

Analysis of mathematical literacy ability based on self-efficacy in model eliciting activities using metaphorical thinking approach

C Setiani^{1,*}, S B Waluya¹ and Wardono¹

¹Postgraduate program, Universitas Negeri Semarang, Indonesia

*Corresponding author: crisillia28@gmail.com

Abstract. The purposes of this research are: (1) to identify learning quality in Model Eliciting Activities (MEAs) using a Metaphorical Thinking (MT) approach regarding qualitative and quantitative; (2) to analyze mathematical literacy of students based on Self-Efficacy (SE). This research is mixed method concurrent embedded design with qualitative research as the primary method. The quantitative research used quasi-experimental with non-equivalent control group design. The population is VIII grade students of SMP Negeri 3 Semarang Indonesia. Quantitative data is examined by conducting completeness mean test, standard completeness test, mean differentiation test and proportional differentiation test. Qualitative data is analyzed descriptively. The result of this research shows that MEAs learning using MT approach accomplishes good criteria both quantitatively and qualitatively. Students with low self-efficacy can identify problems, but they are lack ability to arrange problem-solving strategy on mathematical literacy questions. Students with medium self-efficacy can identify information provided in issues, but they find difficulties to use math symbols in making a representation. Students with high self-efficacy are excellent to represent problems into mathematical models as well as figures by using appropriate symbols and tools, so they can arrange strategy easily to solve mathematical literacy questions.

1. Introduction

Mathematics is regarded as a universal science which becomes the underlying of other disciplines; it also supports the development of science and technology. The advancement of science and technology requires any individual to cope with life challenges and daily problems. Programme for International Student Assessment (PISA) is an international standard assessment for school students at the age of 15. The mathematics competency achievement accomplished by Indonesia is increasing from 375 points in 2012 to 386 points in 2015. However, the PISA result shows that Indonesian students are less familiar and undertrained to solve PISA-type questions in which mathematical literacy ability is necessarily needed [1].

PISA defines mathematical literacy is an individual's capacity to formulate, employ and interpret mathematics in a variety of contexts [1]. Asikin [2], asserts that mathematics is viewed as a difficult subject, it is frightening and less beneficial for daily life. Self-efficacy affects many aspects of one's



life such as motivation and persistency level to confront difficulties and hopelessness, endurance to face problems, and analytical thinking quality [3]. Hacket & Betz [4], declare that the influence of self-efficacy toward performance in mathematics is as strong as the influence of common mental ability. Research conducted by Gaskill and Murphy [5] proves that self-efficacy affects academic achievement significantly, and it becomes the most critical fundamental indicator for performance prediction in mathematics tasks. Mathematical self-efficacy is crucial in mathematics subject to improve self-confidence in solving problems [6]. The result of observation in SMP Negeri 3 Semarang Indonesia shows that the learning activities have not optimized learning innovation yet. The initial test shows that students are unable to create mathematics model and figures using suitable mathematics symbols and mathematical tools, and they find difficulties in arranging strategies to answer questions and make the reasonable conclusions. Figure 1 shows the student's result of initial mathematical literacy test.

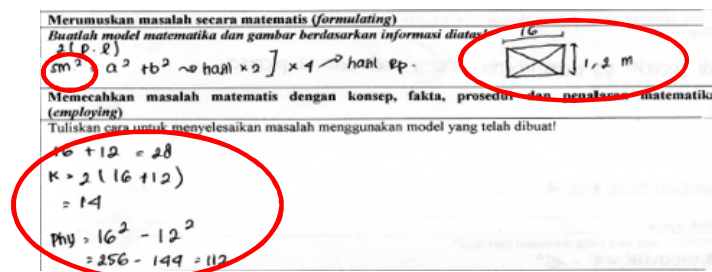


Figure 1. Result of Initial Mathematical Literacy Test

Based on the result and the analysis of Indonesian students' mathematics ability in PISA study, it is suggested to improve learning process in schools by applying Model Eliciting Activities. MEAs presents problems in real life; therefore this model is considered appropriate to support teachers in giving exercises to students so that it enables them to solve problems they have. The activities in MEAs consist of four primary parts which are, reading passage, readiness questions sections, data section, and problem-solving tasks [7]. A certain learning approach is needed to assist students in reassigning abstract mathematics becomes concrete mathematics. A MT approach is attempted to support students to make this reassignment by relating to the mathematics activities [8]. It is by constructivist's philosophy from Piaget and Vygotsky [9] whereas one constructs one's understanding concept of one's experience.

