

Language Competences as a Contributing Factor in Solving Mathematical Problems

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Abstract—Mathematics is a compulsory subject for both elementary and high school students. The materials covered in this subject, which are mostly abstract with numbers and verbal symbols, have made it seem very hard to learn. In addition to its abstract characteristic, the lack of understanding on the language used in formulating mathematical concepts, especially in solving everyday problems, have contributed to the challenges faced by students upon their learning. In addition, teachers' lack of understanding of the importance of language competence in learning mathematics has made the learning method focus mainly on the procedures for solving problems. This paper discusses various challenges faced by students in solving mathematical problems and their contributing factors. This study uses a qualitative method. The results of this study that the difficulties in comprehending basic mathematical skills have departed from the inability to implement mathematical concepts in various topics and subjects, which are falling within five major areas: (1) number facts, (2) arithmetic, (3) information, (4) language, and (5) visual-spatial. There are some factors contributing to the challenges in solving mathematical problems, namely external and internal.

Keywords—competence; language; learning; mathematics; problem solving

I. INTRODUCTION

Mathematics is pivotal for human kind in the advancement of science and technology, thinking skill development, and problem solving in everyday life. Research done by National Research Council (NRC) in 1989 has shown that, "Mathematics is the key to opportunity". By learning mathematics, it will be easier for someone to solve problems and make logical decision, and thus leading to the ability to compete in the field of economy and technology.

The ability to solve problem is one of the objectives in learning mathematics. Krulik states that students learn mathematics to be able to use the acquired facts, skills, and information to solve problems [1]. Furthermore, a study by National Council of Teachers of Mathematics (NCTM) has revealed that through problem solving in mathematics learning, students can highly develop their thinking skills, tenacity, curiosity, and confidence.

The learning materials in mathematics are often abstract. Numbers and figures presented are actually the results of human thoughts, which are more logical instead of empirical.

Due to this situation, the delivery of the materials in teaching mathematics tends to use specific agreed symbols, which are commonly known as language. Therefore, there is a close relationship between mathematical mastery and mastery of language in students.

Based on those characteristics, most students believe that mathematics is a difficult subject [1]. This situation not only happens in Indonesia but also in other countries. Bynner and Parsons mentioned that many students in Basic Skill Agency, England, feel that they do not get enough basic skills at school, and get disappointed with mathematics and question its advantage in the real life.

Similar conditions are also faced by most students in Malaysia and Indonesia. A study by Trends in International Mathematics and Science Study (TIMSS) in 2007 reported that the average test score of Malaysian students is 474, which was below their standard score of 500 [2]. It has shown that the students were only able to do basic computing such as additions, multiplications, and other simple problem-solving activities. Similarly, the results in the subsequent study by the same team in 2005 in Indonesia revealed that Indonesian students obtained 397 and were at the 45th rank out of 50 countries. It has figured out that Indonesian students generally have average skills in both content and cognitive aspects. In other words, they seem to be good at solving routine, simple, and factual problems, especially those related to daily life.

Suprayitno postulates that the results in PISA test in 2015 have shown that Indonesian students' achievement in mathematics is in the 64th rank out of 72 countries [3]. The results show that there was a rise of 22.1 point in the students' achievement in Indonesia compared to that in the previous score, increasing from 375 in 2012 to 386 in 2015. However, although there was an increase in their achievement level in mathematics, Indonesian students' mastery in this subject has not been at the advance level. Jenkins asserted that many students are neither able to solve problems systematically, present concepts, express arguments, nor demonstrate mathematical concept.

Given Indonesian students' low achievement in mathematics, it is of urgency to investigate why the test results are far below students' score in other countries. This paper discusses the issues of students' low achievement in

mathematics, the contributing factors, and some possible solutions to the problems.

II. LITERATURE REVIEW

A. Learning Objectives of Mathematics

Mathematics plays a crucial role in numerical, logical thinking, and advanced cognitive skills [4]. It helps to improve one's abstract, quick, creative, and aesthetic thinking skills. Besides, it supports the mastery of other fields, such as physics, engineering, and statistics. Mathematics plays a significant role in daily life, career advancement, as well as science and technology [5].

