International Journal of Evaluation and Research in Education (IJERE)
Vol. 12, No. 4, December 2023, pp. 2280~2285
ISSN: 2252-8822, DOI: 10.11591/ijere.v12i4.27224

Students' mathematical literacy skill in term of gender differences: A comparative study

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Article Info

Article history:

Received Apr 3, 2023
Revised Oct 2, 2023
Accepted Oct 16, 2023

Keywords:

21st century
Gender differences
Learning
Mathematical literacy

ABSTRACT

The emergence of the 21st century requires the younger generation to be able to face increasingly fierce global competition. One of the skills needed by the younger generation in this century is mathematical literacy. This ability needs to be improved in learning at school. One important factor that must be considered in learning mathematics literacy is gender differences. Therefore, this study aimed to identify students' literacy abilities and find out the differences between male and female students at Madiun State Middle School, Indonesia. This research used a quantitative approach in the form of a comparative study. The research sample of 336 students was analyzed using descriptive analysis and the Mann-Whitney test. The results of the study concluded that the ability of female students' mathematical literacy was much higher than that of male students. Female students excel in terms of representation, modeling, mathematical communication, and problem posing and solving skills. Meanwhile, male students excel in terms of using math symbols and mathematical thinking and reasoning.

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1. INTRODUCTION

Education as an important investment in facing global competition needs to be well designed. This is to prepare young people who are able to collaborate, think critically, be creative and communicative, as a form of life skills needed in the 21st century. One of the abilities needed and needs to be trained to make this happen is literacy skills. Literacy is a person's ability to read, write, use, and interpret knowledge that has an impact on social intelligence to increase competitiveness in dealing with 21st century skills. One of the important components needed to build the skills needed in the 21st century is mathematical literacy [1], [2].

Mathematical literacy can be interpreted as an individual's ability to formulate, employ, interpret, decode, articulate, and predict mathematics against the phenomenon of situations encountered in various complex contexts that require high-level thinking activities [3]. Mathematical modeling can be defined as using mathematics to explain and define the events in real life, to test ideas and to make estimations about real life events [4]. This means mathematical literacy is used to emphasize of mathematics in everyday life. Mathematical literacy is not only limited to the implementation of certain procedures and basic knowledge of mathematics. According to Lailiyah [5], mathematical literacy includes eight skills that individuals must possess. However, in this study, researchers only used six skills, namely: symbols; representation; modeling, mathematical communication; problem posing and solving; and mathematics thinking and reasoning.

The importance of mathematical literacy in facing the 21st century is not balanced with the achievement of students' mathematics learning achievements in Indonesia. Currently, their mathematics learning achievement is still relatively low. This is allegedly caused by the low mathematical literacy of students in Indonesia. Based on the results of the Program for International Student Assessment (PISA) Survey conducted by the Organization for Economic Cooperation and Development (OECD) on children aged 15 years in 2015, the mathematics ability of Indonesian students is ranked 63rd out of 72 countries. In 2018, PISA also provided scores and rankings of OECD countries in mathematical ability, where Indonesia ranks 72 out of 78 countries with a score of 379 below the average OECD country score for mathematical ability, which is 489 [6]. These results indicate that the mathematical literacy of Indonesian students based on international studies is still not satisfactory. Mathematical skills that students need to know do not only refer to basic calculations, but also how to use mathematics to analyze complex problems, to reach logical solutions, and to estimate the efficiency of different ways to solve a problem [7]. Because of the importance of mathematical literacy, it must receive special attention in the world of education and be made one of the main focuses that need to be improved in learning in schools.

Many factors must be considered in the study of mathematical literacy, among others: the willingness, ability, and specific intelligence, readiness of teacher and students, curriculum, and methods presented, a factor that is not less important is the gender factor [5]. Therefore, researchers feel interested in investigating further about mathematical literacy skills that focus on gender differences in junior high school students in Madiun, Indonesia. Several previous studies examined gender differences in the six components of mathematical literacy skills which consisted of mathematical communication, modeling, representation, mathematics thinking and reasoning, problem posing and solving, symbol or using mathematic tools.

In the communication component, it was found that the communication skills of female students were far better than those of male students [8], [9]. Likewise with mathematical abilities [10], [11], representation [5], [12], and the ability to use problem solving strategies [5], [10]–[14], female students are also superior to male students. Then for mathematics thinking and reasoning, male students are much better than female students [5], [10], [12], [15], [16]. Gender differences are often cited as one of the factors that influence a person's development, both in terms of physical development and in terms of cognitive development. Likewise, a person's thinking ability can be influenced by gender factors [17]. In addition, male students are also superior to female students in terms of using mathematical tools, such as measurements, operations, and symbols [5], [12].