Lusby [10] suggest that mathematics subject is a difficult subject whereas it often causes hopelessness; thus it needs motivation, persistence, and endurance during mathematics class. Afrilianto [11] explains that thinking metaphorically is a thinking process which involves metaphors to comprehend a specific concept. The three metaphoric ideas are Grounding Metaphors, Linking Metaphors, and Redefinition Metaphors. Based on the above elaboration, this research aims to: (1) identify learning quality applying MEAs using MT approach toward mathematical literacy ability, (2) analyze mathematical literacy ability of Junior High School students in MEAs learning using MT approach covering students with high, medium, and low level of self-efficacy.

2. Methods

This research is mixed method research with the concurrent embedded model with the qualitative model as a primary method. Quantitative analysis is used for finding the quality of MEAs learning using MT approach quantitatively, while qualitative research is used for analyzing mathematical

literacy ability of students. The quantitative analysis that is used is quasi-experimental designed research with non-equivalent control group design. This study is carried out in SMP Negeri 3 Semarang Indonesia at VIII grade academic year 2015/2016, prism and pyramid. The subjects of the quantitative study consist of VIII A as an experimental class and VIIB as a controlled class. Initial ability test is given to both classes with prerequisite material which have been learned in prior which is Pythagoras to obtain initial data.

The initial data of mathematical literacy ability is then examined using normality test, homogeneity test, and mean equality test to find out if the classes have the equal knowledge so that they can be used as research subjects. The subject of qualitative research that is used is experimental class only, whereas the subject is chosen by using purposive sampling technique. Self-efficacy data is collected by using scale technique adapted from Pajares self-efficacy scale [12]. Learning quality of this research includes planning, realization, and assessment. The mathematical literacy ability based on self-efficacy is analyzed descriptively according to the documents of test result and interview toward students representative. Data validation applies triangular technique whereas the interviewees not only consist of student representatives but also other students who are considered having equal self-efficacy level and mathematics teacher of VIII grade. The analysis of qualitative data refers to Miles & Huberman concepts [13], including data reduction, data display, and conclusion.

3. Results and discussion

According to initial data analysis, it is obtained that both sample classes are from the normal distributed population, have a similar variance or homogenous, and have an equal mean of mathematical literacy ability between both samples. The result of learning devices assessment by expert validator shows that the validated means is included into good and excellent criteria. It means that learning devices are appropriate to use in the learning process. The mean of observation result on learning realization for all four meetings is considered good criteria. It proves that MEAs learning using MT approach is well-conducted. Professional teachers can carry out well-managed learning which influences students' learning quality [14].

Furthermore, the result of students' response questionnaires in assessment stage reaches 80% which is included in proper criteria. It establishes that most students regard learning process which has been carried out is well-conducted. Final data analysis is used to identify the quality of learning quantitatively. Before analyzing final data, normality test is completed toward final data; it obtains significance value = $0.173 = 17.3\% > 5\% (\alpha)$; therefore it is known that final data is from the normal distributed population. The quality of learning is quantitatively established based on learning completeness test. The calculation of mean completeness test with $\alpha = 5\%$, with degrees of freedom $df = 31 - 1 = 30$, it is obtained $t_{(1-\alpha), (n-1)} = 1.70$ and $t_{calculated} = 3.352$. Because $t_{calculated} > t_{table}$, hence H_0 is rejected and H_1 is accepted. Therefore, it can be concluded that the mean of mathematical literacy ability of students in experimental class is higher than 75. Based on standard completeness test, it is obtained $z_{calculated} = 1.918$ which is more than $z_{table} = 1.64$, with significance level at 5%, hence H_0 is rejected. It means that the completeness proportion of mathematical literacy ability of students in experimental class accomplishes established classical passing grade, whereas students who perform minimum completeness are more than 75%. The result of differentiation means test on students' mathematical literacy ability is $t_{calculated} = 4.665$. The value of t_{table} for $\alpha = 5\%$ and $df = 61$ is 1.678; therefore H_0 is rejected. Hence, it can be concluded that the mean of students' mathematical literacy ability in experimental class is higher than the mean of students' mathematical literacy ability applying Discovery Learning. The result of comparative differentiation test using z test with

significance level at 5% is $z_{calculated} = 4.791$ and $z_{table} = 1.64$. $z_{calculated} \geq z_{(0,5-\alpha)}$, thus H_0 is rejected, and H_1 is accepted. It can be concluded that the completeness proportion of students' mathematical literacy ability in experimental class is more than controlled class.

