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# An Analysis of Problem Solving Ability using mathematical modeling strategies in Brain-Based Learning

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Abstract

Problem-solving ability learning (PSA) is a fundamental problem that needs to be developed in learning mathematics at school. In this research mathematical modeling strategies (MMS) are developed for problem solving. This study aims to investigate how the implementation of MMS for problem-solving in mathematics learning. This study was conducted at SMP Negeri 34 Semarang. This research used sequential explanatory design. The quantitative research design is a quasi experimental design with the nonequivalent posttest-only control group design. Data collection techniques used in this study are documentation, tests, scale, interview, and observation, then processed with a classical completeness test, t-test, and proportion test. The results of this study indicate that (1) PSA on the application of mathematical modelling strategies on Brain-Based Learning (BBL) has achieved classical mastery learning; (2) the PSA of the experimental class by applying mathematical modeling strategies to Brain-Based Learning is better than the control class that uses the Problem Based Learning; and (3) two subjects with high category self-efficacy (SE) have high PSA, two SE subjects are categorized having middle PSA, and two low SE subjects have a low PSA.



## 1. Introduction

National Council of Teachers of Mathematics or NCTM (2000) writes that five basic mathematics abilities must be mastered by students, namely problem-solving abilities, reasoning and probability, mathematical communication abilities, mathematical connection abilities, and representation abilities. The National Education Association (2015) wrote that "The Importance of Teaching the 'Four Cs': critical thinking and problem solving, communication, collaboration, and creativity and innovation*"*. Problem-solving is an important ability in mathematics that students need to apply and combine several mathematical concepts and decision making (Tambychik & Thamby, 2010). That statement above drive that problem solving is one of the most important abilities that must be developed in students because in students' problem-solving abilities are required to use structuralized processes and strategies in solving mathematical problems.

The ability in solving the problems is developed by some experts, including by Polya (1981), Krulick & Rudnick (1996), Zalina (2005), Canadas (2009), and Tambychik (2010). According to Tambychik (2010), there are three steps in problem-solving abilities, namely (1) the phase of reading and understanding problems, (2) the phase of the organizing strategy and solving problem, and (3) the phase of confirming of the answer and process.

The problem-solving ability is significant to master because it affects the cognitive development aspect of students, but in reality, it has not been matched with students' mathematical achievements. The report of the Education and Culture Education Ministry Assessment Center in 2018 also showed that the percentage of mastery of material on the National Examination (UN) in the junior high school/islamic junior high school mathematics study year 2017/2018 gets a low percentage, including in one junior high schools in Semarang (Puspendik, 2018). Based on the National Examination (UN) report in mathematics

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subject in one of the junior high schools in the city of Semarang, it is obtained that mastery of the mathematic material is still low, especially algebraic test material, geometry and measurement. In line with Asikin (2011) which states that one of the biggest problems in the world of mathematics education is mathematics subjects are still considered as difficult, frightening, and less useful subject for daily activity.

Strategies that are considered as an appropriate strategy that can connect the students to be able to understand and solve the abstract mathematical test, one utility to solve them is by using mathematical modelling. According to Ang (2010), "Mathematical modelling is commonly regarded as the art of applying mathematics to a problem to better understand the problem. As such, mathematical modelling is related to problem-solving". General steps which are taken to solve the problem based on mathematical modelling according to Kharisudin (2018), namely: (1) identify all the quantities involved in the problem, then the quantities identified are given symbols, are assigned units (in a unit system), and sort out which variables and which are constants; (2) determine the law that controls the problem, these laws form a mathematical model that defines the relationship between each variable and constant; (3) determine model solutions; and (4) interpreting model solutions in the form of problem solutions.

Besides the cognitive aspects, it is needed the affective aspects. The affective aspects are the aspects that influence a person's values and attitudes. The existence of affective aspects in learning mathematics trigger the students having pleasure, curiosity, interest in learning mathematics, having a diligent attitude and confidence in solving mathematical problems. Then, one of the affective aspects that need to be instilled in students is self-efficacy. According to Bandura (1997), "Self-efficacy is defined as one of the beliefs that she or she can complete specific tasks successfully and this confidence in performance and perseverance in a variety of endeavours". According to Bandura (2006), the measurement of a student, self-efficacy refers to three dimensions, namely: (a) level, (b) strength, and (c) generality.