Most of the previous studies measured students' mathematical literacy skills based on whether or not they were able to answer the questions given, while explicit calculations confirming differences in mathematical literacy skills based on gender had not been widely carried out. Based on this review, it is necessary to identify students' mathematical literacy skills to determine the differences on the abilities of male and female students in state junior high school, Madiun, Indonesia. This is expected to be an overview and recommendation for teachers in designing and implementing effective mathematics learning in the classroom. The learning in question can be adjusted to the gender of students, so that they can achieve optimal mathematical literacy skills.

2. RESEARCH METHOD

The research design is quantitative with a comparative research type that aims to compare students' mathematical literacy skills based on gender. The data collection technique was obtained through a mathematical literacy ability test with a score of 4 criteria, where a score of 0 means "no answer", score 1 "able to simplify information in contextual problems, but the solution is wrong", score 2 "able to simplify information in contextual problems, but completion is still incomplete", and score 3 means "able to simplify information in contextual problems and solve them correctly and completely". The population of this study was students of class IX at State Middle School in Madiun City, Indonesia, while the research sample consisted of 336 students who were calculated using the Slovin formula [18]. The subjects of this study were 14 public junior high schools in Madiun City, then the schools were classified into three strata: A (high), B (moderate), and C (low) according to the Regional Education Standards Assessor scores for junior high schools in Madiun in 2022, then samples were taken by means of stratified random sampling. The instrument for measuring mathematical literacy skills uses 6 skill component which are described in Table 1 [5].

The reliability test to measure the consistency of the six components obtained Cronbach's alpha (using math symbols=0.703, representation=0.604, modeling=0.650, mathematical communication=0.665, problem posing and solving=0.662, mathematics thinking and reasoning=0.658) exceeding the minimum requirement of 0.6 [19]. Data analysis techniques used descriptive analysis and Mann-Whitney test with the help of IBM SPSS Statistics version 20. The Mann-Whitney test was carried out, because each component of mathematical literacy ability was not normally distributed (probability value<0.05) [20]. The hypotheses tested in this study include: i) There are significant differences in using math symbol skills between male and female students at state junior high school Madiun (H1); ii) There are significant differences in representation skills between male and female students at state junior high school Madiun (H2); iii) There are significant differences in modeling skills between male and female students at state junior high school Madiun (H3); iv) There are significant differences in mathematical communication skills between male and female students at state junior high school Madiun (H4); v) There are significant differences problem posing and solving skills between male and female students at state junior high school Madiun (H5); vi) There is a significant difference in mathematical thinking and reasoning skills between male and female students at state junior high school Madiun (H6).

Table 1. Component of mathematic literacy skill

Component	Definition
Symbols	Using symbolic, formal, and technical language and operations.
Representation	Decoding, encoding, translating, distinguishing between, and interpreting different forms of representations of mathematical objects and situations as well as understanding the relationship between different representations.
Modeling	Structuring the field to be modeled; translating reality into mathematical structures; interpreting mathematical models in terms of context or reality; working with models; validating models; reflecting, analyzing, and offering critiques of models or solutions; reflecting on the modeling process.
Mathematical communication	Expressing oneself in a variety of ways in oral, written, and other visual forms; understanding someone else's work.
Problem posing and solving	Posing, formulating, defining, and solving problems in a variety of ways.
Mathematics thinking and reasoning	Posing questions characteristic of mathematics; knowing the kind of answers that mathematics offers; distinguishing among different kinds of statements; understanding and handling the extent and limits of mathematical concepts

3. RESULTS AND DISCUSSION

There were 336 students who came from several public junior high schools in Madiun as research respondents. Of this total, there were 175 female students, while the remaining 161 students were male. Mathematical literacy skills are reflected in the six ability components presented in Table 2. Most students get the highest scores on the ability to use mathematical symbols and representations, while the other four abilities consist of modeling abilities, mathematical communication, problem posing and solving, and mathematical thinking and reasoning tend to get low scores.

Table 2. Number of students based on mathematical literacy skill component scores

Score	Using math symbol	Representation	Modelling	Mathematical communication	Problem posing and solving	Mathematics thinking and reasoning
0	9	16	13	23	34	34
1	60	105	262	163	287	236
2	47	46	40	66	6	39
3	220	169	21	84	9	27

Description: 0 (very low), 1 (low), 2 (high), 3 (very high)

Table 3 shows the mathematical literacy abilities of both genders. The results show that male and female get very high scores on the ability to use mathematical symbols, while male and female scores tend to get low scores on the components of modeling skills, mathematical communication, problem posing and solving, and mathematics thinking and reasoning. However, different results were found for representational abilities where female scored very high, while male students scored low on this ability component.

