning.

1. Introduction
Evaluation is a way to see the effectiveness of a process. The effectiveness of learning should be tested to see the extent to which learning is able to improve students’ abilities. Evaluation through test instrument is a type of evaluation that is often used. The Test instrument is a tool that can measure the level of student understanding of learning.

At State University of Medan (Unimed) itself, tests are used as a tool to measure students’ abilities. A good instrument test according to Arifin [1] is a test instrument that meets the criteria: (1) valid, (2) reliable, (3) the level of difficulty, (4) power difference, and (5) decept. The test instrument currently used in the Unimed environment can be said not to be a good test instrument. This is because the test instrument imposed on students have not been tested by these five criteria. To improve the quality of the assessment of student understanding, a good test is needed. This is very important in improving the quality of learning in the Unimed environment. Jurnaidi [2] argued that the problem faced by the teacher is the lack of availability of specifically designed questions that are in accordance with the students' potential and student character so that the potential of students to use reasoning in each answer to the question has not been optimally developed. This also happens in the mathematics department, tests that have been compiled have never been specifically arranged to improve students' mathematical knowledge.
Adegoke [3] in his article showed that mathematical reasoning ability predicted mathematical achievement quite well. In the learning process, lecturers need to train students with practice questions that lead to reasoning skills so that students get used to give an explanation in solving problems. If reasoning skills are developed in mathematics courses, the reasoning ability that can be measured is mathematical reasoning abilities. Hapizah [4] revealed that problems can be solved well if students have good reasoning skills. While Sukirwan et al [5] revealed that although students generally still have problems with reasoning, students tend to imitate thinking which means that students tend to use routine procedures when dealing with reasoning. According to Nurhayati [6], reasoning is the process of thinking in drawing conclusions in the form of knowledge, linking facts or evidence that are known to lead to conclusions. In evaluating, a test instrument is needed to determine the extent of students' mathematical reasoning ability in understanding the material that had been taught. Therefore this study used a test instrument to improve students' mathematical reasoning.

The topics selected were System of linear equations and matrix. The test instrument had to be valid, reliable, level of difficulty and power difference check. The fifth criteria, deception, was not included because the selected test is an essay test. Focused on improving students' mathematical reasoning, the test instrument was prepared in accordance with the target of achieving learning quality in the IQF curriculum applied at the State University of Medan.

The Four-D Model of Sivasailam Thiagarajan, Dorothy S. Semmel and Melvyn I. Semmel [7] is a model for developing learning devices. This development model consists of four main stages, namely determining, designing, developing and disseminating. There is a lot of development research that used this model. Azlina [8] used this model to improve students' mathematical reasoning and emotional intelligence. She found that there was a significant increase in mathematical reasoning skills of students using the 4-D model in learning. The research was conducted to develop a test instrument that was able to measure the level of mathematical reasoning of mathematics students in field state universities specifically on the topic of systems of linear and matrix equations.

The technique of preparing a test instrument in the development of learning outcomes tests presented by Mardapi in Widoyoko [9] consists of nine steps, namely, (1) Compiling test specification techniques, (2) Writing exam questions, (3) Examining exam questions, (4) Test exam questions, (5) Analyze items, (6) improve, (7) Assemble tests, (8) Carry out tests, and (9) interpret test results. According to Arifin [1a], the aspects that must be considered in the development of tests are the aspects to be measured, the compiler, the purpose of using tests, samples, validity, reliability, administration, how to score, answer keys, assessment and interpretation of tables.

In this article, the problem raised is how the effectiveness of the instruments from the tests developed. Usman H [10] in his research raised the issue of developing tests to measure the reasoning ability of Middle School level students with the topic of mathematics as a whole. This study chose the topic of Systems of Linear Equations and Matrices to see their effectiveness from instruments developed to measure mathematical reasoning of college-level students.

2. Method

The type of this research is development research using the development model of Thiagarajan, Semmel, and Semmel, namely the 4-D model (define, design, develop, disseminate). This article is only limited to looking at the effectiveness of the standard tests developed. The research subjects were the first-semester mathematics students from the regular class. While the object of research is a test instrument to improve students' mathematical reasoning. The instrument used to collect data is tests and questionnaires. The test is composed of 20 essay test questions. The questionnaire was adapted from previous research, namely research conducted by Darmawati [11] as many as 6 questions. To find out the effectiveness of standard test instrument developed, it can be seen from the results of tests of mathematical reasoning ability and student response questionnaires on reasoning questions.

The test instrument designed has 3 reasoning indicators, namely: (1) presenting presumptions; (2) do mathematical manipulation and; (3) drawing conclusions, collecting evidence, giving reasons or
proof of the correctness of the solution. The test characteristics used as valid, practical, and effective references.

