

Mathematical Reasoning and Communication Levels Ability based on Gender Differences

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Abstract

Issues about gender seems to be endless in various countries in the achievement of student learning outcomes, even in mathematics learning between male and female students. This qualitative research aims to explore the levels of mathematical reasoning and communication abilities of students who attend language class programs in senior high schools based on gender. Respondents were students who had abilities with different levels of ability, two each representing male and female students. Data analyze from the results of tests of mathematical reasoning and communication abilities and in-depth interviews using method and time triangulation techniques. The results show that female students are superior in reasoning and communicating than male students in solving math problems.

Keywords: Reasoning, communication, gender, mathematics ability.

INTRODUCTION

Mathematics plays a significant role as an abstract science in many fields and develops human thought. All educational levels must include mathematics courses to teach students the tools they need to think critically, rationally, analytically, methodically, and artistically. Students must possess these skills to obtain, manage, and make use of knowledge in a constantly changing, uncertain, and competitive environment.

The main aims of mathematics education are to help students develop reasoning skills and abilities. The ability to discuss quantitative situations and draw logical mathematical conclusions from them depends on: (a) understanding of the nature number system and in particular the principles and relationships that make mathematics a tool for quantitative thinking; (b) the order of symbolic language in mathematics; (c) the order of the fundamental thiking processes; (d) the ability to correlate the rules of thinking systematically and schematically explained to certain social situations with previously studied mathematical principles (Harold E. Moser, 1948). The objectives of learning mathematics have been defined in content (process) standards by the *National Council of Teachers Mathematics* (NCTM), then there are four abilities in the curriculum and regulations of the Indonesian national education minister based on NCTM including: (1) Problem-solving, (2) Reasoning and Proofing, (3) Communicating (4) Connecting, (5) Representating and creating mathematical ideas in various mathematical phenomena (Depdiknas, 2006; NCTM, 2000).

Level of mathematics ability student are different based on their level of education. For example, the level of difficulty in junior high school for student is very different from elementary school. Every student experiences different levels of intellectual development. Children aged 11-18 years, namely in the formal operational stage, children are already able to use their concrete operations to form more complex operations, meaning that children have started to think abstractly without needing help from concrete objects or events and to think logically using thinking patterns “possibility” (F. Piaget, 1995; J. Piaget, 2010). Children already have a scientific thinking model with a hypothetical-deductive type, with the ability to draw conclusions, develop and hide hypotheses. It can be said that learning mathematics is a planned and directed empowerment in order to fulfill competency achievement and basic needs.

Gender Issues in Mathematics

Gender is the difference as roles, functions and responsibilities between men and women which are the result of social construction. It can change according to the development of the era and the cultural and social values that apply to a certain period of time. However, the gender referred to in this study is sex (sex) on field facts which state that gender in daily life is sex. The differences between men and women include: women in general pay attention to things that are concrete, practical, emotional and personal, while men are focused on things that are intellectual, abstract and objective (Arani & Mobarakeh, 2012; Hall & Norén, 2021)

These gender differences also raise the question of whether learning, thinking, or concept formation also differs based on gender. Thus, gender differences are differences in roles, functions and responsibilities between men and women, are the result of social construction processes and can change over time. The effect of gender differences in math learning has attracted the attention of educational research since the early four decades, when several studies highlighted male dominance in mathematics and science. It shown that haow high the gap is between male and female students in mathematics assessment (Perez Mejias et al., 2021), and it cannot be denied that even though the shift in mathematics attention has now been dominated by female students but the fact is that there are still real gaps in assessing mathematics learning outcomes. Furthermore, research of affective characteristics based on gender differences found that female students tend to experience a decrease in interest and self-confidence which results in their mathematics learning process at higher levels such as at university level (Ghasemi & Burley, 2019). Another research supports that female students are superior in persistence and mathematical concepts than male students the results show that female students tend to be more resilient in maintaining their own condition, diligently and conceptually understanding mathematics (Brown & Kanyongo, 2010; Gevrek et al., 2020).

Gender, social, and cultural influences on mathematics learning from elementary school age (Keitel, 1998), several studies to examine how gender differences relate to mathematics learning, males and females were compared using variables including innate abilities, attitudes, motivation , talent, and performance (Goodchild & Grevholm, 2009; Unesco, 2022). Biological differences between male and female brains which are known from observation that male tend to be better in language or writing than female because of their superior spatial skills influence the impact of gender factors on mathematics (Geary et al., 2000). Therefore, it is very hard to change gender differences in mathematics. Several studies show, however, that there are no mutually exclusive male and female roles in the field of mathematics. In this respect, females can stand up to male in different areas regarding mathematics.

