Improving Students’ Mathematical Literacy Skills Through Multiple Intelligences Approach in Problem Based Learning

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Abstract. This literature study was focused on Multiple Intelligences approach in Problem Based Learning to improve Students’ Mathematical Literacy Skills. There are some relevant researches to describe Multiple Intelligence approach in Problem Based Learning and improve mathematical literacy skills. Now, the implementation of mathematics education should emphasize how the concepts learned by students can be applied in the real life context. This means that students are expected to not only able to solve problems at school, but also the problems outside of school. This ability is called mathematical literacy skills. The implementation of Problem-Based Learning methods can be applied by teachers to be able to improve students’ mathematical literacy skills. Problem-Based Learning is a student-centered learning method in which students actively participate in discussion groups where they discuss problem solving strategies. However, not every student is logically intelligent. Therefore, the implementation of Problem Based Learning must be combined with multiple intelligence approaches that can enhance each type of students’ intelligence.

1. Introduction
Mathematics is one of the branches of science that becomes one part of the education curriculum and has a big role in transforming human civilization, thus, it needs to be mastered by students from elementary school level [1]. Mathematics is not only taught in schools but also implemented in daily activities. Therefore, the method of engaging mathematics in schools with everyday life has become a priority in designing school mathematics curriculum [2].

Mathematical literacy has become an important topic in mathematics education. Various studies on mathematical literacy have been conducted. Based on the resolution proposed by PISA, mathematical literacy is the ability of individuals to implement the knowledge and concept of mathematics to solve the problems in daily life. It includes the ability in reasoning mathematically by using mathematical concepts, procedures, facts, and mathematical tools [3].

In Indonesia, Mathematics teacher face some problems as a result of there are still many students who are anxious in facing mathematics problems [4]. To be able to facilitate the students to be literate in mathematics, teachers cannot only use traditional methods that are often implemented in schools. Traditional method will only give the students a little understanding of what they are doing or why they are doing it. Students only learn to memorize procedures and to match the same problems in exams. Therefore, they never learn to think mathematically and they assume that mathematics is a boring subject, not applicable, useful in real life, and increasingly unable to be understood [5]. Hence,
the efforts to create the optimal learning process by using the Problem Based Learning method are definitely needed. Problem Based Learning is the method that emphasizes in giving mathematical problem at the beginning. According to Denise [6], by implementing this method in the classroom, teachers can help students to find and analyze information critically to solve the problems.

Levy [7] stated that students have different abilities, learning styles, and personalities when they entering the classroom. It should also be noted that not every child is intelligently good at logical mathematics so that Problem-Based Learning approach needs to be combined with multiple intelligence approaches in order to enhance and improve each type of students’ intelligence. Furthermore, Eissa and Mostafa [8] stated that students come to school with various abilities: low, medium, and high. Teachers must realize and focus what was important for students to know in studying mathematics and find ways of accomplishing teaching. Gardner [9] defines intelligence as the ability to solve a problem, create products that have a culture value, and divide intelligence into existential, linguistic, spatial, logical, kinesthetic, musical, naturalist, interpersonal and intrapersonal intelligences. Regarding those nine intelligences, the teacher needs to consider the characteristics of students and use them as a benchmark so that learning can take place according to the interests and needs of students.

2. Method
This article is a theoretical study that can provide information or descriptions of learning approaches that have potential to improve mathematical literacy skills theoretically. Data were collected and analyzed in the form of literature obtained from the review 19 of journal articles and 9 relevant research results from related scientific journals that related to Problem-Based Learning with multiple intelligences approach. First, the author collected a theoretical study of problem based learning methods, multiple intelligences approaches and mathematical literacy abilities. Second, the author sought and collected some relevant research results. The results of various literature reviews will be used to see the correlation between Multiple Intelligence in Problem-Based Learning and Mathematical Literacy and to identify potential research of Multiple Intelligences approach in Problem Based Learning that can improve mathematical literacy skills. Last, the author drew conclusion that the approach of multiple intelligences has the potential to improve the ability of mathematical literacy.