In Malaysia, mathematics instructional activities aim to develop one's skill in thinking systematically, implementing mathematics in solving problems effectively, and making decision, as well as developing the ability to face some challenges following the advancement of science and technology. One of the objectives of learning mathematics is to encourage students to use previously obtained facts, skills, and information to solve problems [1]. Solving problems in mathematics is necessary in this ever-changing world [1].

Similar to Malaysia, mathematics is learned by all students from elementary to high schools in Indonesia. It aims to equip students with the ability to think logically, analytically, systematically, critically, innovatively, creatively, and cooperatively [6]. It is also expected that students develop their logical and systematic reasoning, communicative skills, and problem-solving skills through mathematics. In a similar vein, Soejadi has mentioned that mathematics instructional activities aim to develop cognitive, affective, motoric, and psycho-motoric skills that are based on logic [1]. In terms of cognitive skills, mathematics helps to foster intellectual thinking skills. On the other hand, it develops the ability to apply mathematical concepts when it comes to psycho-motoric skills. Also, it improves the ability to display good attitude in facing problems in real life, which demonstrates good affective skills.

III. METHOD

This study uses a qualitative method. The data of this study are both teacher's statements about the difficulty of students learning problem solving in mathematics and the contributing factors. Data was collected by interview and questionnaire method.

In accordance with the problems and purposes of this writing, the method used is literature review. Some of the literature reviewed include research reports published in scientific journals, lectures, textbooks and printed mass media. From the library materials is done exploration, interpretation, and elaboration.

IV. FINDINGS AND DISCUSSION

A. Challenges in Learning Mathematics

The challenges faced by students in learning mathematics come in different forms, such as the lack of comprehension, concept application, and problem solving in mathematics. The

students seem to be at lower level in both mathematical and cognitive contents, including numbering, geometry, data presentation, comprehension, application, and reasoning. That being said, students are only able to solve problems which are routine, simple, factual, and related to everyday situations. Clearly, advanced level in mathematics has yet to be achieved by most students. Jenkins argues that excellent comprehension in mathematics is manifested in mathematical thinking, which is reflected in how students comprehend mathematics, what strategies they use in solving problems, what conceptual representation and arguments they make, and what conceptual comprehension they demonstrate [5].

The difficulties in comprehending basic mathematical skills have departed from the inability to implement mathematical concepts in various topics and subjects, which are falling within five major areas: (1) number facts (2) arithmetic (3) information (4) language, and (5) visual-spatial. Understanding number facts includes the ability to understand facts in the form of numbers, tables, and mathematical principals; arithmetic ability includes accuracy and logarithm in computation; information skills are related to the ability to relate information to concepts, operations, and mathematical problems; language skills refer to the ability to understand terminologies and their relevance with mathematical information; and visual-spatial skills include the ability to visualize mathematical concepts, as well as manipulate geometry and functional space.

Students' low cognitive skills in mathematics refer to the ability to think and learn to pay attention, describe places, make visual and auditory perception, remember simple things, and understand language. The difficulty in thinking leads to the difficulty in making decision and solving problems [7].

B. Low Language Competence as a Contributing Factor in the Difficulty in Solving Mathematical Problems

One of the student difficulties in learning mathematics is caused by their lack of ability to solve mathematical problems. The low confidence in solving problems, challenges in understanding mathematical terms and language, confusion in determining mathematical operations, as well as low conceptual and procedural skills in solving problems are among the most frequent issues encountered by students. Many students are not able to interpret mathematical problems due to their limited ability in understanding information, language, and visual-spatial aspects.

Misunderstandings in concepts experienced by learners. First, some learners misunderstand the concept of "capacity". This concept is perceived as weights and volume. When learners are assigned to decide volume and capacity of a beverage product through this problem, "After the drink has been finished, is it the capacity or volume which is decreasing?" The volume of a container (geometry) is the number of volume (measurement unit) used in filling up the container. The formula of geometry can be adapted from the volume of a rectangle. It is believed that the misunderstanding of this concept leads to errors in solving mathematical problems.

Secondly, some learners misinterpret the concept of “weight”. It is often considered to be similar to mass. In fact, these two are contradicted. Mass constitutes materials that make it possible for an object to be greater in size without the gravity effect. It is also eternal; so, mass on earth is equal to that on the moon or anywhere else. In contrast, weight is a measurement affected by gravity. In other words, the power of gravity determines the decrease or increase of the weights. Besides, the weights of an object on earth will be different from its weight when on the mountain. Mass measurement (commonly known as weights) in numerical system includes kilogram, gram, quintal, and tons.