Reasoning and Communication Ability

Reasoning and communication are two very important and essential aspects of learning mathematics. Reasoning is a high-order thinking skill activity which, if it is habituated and developed properly and consistently, will make it easier to solve mathematical problems. Complexity in mathematical reasoning is not easily achieved in an instant, it takes repetition in problem solving exercises which are

also influenced by the learning environment (Sukirwan et al., 2018). Learning experiences related to a series of brain activities, of course, have no meaning if they are not formulated in the form of oral or written communication. In this case, mathematics is a symbolic language of abstraction.

In addition, in conveying an idea or reason, a tool is needed to convey it, so that communication here becomes a tool that plays an important role in achieving competence. Without communication it is very difficult to be able to improve one's mathematical ability as the learning objectives have been set. The communication process will help students build meaning, convey ideas correctly, and make it easier to explain these ideas to others so that the information obtained is easy to understand. Therefore, every student needs to have reasoning abilities in mathematics, where mathematics uses logic related to reasoning. It is not only because mathematics is a knowledge acquired by reason, but also because one of the objectives of learning mathematics is to enable students to use reasoning for patterns and properties, to perform mathematical operations for generalizations, proofs, or explanations of mathematical concepts and statements.

Gender issues and gaps are cited as a problem in achieving the educational objectives of mathematics. Surprising results in self-assessment between male and female obtained that the percentage of around 60% of female had a high level of confidence, while male were at 56% with the intensity of confidence in mathematical abilities (Anaya et al., 2022). The history of mathematics achievement based on the gender gap has been dominated by male, but this gap has begun to shift and be dominated by female in recent decades, especially in developed countries where a lot of recruitment has been done using tests of interest in mathematics for both male and female. (Forgasz et al., 2014; Lonnemann et al., 2013; Sarouphim & Chartouny, 2017). The gaps involving gender need to be solve from exploring in depth so that the linkages between reasoning, communication and gender in the management of mathematics learning objectives can be resolved not only as a prolonged issue, so this paper is written to explore the level of students' mathematical ability based on gender.

Mathematical ability can be described to explain mathematical ideas with pictures or graphs, connect pictures, graphs or situations to mathematical ideas, and explain and make questions about mathematics. There are statements drawn from the following characteristics of mathematical material facts; (1) If you want to have good reasoning, you should be learning mathematics, and if you want to understand about math you should learn mathematics used reasoning,(2) The result of learning mathematics is students were able to solve problems by utilizing the studied mathematical objects, both direct objects (facts, concepts, principles, and skills) and indirect (mindsets).

METHODS

This study used a qualitative approach with method and time triangulation techniques. Series data collected from the tests carried out on 36 students with 21 female and 15 male, interviews than describing in detail four subjects which have been assigned to females having an upper or lower intelligence level. Research subject are in 3rd grade students at senior high school who takes language program concentration class at Madrasah Aliyah Negeri 2 Kota Bima, West Nusa Tenggara, Indonesia. Assessment of the student's mathematical ability on the basis of diagnostic tests and results from a final evaluation of their mathematics. The criteria for grouping level mathematical reasoning ability and communication are as high level ability value is $75 < x < 100$ and average level value is $55 < x < 75$.

The test for mathematical reasoning and communication ability was based on indicators for the achievement of mathematical reasoning and communication, and the tests for the research subjects based on gender were carried out for further interviews. In determining the level of students' reasoning and communication abilities in working on a given test, a scoring rubric is used as guidelines scale for reasoning and communication ability test scores. Indicators used in the guidelines include: (a) Expressing mathematical ideas using mathematical language (tables, matrices, systems of linear

equations), (b) proposing a mathematical conjecture with clear and precise, (c) proving the reasons for the correctness of the solution, (d) checking whether the argument is valid, and (e) drawing conclusions (*generalize*). To classifying the level of reasoning and communication capabilities used holistic assessment based on the above analytical rubric, such as the following:

Superior	: $3.5 \leq x \leq 4$
Satisfactory	: $2.5 \leq x \leq 3.5$
Quite satisfactory	: $1.5 \leq x \leq 2.5$
Unsatisfactory	: $x < 1.5$

RESULT AND DISCUSSION

Result

Based on the criteria established by NTCM and the Director General of Education Regulations, the following are indicators such as parameter of mathematical reasoning and communication used are; (1) Expressing mathematical ideas using mathematical language (tables, matrices, systems of linear equations), (2) Proposing a mathematical conjecture with clear and precise, (3) Proving the reasons for the correctness of the solution, (4) Checking whether the argument is valid, (5) Drawing conclusions (*generalize*)

Each indicator of the attainment of reasoning and communication skills is independent of each other, but the indicators can be combined. Therefore, there is a possibility to devise an assessment tool that only trains and measures student ability to make predictions or just train and measure their mathematical manipulation abilities, but assessment instruments can also be arranged that train and measure students' abilities in making conjectures as well as training and measuring the ability to make predictions, and manipulation of mathematics.