3. Result and Discussion
3.1. Problem Based Learning
Problem-Based Learning is one of the learning methods that has been widely known in the education world. That method is a method where practically in the learning process, students are encouraged to study independently to build their own knowledge while the teacher's role is as a facilitator. Barrows and Kelson [10] define Problem-Based Learning as a curriculum and learning process that is designed with problems that require students to acquire important knowledge, in order to make them proficient in problem solving. In addition, Savery [11] stated that problem-based learning emphasizes a process in empowering students to conduct research, apply knowledge and skills in order to get the great solutions to solve problems. Further, Roh [12] suggested that problem based learning defines as a learning process where learning begins with a problem to be solved by students. So, students need to gain new knowledge before they can solve the problem.

According to Barrows and Kelson’s theory [10, 13], there are four characteristics of Problem-Based Learning, namely: (1) learning is student-centered, the learning process with problem based learning emphasizes students as learners. This learning is supported by the theory of constructivism where students are encouraged to be able to develop their knowledge individually; (2) authentic problems form the organizing focus for learning, the topics of the problem that are presented to the students are authentic issues so that students are able to easily understand the problem and implement it in daily life; (3) new information is acquired through self-directed learning, in the process of problem solving, students are considered not yet aware of and understand all concepts that lead them to find information through various sources independently; (4) learning occurs in small groups, in Problem-Based Learning, students discuss in a heterogeneous small group where there is an interaction in solving a
problem; and (5) teachers act as facilitators, teachers only act as mentors who monitor the improvement of student activities and encourage students to achieve goals they set.

While Barret [14] explained the steps of problem based learning method into: (1) teacher give the problems to students; (2) students have discussion in small groups such as clarifying cases of problems given, defining problems, exchanging ideas based on their knowledge, and deciding things needed to solve the problem; (3) students do independent study materials about the problems that must be solved, and they can do it by looking for references or making observations; (4) students return to their previous group to exchange information and cooperate in solving problems; (5) students tell the solutions they find; and (6) students have evaluation related to all learning activities with the teacher. This includes the extent of the knowledge obtained by students and the roles of each student in the group.

Some of the findings of Problem-Based Learning method in mathematics learning studies have been conducted in the world of education. Research conducted by Astriani, Surya and Syahputra [15] concluded that Problem Based Learning has a good effect for improving students’ mathematical problem solving abilities. Also, Tandililing’s findings [16] concluded that Problem Based Learning method is effective in terms of students’ mathematical representation abilities. Not only able to improve problem solving abilities and mathematical representations, it is also proven to be able to improve students’ critical thinking skills in mathematics [17]. In addition, Masitoh and Fitriyani [18] stated in their findings that Problem-Based Learning method can improve students' self-efficacy in learning mathematics, while Hendriana, Johanto, and Sumarmo [19] stated that this can help students improve their self-confidence in mathematics. Further, Santria and Jailani’s findings [20] concluded that Problem-Based Learning helped students to improve interpersonal skills.

From several studies conducted previously, Problem-Based Learning has a positive effect if implemented in a process of learning mathematics. By implementing this method in the classroom, students have the opportunity to develop and improve their own mathematical concepts in solving mathematical problems. Thus, Problem Based Learning is potentially able to help students develop and improve their skills and abilities in learning mathematics.

3.2. Multiple Intelligences

Howard Gardner (1983) introduced the existence of multiple intelligence theories. In his book entitled Frames of Mind: The Theory of Multiple Intelligences, Gardner [9] defined intelligence as the ability to solve a problem and create products that have cultural value. Gardner divided the intelligence category into nine categories that presented in the following table [9, 21]:

| Multiple Intelligences       | Description                                                                 |
|------------------------------|-----------------------------------------------------------------------------|
| Verbal-linguistic intelligence | The ability of individuals to use language and words in both spoken and written expressions can be reasoned abstractly, and have conceptual patterns. |
| Logical-mathematical intelligence | The ability of individuals to process numbers accurately and correctly, well-reasoned. This includes the sensitivity to patterns and logical relationships that can convey causal relationship |
| Musical intelligence        | The ability of individuals to create, produce and express is related to tone, music, rhythm, rhythm. |
| Spatial intelligence        | The ability of individuals to understand, recognize and create all forms of images, space, and direction. |
| Body-kinesthetic intelligence | The ability of individuals to optimize the body work. Someone in this intelligence prefers to do physical activity directly. |
| Intrapersonal intelligence   | The ability of individuals to reflect and analyze him/herself. Someone in this intelligence is more likely to understand themselves than others. |
### Multiple Intelligences and Description

| Intelligence                  | Description                                                                                                                                 |
|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Interpersonal intelligence   | The ability of individuals to work with others in small groups, as well as the ability to communicate verbally and nonverbal.                  |
| Naturalistic intelligence    | The ability of individuals to recognize and classify certain objects related to their patterns in nature. Someone with this intelligence tends to have activities outdoors/deal directly with nature. |
| Existential intelligence     | The ability of individuals to answer problems about human existence.                                                                         |

In Gardner's perspective, each of the nine intelligences has an important role in learning and multiple intelligence theory can motivate teachers to use and implement various methods to help their students in mathematics [9, 22]. This theory does not only discuss intelligence, but also explains how children learn and can help their teachers in teaching practices and how to manage classes well [22]. Furthermore, Armstrong [23] mentioned the four main components of multiple intelligences theory namely: (1) everyone has each of nine types of intelligence; (2) intelligence in each individual can be developed; (3) intelligence usually works in a complex scope; (4) there are many ways to be smart in each category.

#### 3.3. Mathematical Literacy

Mathematical literacy can be defined as the ability of students to implement mathematical concepts and knowledge that they have learned in class into everyday life. These abilities are in the forms of the ability to employ, formulate and interpret concepts in real life contexts. Ojose [24] the ability of mathematical literacy is defined as knowledge to know and implement the basis of mathematics in daily life. There are seven indicators of literacy skills that students need to have [25]. The indicators are: (1) communicating, students are able to identify and understand a problem such as reading, translating, and interpreting statements where questions and solutions can be presented; (2) mathematizing, students are able to compile, conceptualize, make predictions and formulate mathematical models and solve the problems by using mathematical solutions; (3) representation, students are able to represent objects and mathematical situations involving interpretation, translation, use of various representations in the form of tables, graphs, images and diagrams to interact with various problems; (4) reasoning and arguments, students are able to involve logical processes to reason, analyze, and argue in exploring problems to draw conclusions and examine the truth of a statement; (5) devising strategies for solving problems, students are able to find and create the solution for solving mathematical problems, (6) using symbolic, by involving understanding, students are able to interpreting, manipulating and utilizing symbolic expressions by understanding definitions, rules and algorithms; and (7) using mathematical tools, students are able to use mathematical tools as measuring instruments.

In addition, Magen [26] stated that mathematical literacy includes two aspects of individual abilities, those are: (1) aspects of understanding, the ability in knowing facts, concepts and interpreting mathematics into various contexts; (2) aspects of application, this aspects include where students can use the ability in using concepts, facts, and procedures for solving mathematical problems; (3) aspects of reasoning, the ability to reason and analyze by providing explanations and justifications; and (4) aspects of communication, the ability to communicate or explain the explanations and problem solving.

#### 3.4. The Correlation between Multiple Intelligence in Problem-Based Learning and Mathematical Literacy

Arends [27] explains that Problem-Based Learning presents real life problems and is useful for students. Consequently, this can be students’ milestones to observe and explore their knowledge. Problem-Based Learning is an implementation of learning that has been widely used as a research material or implemented in the learning process in schools. However, teacher must realize that every student has a various intelligences in class so Problem-Based Learning need to be combined with
multiple intelligence approaches in the learning process. Teachers need to understand and to be aware of the students’ characteristics and intelligence. Supartono and Waluyo [28] also explains that basically, one of the most important thing in the learning process was how the teacher can deliver any information well called teaching styles. While the students should be able to receive the information from the teacher well called learning styles.