Table 3. Number of students based on mathematical literacy skill component scores by gender

Score	Using math symbol		Representation		Modelling		Mathematical communication		Problem posing and solving		Mathematics thinking and reasoning	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
0	4	5	3	13	4	9	8	15	9	25	17	17
1	42	18	36	69	129	133	65	98	154	133	133	103
2	37	10	28	18	28	12	40	26	4	2	18	21
3	92	128	108	61	14	7	62	22	8	1	7	20

Description: 0 (very low), 1 (low), 2 (high), 3 (very high)

The difference in mathematical literacy ability between male and female students will be tested statistically. The results of the Mann-Whitney differential test produced significant differences in the overall components of mathematical literacy ability of male and female students at a significance level of 5% (p-value<0.05), so that the first hypothesis against the sixth hypothesis (H1-H6) was accepted as presented in Table 4. Based on the table, male students are superior to female students in the ability to use mathematical symbols and the ability to think and reason mathematics. Female students are superior to male students in terms of representation, modeling, mathematical communication, and posing and problem-solving skills.

Table 4. Mann-Whitney Test based on gender

Mathematic literacy skill	t-value	p-value	Mean rank	
			Female	Male
Using math symbol	-4.706	0.000	148.33	190.42
Representation	-5.256	0.000	192.98	141.89
Modelling	-3.136	0.002	180.04	155.96
Mathematical communication	-5.415	0.000	194.06	140.72
Problem posing and solving	-3.734	0.047	180.13	155.85
Mathematics thinking and reasoning	-1.989	0.000	160.35	177.36

The ability of male students in using mathematical symbols and mathematical thinking and reasoning is far superior to that of female students. These results were supported by previous researchers who stated that female students in the mathematical thinking and reasoning component could not finish well [11]. In addition, males had better results than females in using mathematical symbol [21]. Knowing the differences in characteristics between male and female is expected to provide the right strategy to reduce gaps, especially in mathematical reasoning [22]. There were differences in the reasoning of male and female student, in which at the stage of understanding the problem, the answers given by the male student was more detailed than those by the female one [23].

The representational ability of female students is higher than that of male students, supported by previous research [24]. Female students have higher modeling abilities than male. Female say they enjoy working on modelling problem because they think this type of problem can improve their current family life. Meanwhile, male students tend to do better in visuospatial terms than reading competence [25]. Mathematical communication ability of female students is also higher than that of male students. Male students with low mathematical abilities often misinterpreted the problems given so that it is necessary to demonstrate literacy problems that contain aspects of communication as an exercise to improve communication skills. Teachers should be able to stimulate students' mathematical communication skills through creative and innovative learning activities [26]. Female students are much better at problem posing and solving skills, as the results of previous research [27], [28].

Gender differences were evident in success patterns and in strategy use on conventional and unconventional problems. Specifically, female students were more likely than male students to correctly solve conventional problems using algorithmic strategies. Gender differences in mathematical problem solving, that is believed to be an important factor that contributes to gender differences in mathematics performance [29]. Computational thinking (CT) skills for mathematics, female students are better than male students in solving mathematical problems [30]. Mathematic achievement is related to CT skills. Therefore, basic mathematical knowledge, including computational areas involving algorithms, should be emphasized early in teaching and learning activities to enhance critical thinking skills. Improvements in critical thinking skills will stimulate students to solve problems, thereby enhancing CT skills and student engagement in science, technology, engineering, and mathematics fields [31].

4. CONCLUSION

Mathematical literacy is one of the abilities that students must have in facing competition in the 21st century. In testing differences in mathematical literacy skills between female and male students, it was found that there were significant differences in all components of mathematical literacy ability. Male students outperformed female students in two components, namely using math symbols and mathematical thinking and reasoning, while female students outperformed male students in four components, namely representation, modeling, mathematical communication, and problem posing and solving abilities. From these results it can be said that the ability of female students' mathematical literacy is much higher than that of male students.

Suggestions for educational institutions, especially in public junior high schools, need to pay attention to the abilities of male and female students in providing mathematics learning, because both have different abilities, so they cannot be equated. Teachers need to provide learning that focuses on representation, modeling, mathematical communication, and problem posing and solving abilities for male students and the ability to use math symbols and mathematical thinking and reasoning for female students. Future research needs to identify mathematical literacy skills by adding two other components, namely mathematical argumentation and tools and technology.

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