Based on the above explanation, Model Eliciting Activities learning using MT approach is considered well-qualified. It is because (1) sets of instrument result that is validated by expert is included into right criteria; (2) learning realization observation result is incorporated into minimally good rules; (3) students' responses toward the learning is as much as 80% which is included into good criteria; (4) mathematical literacy ability of students in experimental class accomplishes learning completeness, covering the mean of students' mathematical literacy ability in experimental class considered more than 75 and the completeness proportion considered higher than 75%; (5) mathematical literacy ability of students in experimental class is considered higher than mathematical literacy ability of students in controlled class, and completeness proportion in experimental class is higher than completeness proportion in controlled class. The use of contextual problems in daily life establishes better mathematical literacy ability in the learning process. It is following a research conducted by Wardono et al. [15] which claims that the application of realistic approach enables students to enhance their mathematical literacy ability. Research carried out by Mousoulides [16] proves that MEAs can develop mathematical literacy ability and concept understanding. Furthermore, MEAs also supports teachers to broaden their views which can be applied to teaching practices. Teachers also become able to reflect their ideas in teaching mathematics to increase the quality of learning [17]. Learning that is carried out in a well-managed way can support students to learn much deeper by memorizing what they have learned before and connecting what they have learned into contextual problems [18] Model-Eliciting Activities generates opportunities for students so that they can control their own learning [19]. MEAs learning using MT approach can help students to confront daily life problems. It is as Hamilton et al. [20] declare that the principal of MEAs which emphasizes daily life contexts can become a motivation to create mathematics models more generally.

The analysis of students' mathematical literacy ability applying MEAs learning using MT approach is classified into three groups: students with low self-efficacy are represented by subjects E-6 and E-30, students with medium self-efficacy are represented by subjects E-12 and E-19, and students with high self-efficacy group are represented by subjects E-9 and E-24. The analysis is completed by describing mathematical literacy components according to OECD [1] covering communication, using mathematical tools, devising strategies for solving problems, representation, reasoning, and argument, mathematizing and using symbolic, formal and technical language and operation. Based on the analysis of the result of the mathematical literacy test, researches found difficulties experienced by students in working on the test result are presented in Figure 2, Figure 3 and Figure 4.

Based on Figure 2, students with low self-efficacy find difficulties to solve problems. It can be seen from their incomplete assignments. Students with low self-efficacy can present what is known and what is asked in given problems. However, they present it incompletely. All given problems involve mathematical model devising, yet all students with low self-efficacy are not able to apply the concepts and make mathematical equations which enable them to solve the given problems. Students with low self-efficacy can represent given problems into figures and formula. However, there are several questions in which they only provide formula or figures. The representation established by students with low self-efficacy is inappropriate. They are lack ability to manipulate numbers, algebra forms, equations, and geometry shapes. Students with low self-efficacy can make figure representations, but they do not use suitable unit which is provided in given questions. Students with low self-efficacy are lack ability to use mathematical symbols based on the proper mathematical principles. They are still

writing down full sentences instead of using mathematical symbols to make brief and clear mathematical models. Regarded from figure representations which are created, they do not equip mathematical tools in making figures. It results in uncertain figures.

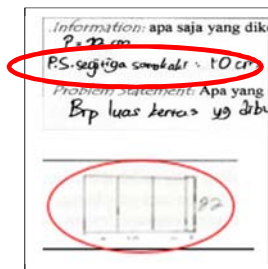


Figure 2. Part of Low Self-Efficacy Students' Answer on Number 2

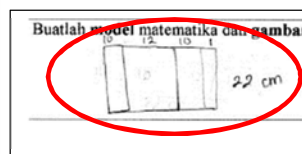


Figure 3. Part of Medium Self-Efficacy Students' Answer on

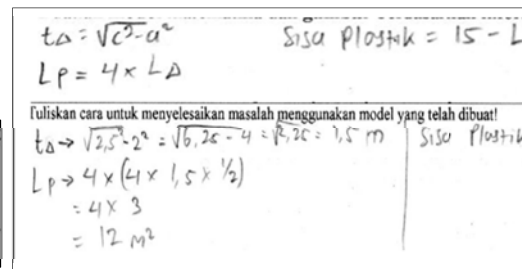


Figure 4. Part of High Self-Efficacy Students' Answer on Number 4

The works completed by students with low self-efficacy are unsystematic and incorrect. If the created model is incorrect and the questions are understood incorrectly, thus the solving problem steps are considerably incorrect as well. Students with low self-efficacy are not able to determine correct strategies to solve given problems. It means that students with low self-efficacy are considered lack of devising strategy for solving problems. They are less ability to design and implement strategies to find out mathematical solutions. The level of self-efficacy also affects reasoning and argument ability. Correct answers will result optimized conclusions. Students with low self-efficacy are lack ability to reflect their mathematical ideas and to evaluate reasonable basic reasons for solutions. Based on the analysis of assignment results and interviews toward students with low self-efficacy explanation above, and based on the interviews toward Mathematics Teachers and other students with equal self-efficacy level, it can be concluded that mathematical literacy ability of students with low self-efficacy is considered low. They can identify information in given problems, but they are not able to answer mathematical literacy questions completely.