Mathematical literacy has seven aspects namely communication, mathematizing, representation, reasoning-argument, devising strategies for solving problems, using symbolic, and using mathematical tools [25]. The stages of multiple intelligences approach in Problem-Based Learning can potentially improve students’ mathematical literacy skills. Students can discuss in groups and present solutions with various ways of thinking. When concluding the results of the discussion, students can present the results in a verbal form, diagram or other media. Also, at this stage, students are expected to be able to use symbols or mathematical tools so that, unconsciously, they can practice communicating and presenting the results of the discussions in accordance with the intelligence or knowledge they posses.

As stated by Saeidi [29], multiple intelligence theories can be used as a tool to create various tasks and activities that are meaningful and interesting for students as it is in line with their interests.

At the stage of determining the topic, identifying, analyzing and collecting information from various types of problems, students perform the mathematizing process. Students discuss in groups to design or set a completion strategy in solving problems. In this process, students can reason and argue with various intelligences and ways of thinking through group discussions to solve problems. Gouws [20] stated that paying attention to students’ intelligence is as same as creating opportunities for students and encouraging them to think about making the learning process better and assessing it in different ways in order to meet the students’ needs of various intelligences. In addition, by applying the multiple intelligences approach in the classroom, will make students feel comfortable and students will appreciate their intelligence more [30].

Research conducted by Kartikasari and Widjajanti [31] concluded that the multiple intelligence approach in Problem-Based Learning was effective in terms of connecting ability and students’ self-esteem. Not only in terms of connecting ability and students’ self-esteem, but also multiple intelligence approach in Problem-Based Learning has a good effect to improve the learning achievement. Furthermore, the results of the research conducted by Rafianti [32] showed that there was an increase in conceptual comprehension and students’ self confidence in mathematics learning bases Multiple Intelligences. Research conducted by Septiana and Ikhsan [33] also showed the same results that Problem-Based Learning with the multiple intelligences approach can improve students’ ability to understand concepts and think creatively. All the research concluded that multiple intelligences in Problem Based Learning was better to improve students’ ability than the traditional method in learning mathematics.

Regarding some of the results of the research described previously, implementing Problem-Based Learning with the multiple intelligences approach can improve the components of mathematical literacy itself such as formulating, interpreting, reasoning, interpreting, communicating, and explaining problem solving in everyday life effectively and efficient. Based on the stages of Problem-Based Learning methods that facilitate the abilities and skills of students like problem solving skills, mathematical reasoning, mathematical connections, mathematical communication and mathematical representation. Where from these abilities is a component of mathematical literacy. In addition, the multiple intelligences approach can be used as a foundation of the learning process in the classroom. The activities of students in the classroom can be tailored to their interests and needs so that the optimal learning process can be created. Therefore, it can be concluded that Multiple intelligences approach in Problem-Based Learning can potentially improve students' mathematical literacy skills. In short, the relationship between Problem-Based Learning and multiple intelligences approaches with mathematical literacy skills is explained by the illustration below.
4. Conclusions
According to the studies described previously, theoretically, multiple intelligences approach in Problem-Based Learning has the potential to improve students’ mathematical literacy skills. By implementing Problem-Based Learning methods, students can actively develop their skills and abilities in solving mathematical problems through the stages of Problem-Based Learning. In addition, students are able to develop their own mathematical concepts through group discussions. Teaching by paying attention to each student's intelligence and characteristics can also help teachers manage the class well. Learning can be tailored to the students’ interests and needs as multiple intelligences approach can enhance each type of students’ intelligence.