The main characteristic of training and measuring reasoning and communication skills is a type of assessment instrument that requires students to carry out activities of investigating/checking the truth of a statement, finding, proving, concluding (based on known statements), manipulating (facts, concepts, principles, skills), conjecture, give logical reasons. The following is the data obtained based on the questionnaire and data analysis on the level of mathematical ability. Based on the results of subject data, mathematics evaluation scores were obtained from four students, including two men representing high and medium ability (score: 87 and 75) and two women representing high and medium ability (score: 90 and 75). Also obtained was an analysis of the characteristics of students who tended to be at a medium level who had feelings of attitude, namely being quiet and lacking self-confidence. On the other hand, students who tend to be at a high level have the same character, namely good at speaking and very confident.

After grouping based on mathematical abilities, four students were taken as respondents, namely two male students and two female students, each representing high and medium abilities. Furthermore, data on the results of reasoning and communication ability tests from selected respondents are presented in the following graph.

Graph 1. Reasoning and Communication Level Ability's Student

Score	M-1	M-2	F-1	F-2
	Male		Female	
Indicators 1	1.25	1	3	4
Indicators 2	1.5	1	2	3
Indicators 3	2.5	2.5	3	1.5
Indicators 4	1	1	1.5	2.5
Indicators 5	1.33	2	3.33	4
Mean	1.52	1.50	2.57	3.00

Based on these data, show that in average ability of male students is at a quite satisfactory level, while the scores obtained by female students are at a satisfactory level.

Reasoning and Communication Ability of Male and Female Students

The concept of problem solving used by male students generally focuses on result without considering the process. For example, respondents may state their problems in stating the problem in tabular form but experience a misunderstanding of the x and y values. Furthermore, respondents have different creativity in solving systems of linear equations with their own methods without paying attention to the question requests, namely solving problems using matrices. It appears that the mathematical reasoning of male students is generally logical even though they are considered to be less capable of communicating their reasoning.

The concept of problem solving used by female students generally focuses on goals. If men pay less attention to goals in the sense of not giving conclusions, it is different from women. Besides being able to solve problems using logical reasoning, female students can communicate their reasoning well. For example, by providing logical reasons and mathematical evidence related to the answers given. Judging from the test results and supported by some of the respondents' answers from interviews, the respondent's ability to analyze the problems given is good quite but in presenting problems for mathematical modeling is very lacking.

Discussion

It is important that children are given a clear understanding of the need to provide reasons for mathematics statements, according to their experience in math communication. This is the first step in recognize that mathematics reasoning and communication are based on fundamental assumptions and rules, which have a systematic way of defining math. This reasoning is found in all materials with different accuracy requirements at all grade levels.

Reasoning and communicate mathematics is built into the learning process so that students can understand reasoning and proof in its basic aspects, such as creating and investigating math conjectures; building and evaluating arguments and proofs; and choosing and applying a variety of explanations and methods of proving. Reasoning is one of the basic mathematical competencies in addition to understanding, communication and problem solving.

Reasoning and communication are mental processes in developing thoughts from some facts or principles. Reasoning is a thinking process that is carried out in one way to draw conclusions both between inductively and deductively. Mathematical reasoning abilities include general reasoning related to the ability to find solutions or solve problems; abilities related to drawing conclusions, such as syllogisms, and related to the ability to assess the implications of an argument; and the ability to see relationships, not only between things but also between ideas, and then use those relationships to derive other things or ideas. Assessing the real of mathematical reasoning and communication, means assessing competence in reasoning and communicating mathematical ideas that are routine or non-routine, the indicators of which can be known from presenting mathematical statements orally, in writing, pictures and diagrams; submit allegations; Perform mathematical manipulations, draw conclusions, compile evidence, provide reasons or evidence against the truth of the solution, draw conclusions from statements, verify the validity of arguments, and find patterns or properties of mathematical phenomena to make generalizations.

In order to develop thinking based on facts or principles that can be explained, the capability of mathematical reasoning and communication requires an understanding of thought in logical and

analytical terms. Accordingly, there is a marked gender gap in achieving the standards for mathematical competence. To learn math in school is determined by this fundamental abilities difference.

CONCLUSIONS AND SUGGESTIONS

Male respondents have reasoning and communication skills that are moderate or can be said to be quite satisfactory. Where several indicators of reasoning and communication as a whole are not fulfilled. Meanwhile, for female respondents, overall the five indicators that have been formulated have been sufficiently fulfilled, one of the respondents met the title of satisfactory and the other one was quite satisfactory. Several deficiencies that occurred during the test were resolved during the two-stage interview, and this clarified the parts of the indicators that had been met or not sufficiently met. Reasoning and communication tests as well as several interviews that have been carried out for paying attention to all aspects of the indicators. The fact that report card scores often do not match the actual capabilities of students is sometimes unfair to some students. In general, the mathematical reasoning and communication abilities of female students are superior when compared to male students.

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