Thirdly, there is a misinterpretation of circumference concept. Many learners do not understand that circumference is gained by adding the length of each side of an object or area. It shows when learners are given the combinations of some flat objects. They think that the circumference is gained by combining the circumferences of all objects instead of adding the lengths of all sides of the newly constructed object. The same thing happens when they are given half circle. They tend to count the circumference by using a formula without adding the diameter. In fact, it is important for learners to understand that the concept of circumference is the addition of the length of each side of the measured object or area.

Some data show that misunderstanding of these concepts reveals that there is a significant correlation between language competence and problem-solving competence. Zhining divide problem solving into two categories, (1) the expression of problems through language (words) or non-language (picture); and (2) the explanation of the structure of the problems—information about the object and action plan [5]. Problem solving in mathematics is done in the following processes: (1) reading and understanding the problem, (2) organizing strategies in solving problems, and (3) reporting the result and the process of the problem solving [8]. Needless to say, when learners have limited language competence, they will also have difficulties in solving mathematical problems. In solving mathematical problems, learners go through the following steps (1) understanding the problems, (2) planning the solution (3) implementing the plans, and (4) checking the solution [1]. Firstly, learners try to understand some problems by reading the problems twice for accuracy. They will internalize the problems in their mind and associate them with real life events or their background knowledge. Then they will do calculations in their mind to understand the problems better. Secondly, learners build an imaginary solution in their mind using their schemata before rechecking it to make sure that it is the right solution. Thirdly, learners solve the actual problems based on their plans by writing them in complete sentences. Last but not least, learners recheck the solutions by substituting their answers into the suitable equations.

A study by Mairing has reported that mathematical problem solving requires a critical understanding of texts and the ability to report the results creatively. In this case, it requires not only literal but also critical thinking in understanding the implied meaning of the text. This is normally done by internalization, association, inference, and evaluation activities. This being said, higher thinking skill is essential in this process. The Indonesian National Assessment Program administered in the

5th graders of elementary school revealed that the learners’ thinking skills were at the average level [1].

Language and thinking skills are closely intertwined. In terms of understanding and expressing ideas, feelings, messages, information, data, and knowledge to solve mathematical problems, thinking activity plays a significant role. Most importantly, thinking activity allows learners to understand their ideas and express them well. Furthermore, language is the trigger of knowledge [9]. Similarly, language subject at school is the contributing factor to the understanding of other subjects.

Siegel and Fazio conducted a research and found that children who had difficulties in learning language equally faced difficulties in learning mathematics [10]. Those who had difficulties in understanding texts also face similar challenges in solving mathematical problems. It is in line with TIMMS 2015 who conducted a test on students and found that the achievement in mathematical literacy test of Indonesian students was 397 out of 500 maximum point, which has put Indonesia in the 45th rank among 50 countries. Most Indonesian students are only able to solve problems which are routine, simple, factual, and related to everyday situations. They have difficulties in integrating information, making conclusion, and connecting their existing knowledge to other things [11]. In reading literacy, PISA shows that Indonesian students only obtain 397 out of the expected score 500 [12]. The results of National Examination in SMA/SMK (senior secondary school level) in 2011 and 2012 showed that the students’ scores in Bahasa Indonesia subject ranked the lowest [13]. It was reported that the average score in Bahasa Indonesia subject was 7.49 in 2011. The maximum score was 9.90, and the lowest was 0.80. Compared to other subjects, the students’ score in Bahasa Indonesia subject was the lowest. Subsequently, in 2012, it was again the lowest in East Java, especially compared to English and Mathematics. In 2013, the scores in Bahasa Indonesia subject of the national examination were not even better than the previous year. The results from TIMMS, PISA, and the national exam have proven that the students had difficulties in understanding texts. Indeed, good understanding of texts is required in understanding problems and finding solutions. In other words, low language competence contributes to the difficulties in solving mathematical problems.