3. Result and discussion

The process of developing a test instrument through 4 stages, namely define, design, develop, and disseminate. To see the effectiveness of a standard test, it will only be explained until the development stage. From the results of the define phase analysis, it is known that the tests carried out so far are only tests from lecturers that have not been validated and have not been designed to measure students’ mathematical reasoning abilities. Students rarely get questions to hone their mathematical reasoning skills specifically on systems of linear equation and matrix topics.

In the define stage, an analysis of students is carried out on first semester students whose stages of development are able to draw conclusions, interpret and develop hypotheses. In general, mathematical reasoning ability has never been traced either by lecturers or other researchers. Students also rarely get questions that can hone high order thinking skills. The next analysis is concept analysis. The development of standard test instrument to improve students' mathematical reasoning ability provides problems in the category of high order thinking skills in topic systems of linear equations and matrices. Starting from the completion of the system, operations on the matrix arrive at calculating the determinant of the matrix. Task Analysis is the next analysis that must be done at this defining stage. Analysis of the main academic skills developed in learning in accordance with the applicable curriculum. Details of task analysis for matrix topic on core competencies observed refer to basic competencies which are able to describe systems of linear equations and matrices.

In the design stage, the preparation of a Standard test instrument which includes: test grids, test questions, answer criteria and scoring guidelines. The initial stage was carried out by the researcher is to design 20 questions of mathematical reasoning in the form of description tests with categories of analyzing, evaluating, and creating. Test questions are designed based on the material that has been analyzed and compiled the answer criteria. The results of answers from students will be assessed according to the scoring that has been prepared using an evaluation guide that contains guidelines for scoring each item. Next is the preparation of a questionnaire to determine the readability of the question and the response of students to the test instrument mathematical reasoning ability to be used. Questionnaires compiled consist of 6 aspects of assessment with categories: strongly disagree, disagree, agree and strongly agree. This questionnaire was given to 29 math students. In its development, the format chosen is one that meets the criteria of interest, makes it easy and helps in learning adapted to the indicators of the ability of mathematical reasoning. So that the use of lecturers will be easier in conveying learning and students will be helped in understanding the concepts of systems of linear equations and matrices. The results of all design activities are called draft A.

At the development stage, validation of the test and validation of the questionnaire were obtained from the results of the validation of 3 validators, experts in the field of mathematics education, which consisted of three expert lecturers in linear algebra. The test validation results from 20 essays, valid for 15 questions with a slight revision. For the results of the questionnaire validation, the six questionnaires were declared valid with little revision.

| No | Responding Aspects                          | Strongly disagree | Disagree | Agree | Strongly Agree | Total Percentage (%) |
|----|---------------------------------------------|-------------------|----------|-------|----------------|----------------------|
| 1  | The language used is easy to understand     | 3                 | 5        | 18    | 3              | 8% (28%) 21% (72%)   |
| 2  | Interesting/challenging to solve/solve      | 5                 | 7        | 12    | 4              | 12% (41%) 16% (55%)  |
Table 1 is a table of questionnaire results which shows that the test instrument received a good response that is equal to 76\% of students gave a positive response.

Data from the test results that measure students' mathematical reasoning ability can be seen from the final score obtained when working on high order thinking skills test questions. Data from the test results were analyzed and converted into qualitative data to determine the level of students' mathematical reasoning abilities. The results of the analysis are shown in the following table 2:

| Number of tests | Participant score | Frequency | Percentage (%) | Category       |
|-----------------|-------------------|-----------|----------------|----------------|
| 80<score≤100    | 6                 | 20,69     | Very Well      |
| 60<score≤80     | 13                | 44,83     | Well           |
| 40<score≤60     | 5                 | 17,24     | Quite Well     |
| 20<score≤40     | 5                 | 17,24     | Lack           |
| 0<score≤20      | 0                 | 0         | Very Lack      |
| Total           | 29                | 100       |                |
| Average         | 63,60             | 100       |                |

From the results of field trials, it can be seen that the average student score is 63,60 and is in the “well” category. Based on the results of validation from an expert, the test instrument and questionnaire of student responses to the test have been declared valid by the validator. After making revisions, the questions developed have met valid criteria and can be used to measure students' mathematical reasoning ability in field trials. The developed test instrument is said to be effective if: (1) the test results are in a quite well category; (2) student responses in a positive response.

Students' mathematical reasoning ability can be honed through a test. A good test instrument is an instrument that goes through several stages of testing until it can be said to be valid, practical and effective. In this study, the test instruments of mathematical reasoning ability on the LES and matrix topics tested were effective, meaning the test results were in a fairly good category and the students' responses were in a positive response. The instrument of this test can already be used as a tool to measure students' mathematical reasoning ability.

4. Conclusion
Legibility test results and field trials show that the tests developed are effective to measure students' mathematical reasoning ability on the topics of SLE and matrices. Thus this test is standard and feasible to be used by lecturers in classroom learning.

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