Meanwhile, according to Bandura (Sukoco, 2016), individual beliefs about efficacy can be developed through four main sources, namely performance experience, vicarious experience, verbal approach or social approach, and psychological and affective states. That sources making the self-efficacy is important to be implanted to students. The goal is to be able to form confidence in students characteristic because students will be trained to learn from their experience and not quickly discouraged in doing the tasks assigned.

One of the learning models that can provide opportunities for students to optimize learning, self-efficacy and improve problem-solving skills is Brain-Based Learning (BBL). According to Jensen (2008), BBL or brain-based learning ability is learning that is aligned with the workings of the brain that are scientifically designed for learning, not only focused on sequencing but also prioritizing the fun and love to students so that students can easily absorb the material that is studied. The BBL method is divided into seven stages, namely: (1) pre-exposure, (2) preparation, (3) initiation and acquisition, (4) elaboration, (5) incubation and insertion of memory, (6) verification and checking of beliefs, and (7) celebration and integration. All stages above must be fulfilled so that learning activities can run well.

Nursyarifah's research result (2016) shows that an increase significantly in problem-solving skills in social arithmetic materials uses mathematical modelling rather than not using mathematical modelling method. This statement was supported by the statement of Dewi (2018) shows that the results activity of students who received Brain-Based Learning were assisted by the website is higher than students who received conventional learning. Nahar (2018) states that students in the middle and low self-efficacy groups need to be accustomed to concluding with daily sentences from a problem.

Based on the description above, as an effort to improve the problem-solving abilities in terms of self-efficacy in one of the junior high schools in Semarang, the researcher was interested in researching entitled "An Analysis of Problem Solving Ability Using Mathematical Modeling Strategies in Brain-Based Learning Based on Self-Efficacy".

## 2. Methods

The method used in this research is mixed method. Mixed method research is an approach to inquiry involving collecting both quantitative and qualitative data (Creswell, 2013). In this research used sequential explanatory design. Sequential explanatory design is a mixed method strategy involving a two-phase research project where quantitative data is collected in the first phase, analyzing the data, then using the result to plan the second phase, the qualitative phase. The collection and analysis of qualitative data in the second stage aims to strengthen the result of qualitative data in the first stage (Creswell, 2013). The quantitative research design is a quasi experimental design with the nonequivalent posttest-only control group design.

The population in this study were all students of class VII in SMP Negeri 34 Semarang in the even academic year 2018/2019. Then, the samples were taken by simple random sampling technique, so that in class VII A was obtained as the experimental class. The research subjects were taken using purposive sampling technique so that six subjects were selected based on self-efficacy categories by considering students' problem-solving abilities. Six subject were chosen consisting of 2 students from the high group self-efficacy, 2 students from the middle group self-efficacy, and 2 students from the group low self-efficacy.

Those variables in this study are divided into two variables, namely problem-solving variables and self-efficacy. The method used in this study is the method of documentation, tests, scale, interview, and observation. Documentation method was used to get math test data values in the middle of the even semester. The test method was used to collect data on students' problem-solving abilities before and after learning mathematics with the application of mathematical modelling strategies. It was named Brain-Based Learning. Scale method which is used to measure students' self-efficacy so that, it can classify high, middle, and low groups. The interview method is carried out to know and capture all information directly from the research subject related to the problem-solving abilities and student self-efficacy. The observation methods were used to obtain information about the behaviour and the meaning of the research object behaviour.

## 3. Results & Discussions

The data about problem-solving ability was obtained based on the initial ability score. That score is obtained from the Middle Semester Assessment score (MSA) and the experimental class problem-solving ability test (posttest) score. The data score on problem-solving abilities that have been obtained is then analyzed descriptively first. The following Table 1 is presented about descriptive statistics on problem solving abilities.

**Table 1.** Descriptive statistics of PSA.

| PSA Test | $n$ | $\bar{x}$ | $s$ | Min Score | Max Score |
|---|---|---|---|---|---|
| Initial PSA | 32 | 74,03 | 9,282 | 57 | 90 |
| Final PSA | 31 | 75,71 | 8,661 | 60 | 95 |

Based on Table 1, it can be seen that in learning with the application of mathematical modelling strategies to BBL, the average final PSA (posttest) test results are better than the initial PSA average. Based on the results of the final PSA test (posttest), the average problem-solving ability is $75,71$, with a standard deviation of $8,661$. Many students achieved twenty-six learning completeness scores, while students who had not achieved the learning completeness score were five students. Furthermore, the test scores for problem-solving abilities are grouped according to the criteria presented in Table 2 (Azwar, 2005).