Based on Figure 3, students with medium self-efficacy level can complete mathematical literacy problems. However, the given problems are not entirely correctly answered. According to research result, it can be understood that students with medium self-efficacy can provide what is known and what is asked in given problems completely. It shows that communication ability of students with medium self-efficacy is very well. Nevertheless, the mathematizing ability of students with medium self-efficacy is under expectation. Several errors are identified in mathematical models they present. Mathematical models which are designated by students with medium self-efficacy are incomplete. The incomplete mathematical models make them find difficulties in solving problems. The use of mathematical symbols for mathematical models is used inconsistently. Students with medium self-efficacy are sometimes able to use correct symbols based on mathematical principles, but they sometimes are not. Therefore, the ability to use symbols owned by students with medium self-efficacy is considered in medium level; they are lack ability for applying mathematical symbols, facts, rules, and structures.

Students with medium self-efficacy do not optimize the use of mathematical tools in creating figure representations. They sometimes use a ruler when drawing figures, but they sometimes only sketch the figures instead of using a ruler. Students solve given problems unsystematically. It influences their

reasoning and argument ability. They tend to have a medium ability in delivering ideas. They can conclude, but they are not able to explain them completely. Based on the analysis of assignment results and interviews toward students with medium self-efficacy explanation above, and based on the interviews toward mathematics teachers and other students with equal self-efficacy level, it can be concluded that mathematical literacy ability of students with medium self-efficacy is considered medium. Students with medium self-efficacy are considered good enough in completing mathematical literacy questions.

Based on Figure 4, students with high self-efficacy level can complete given problems in perfectly correct answers. Based on the result of this research, it is known that communication ability owned by students with high self-efficacy concerning comprehending, explaining, and formulating problems is considered well. However, there are still weaknesses such as the lack ability to explain what is asked in given questions. Students with high self-efficacy are very good at identifying mathematical components in given problems. They high ability in the mathematising component and they draw mathematical model completely and systematically. They are also able to transfer the problems taken from reality into the mathematical model as well as interpret mathematical models into realistic problems. This ability can be included in representation ability because students with high self-efficacy manage to present questions into figures and formulaic shape. The formulas are written systematically, while the figures are drawn properly by using a ruler as a mathematical tool. It proves that students with high self-efficacy can simplify problems and make them understandable by drawing figures using mathematical tools. They do not find significant difficulties to use mathematical symbols. Students with high self-efficacy can apply mathematical symbols, facts, rules, and structures. They can solve problems through complete and systematic steps (devising strategies). They are also able to apply and implement strategies to find out mathematical solutions. Regarding concluding (reasoning and argument), students with high self-efficacy can explain correctly and completely. Students can reflect their mathematical ideas and evaluate reasonable reasons from solutions. It shows that reasoning and argument ability owned by students with high self-efficacy is considered well. The analysis of mathematical literacy ability owned by students with high self-efficacy as explained before, and based on the interviews toward mathematics teachers and other students with equal self-efficacy level, it can be concluded that mathematical literacy ability of students with high self-efficacy is considered well. Students with high self-efficacy are proved successful to complete mathematical literacy questions very well.

According to the elaboration of mathematical literacy ability based on self-efficacy level—low, medium, high—it can be understood that students with high self-efficacy level are much enthusiastic to bring out their ability; thus their mathematical literacy ability is well-qualified as well. It is as Schunk [21] and Peters [22] assert that students with high self-efficacy level may achieve excellent mathematical accomplishments and that they will work hard to afford success in learning. On the other hand, students who do not own high self-efficacy tend to avoid assignments or tend to do given assignments half-heartedly, and they tend to give up easily when confronting obstacles. It is by mathematical literacy ability owned by students with low and medium self-efficacy identified in this research. Students with low self-efficacy tend to avoid assignments. It can be seen from their empty answer sheets. They seem to give up easily, and they do not try hard to answer given questions completely. The similar case is also found in students with medium self-efficacy.

4. Conclusion

Based on the result and discussion, it can be drawn several conclusions: (1) Model Eliciting Activities learning using MT approach can be said qualified; (2) Students with low self-efficacy are quite able to

identify problems, but they are lack ability to discover strategies. The low self-efficacy implies low criteria of mathematical literacy. Students with medium self-efficacy can identify information, but they are lack ability to use mathematics symbols and instruments. The indicator achievement on mathematical literacy ability of students with medium self-efficacy has not complete yet. Students with high self-efficacy are excellent to identify problems in questions and interpret them into mathematics model and figures completely and can use appropriate mathematics symbols and instruments. These abilities enable them to complete given questions and provide reasonable conclusions.

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