References
[1] Kusmaryono I 2014 Int. Conf. on Math. Sci. Educ. (Semarang State University) p 35
[2] Maulina Y and Retnawati H 2017 ICRiEMS Proceedings of fifth annual conference (Yogyakarta State University) p 467
[3] OECD 2010 PISA 2015 Draft Mathematics Framework.
[4] Djamil Bon Jwan Widjajanti 2013 Journal Technology 2 39
[5] Haglund R 2004 Humanistic Mathematics Network Journal. 1 2
[6] Denise M 2014 Master of Education Program Theses. Paper 53 (Dordt University) p 5
[7] Levy R 2008 Meeting the needs of all students through differentiated instruction: Helping every child reach and exceed standards (Electronic Version vol 4) Clearing House p 161
[8] Eissa Mourad Ali and Mostafa Amaal A 2013 *International Journal of Psycho Educational Sciences*. 2 34

[9] Gardner H 2011 *Frames of Minds: The Theory of Multiple Intelligences* (New York, NY: Basic Books)

[10] Barrows H and Kelson A C 1995 *Problem-Based Learning in Secondary Education and the Problem-Based Learning Institute* (Monograph 1) (Springfield: IL)

[11] Savery J R 2006 *The Interdisciplinary Journal of Problem-based Learning* 1 9

[12] Roh K H 2003 *Clearinghouse for Science, Mathematics, and Environmental Education* (Arizona State University) p 1

[13] Sari M P and Khiyarunnisa *Proceedings National Conference Mathematics and Mathematics Education* (Yogyakarta State University) p 444

[14] Barret T, Mac Labhainn, Fallon H 2005 *Handbook of Enquiry and Problem Based Learning* vol 2, (Galway: CELT) p 15

[15] Nurullita Astriani, Surya E and Syahputra E. 2017 *International Journal Of Advance Research And Innovative Ideas In Education* vol 3 (Medan State University) pp. 3441-3446

[16] Tandililing E 2015 *Proceeding of International Conference On Research, Implementation And Education Of Mathematics And Sciences* (Yogyakarta State University) pp. 147-152

[17] Arviana R Irwan and Dewi M P 2018 *Journal of Computational and Theoretical Nanoscience* vol 24 (American Scientific Publishers) pp. 1-3

[18] Fitriana L and Fitriyani H 2018 *J. Math. Learn.* (Malikusalleh University) pp. 26-30

[19] Hendriana H, Johanto T, and Sumarmo U 2018 *J. Math. Educ.* (Sriwijaya University) pp. 291-300

[20] Santria U and Jailani J 2018 *ICRIEMS Proceedings of fifth annual conference* (Yogyakarta State University) pp. 37-44

[21] Gouws F E 2008 *Africa Educ. Rev.* 2 63

[22] Niroo M, Haji G Nejad H, and Haghani M 2012 *Soc. Behav. Sci.* 47 2170

[23] Armstrong T 2003 *Multiple intelligences in the classroom. 3rd ed* Alexandria (VA: Association for Supervision and Curriculum Development) p 76

[24] Ojose B 2011 *J. Math. Educ.* 4 90

[25] Turner R Dossey, J Blum W, and M Niss 2013 *Using mathematical competencies to predict item difficulty in PISA* (New York: Springer).

[26] Noga Magen Nagar 2016 *Int. J. of Research in Educ. and Sci.* 2 2

[27] Arends R I 2008 *Learning to Teach* (New York: The McGraw-Hill Campanies, Inc)

[28] Rico Prasetya K, Budi W, and Supartono 2015 *Int. Conf on Math. Sci. Educ.* (Semarang University) p 24

[29] Saeididi M 2016 *Journal of Teaching English as a Foreign Language and Literature* 1 111

[30] Widjajanti D B 2012 *Proceedings National Conference on Education Research and MIPA* (Yogyakarta: FMIPA UNY)

[31] Kartikasari and Widjajanti D B 2017 *J. Phys.:Conf. Ser* 812 012097

[32] Rafianfi I 2013 *Journal of Mathematics Research and Learning* (Sultan Agung Tirtayasa University)

[33] Septiana K G and Ikhsan *J. Educ. Math. Sci* (Madiun State University) pp. 44-52