**Table 2.** Criteria for grouping in problem solving capabilities.

| Group | Interval |
|---|---|
| High | $X \geq 84{,}371$ |
| Middle | $67{,}049 \leq X < 84{,}371$ |
| Low | $X < 67{,}049$ |

Note:
$X$: the value of the problem-solving ability test

Based on the results of the problem-solving ability test obtained as many as five students included in the high PSA group, as many as $21$ students included in the middle PSA group, and as many as five students included in the low PSA group. The percentage of each level for problem-solving ability is presented in Table 3.

**Table 3.** Percentage of each problem solving ability group against problem solving ability test results.

| Group | Student Amount | Percentage(%) |
|---|---|---|
| High | 5 | 16,13 |
| Middle | 21 | 67,74 |
| Low | 5 | 16,13 |
| Total | 31 | 100 |

Based on the results of the problem-solving ability test after getting learning with the application of mathematical modelling strategies to Brain-Based Learning, $26$ from $31$ students achieved individual learning completeness or about 83,87% of students in the experimental class. Based on the results of hypothesis 1 test on classical completeness obtained $z_{count} = 1{,}6955$ and $z_{tabel} = 1{,}64$. Obviously $z = 1{,}6955 \geq z_{tabel} = 1{,}64$, so that $H_0$ is rejected. Indeed, the problem-solving ability of students in the quadrilateral with square sub-material and rectangle in the application of mathematical modelling strategies in Brain-Based Learning has reached classical completeness criteria. Previous research by Pambudiarso (2016) stated that the results of the problem-solving ability tests of students who got SPS model learning achieved completeness.

Based on the posttest results showed that the average value of problem-solving abilities of students in the experimental and control classes sequentially is 75,71, and 68,72 with the standard deviation of the experimental class was 8,661, and the standard deviation in the control class was 9,242. Based on the calculation obtained $t_{count} = 3{,}732$ and $t_{table} = 1{,}671$. Obviously $t_{count}$ = $= 3{,}732 > t_{table} = 1{,}671$, so $H_0$ is rejected. So the posttest average problem-solving ability of students with mathematical modelling strategies in Brain-Based Learning is better than the average posttest of students' problem-solving abilities in conventional learning.

Furthermore, the hypothesis 2 test was conducted to find out whether the proportion of experimental class problem-solving ability was better than the proportion of problem-solving abilities in the control class. Based on the calculation obtained $z_{count} = 26{,}74$ and $z_{table} = 1{,}64$. Obviously $z_{count} = 26{,}74 > z_{table} = 1{,}64$, so that $H_0$ is rejected. The posttest proportion of students problem-solving abilities with mathematical modelling strategies in Brain-Based Learning is better than the posttest proportion of students' problem-solving abilities in conventional learning. The data above shows that the problem-solving abilities of the experimental class by applying mathematical modeling strategies to Brain-Based Learning is better than the control class that uses the Problem Based Learning. Same as with Sari statement (2018) which states that there is an increase in problem-solving abilities in students who use mathematical modelling significantly rather than not using mathematical modelling.

The determination of these research subjects in this study uses purposive sampling technique. The research subjects in this study were determined based on grouping the level of self-efficacy (SE) by considering the results of the problem-solving ability test. Then two students from the high self-efficacy group, two students from the middle group self-efficacy, and two students from the low self-efficacy group were selected. Based on the results of grouping the experimental class self-efficacy, six research subjects were selected, which can be seen in Table 4.

**Table 4.** Research subject.

| No | Student Code | Subject Code | SE Level |
|---|---|---|---|
| 1 | E-31 | S-01 | High |
| 2 | E-19 | S-02 | |
| 3 | E-23 | S-03 | Middle |
| 4 | E-03 | S-04 | |
| 5 | E-21 | S-05 | Low |
| 6 | E-08 | S-06 | |

The research subjects were then interviewed to find out students' problem-solving abilities description based on self-efficacy and in purpose to strengthen quantitative data. Interviews were conducted on six research subjects, namely S-01, S-02, S-03, S-04, S-05, S-05, and S-06.

S-01 and S-02 subjects are students in high group self-efficacy with problem-solving abilities classified as high. The following is presented by the results of a qualitative analysis of problem-solving abilities in high group self-efficacy in Table 5.