There are some factors contributing to the challenges in solving mathematical problems, namely external and internal factors. The external factors include teachers’ quality, limited resources, and supporting learning media, teaching methods and strategies, as well as parents. Professional teachers are to understand the characteristics of their students, learning materials, and suitable methods for the learning process. The use of suitable and supportive materials will surely facilitate students in their learning. Also, parents play an essential role in improving students’ achievement in mathematics. The questionnaires administered by TIMMS revealed that parents who did some activities to stimulate their children’s’ numeracy and literacy skills (reading stories, singing together, etc.) achieved 94 higher scores than other students. As for Indonesian students, they got 56 higher scores when their parents gave this sort of stimulus.

Providing stimulus in the form of storytelling can increase children's vocabulary and thinking skills. Indeed, language and thinking skills are closely related. Safir and Wharf maintain that language affects human thinking [14]. It is believed that the way someone thinks is determined by the structure of his/her native language. Moreover, Finegan and Besnier assert that language is a means of expressing one's own thoughts and ideas [14]. It is also a tool for understanding other people's thoughts and ideas.

In addition to the above-elaborated external factors, the internal factors include learning motivation and background knowledge related to basic concepts in mathematics and language competence. Learners who are interested in mathematics will take the most out of their learning process. Whereas, those who are not interested in mathematics will easily get bored upon their learning. Having prior knowledge is imperative when making association in understanding the implied meaning of the text. The lack of prior knowledge will make learners face difficulties in making association. Similarly, low language competence will make them face more challenges in solving mathematical problems. As previously stated, the materials covered in mathematics subject are mostly abstract with numbers and verbal symbols (language). Language skills include the ability to understand terminologies and their relevance with mathematical information. Accordingly, low language competence will hinder learners' ability to solve mathematical problems.

C. Improving Language Competence to Solve Learners' Problems in Learning Mathematics

Considering learners' difficulty in solving mathematical problems and its contributing factors, something needs to be done to effectively help the learners. The following steps can help learners improve their language and mathematical competence [10]. First is using various learning strategies. In learning mathematical language, variations in learning strategies are very important. Woods further suggests the use of modeling and demonstration followed by verbal explanations. The use of calculation tools and number series proves to be helpful in improving learners' comprehension.

The second step is the correct use of language by practitioners as role models. Only when practitioners use mathematical language both in an informal situation and in a learning context, then learners will imitate them and have a good understanding of the language. For instance, when a group of children are playing in a toy shop and hear someone using the words related to position, size, and quantity correctly, they will be able to use those words independently in their daily life. To be specific, when practitioners correctly use mathematical language, students will eventually have the right perception.

Mathematics and Bahasa Indonesia teachers are expected to implement those methods. The main objectives of Bahasa Indonesia subject are to understand and express ideas, feelings, messages, information, data, and knowledge in science and communication, workplace, and daily communications, either orally or in written form. In this case, thinking skill play a pivotal role and acts as a key determining activity that enables

learners to understand and express ideas and other things properly. Hence, teachers need to create a condition for optimal thinking.

Both teachers and learners need to be aware of the optimal thinking process that should happen continuously in every episode of language learning. For instance, when a teacher gives a text, all learners for sure will be able to understand the content well if they are able and willing to think logically, critically, and creatively. Subsequently, it will be easier for them to generate new ideas and other things. Fostering thinking activities can be done by connecting, comparing, refuting, and selecting ideas as well as interpreting data, concluding analysis results to create new ideas or new aspects that will be presented in either oral or written communication. Both language and thinking activities are critical in language learning.

Creating a learning condition that facilitates learners to think logically, critically, and creatively can be done by selecting and developing learning materials, implementing learning methods, using media resources, and evaluations. The materials should then encourage learners to think logically, critically, and creatively. This aspect can be involved in the text given by the teachers, including a number of questions related to the text and the assignments. The questions should vary, and must include comprehension, application, analysis, evaluation, and creativity. By responding to these various questions, learners will be able to literally, critically, and creatively understand the texts that they read or listen to. In other words, learners are not necessarily provided with options for the answers. According to Rahmah, while learners are required to practice solving non-routine problems and using props in learning, teachers need to develop learning methods and reasoning evaluation [15].

V. CONCLUSION

The ability to solve problems is one of the objectives of learning mathematics. Due to the abstract characteristic of mathematics, most students have faced difficulties in learning to solve mathematical problems. One of the contributing factors is the students' low language competence. It is in line with the function of language as a means of understanding and expressing ideas in communication. Consequently, teachers need to do an effort to select and develop learning materials, strategies, and teaching media that encourage students to think logically, critically, and creatively.

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