**Table 5.** The results of qualitative analysis ability to solve the problems in the high self-efficacy group.

| Research Subject | Question Number | Problem Solving Ability Indicator 1 | 2 | 3 |
|---|---|---|---|---|
| S-01 (High PSA) | 1 | M | M | M |
| | 2 | M | M | M |
| | 3 | M | NM | NM |
| | 4 | M | M | M |
| | 5 | M | M | M |
| | 6 | M | NM | M |
| | 7 | M | M | M |
| S-02 (High PSA) | 1 | M | M | M |
| | 2 | M | M | M |
| | 3 | M | NM | NM |
| | 4 | M | NM | M |
| | 5 | M | M | M |
| | 6 | M | NM | M |
| | 7 | M | M | M |

Note:
Meet: It meets the indicators of problem-solving capabilities, and
Not Meet: It does not meet the indicators of problem-solving capabilities.

Based on the results of qualitative analysis of problem-solving abilities in high group self-efficacy, it was obtained information that on indicator 1 namely reading and understanding problems, subject S-01 and subject S-02 were consistently able to correctly identify quantities and units, characterized by S-01 and S-02 subjects were able to write down what was known and asked correctly. In indicator 2, namely organizing strategy and solving the problem (compiling a solution strategy and solve the problems), subject S-01 and subject S-02 are consistent in being able to provide the symbols/variables of the question correctly, able to compile mathematical models based on the law that controls, and able to determine the model solution correctly. The S-01 subject characterizes it, and the S-02 subject can model the problem given, able to write the formula used and be able to complete the modelling that has been made by utilizing the concepts that it has. Then, on indicator 3, namely confirmation of the answer and process (checking the correctness of the answer), subject S-01 and subject S-02 are consistently able to determine the solution to the problem correctly, characterized by S-01 subject and subject S-02 able to write conclusions on the results obtained correctly. The following is presented in one of the student task in Figure 1.

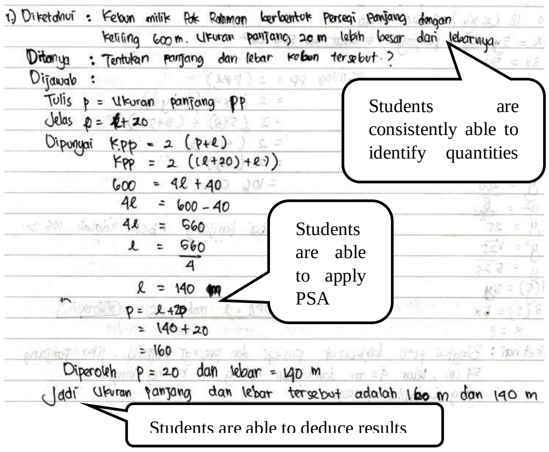


**Figure 1.** Subject test result with problem-solving abilities in the high self-efficacy groups.

In the middle group self-efficacy, there were two research subjects selected, namely S-03 and S-04. Subjects s-03 and S-04 are students who have problem-solving abilities that are classified as middle groups. The following is presented the results of qualitative analysis of problem-solving abilities in the middle group self-efficacy in Table 6.

**Table 6.** The qualitative analysis result of the ability to solve problems in the middle self-efficacy group.

| Research Subject | Question Number | Problem Solving Ability Indicator 1 | 2 | 3 |
|---|---|---|---|---|
| S-03 (Middle PSA) | 1 | M | M | M |
| | 2 | M | M | M |
| | 3 | NM | NM | NM |
| | 4 | M | NM | M |
| | 5 | M | M | M |
| | 6 | NM | NM | NM |
| | 7 | M | M | M |
| S-04 (Middle PSA) | 1 | M | M | M |
| | 2 | M | M | NM |
| | 3 | NM | NM | NM |
| | 4 | M | M | M |
| | 5 | M | M | M |
| | 6 | M | NM | M |
| | 7 | M | NM | M |

Note:
Meet (M): It meets the indicators of problem-solving ability, and
Not Meet (NM): It does not meet the indicators of problem-solving ability.

Based on the results of qualitative analysis of problem-solving abilities in the middle group self-efficacy, information was obtained that on indicator 1 namely reading and understanding problems, the S-03 subject and S-04 subject were consistently able to correctly identify the quantities and units, characterized by S-03 subject and S-04 subject were able to write what was known and asked correctly. In indicator 2, namely organizing strategy and solving the problem (compiling a solution strategy result and solving the problems), subject S-03 and subject S-04 are able to provide symbols/variables of the question correctly, but are less capable of compiling mathematical models based on the controlling law, besides that the subject of S-03 and S-04 is less able to determine the model solution. It is characterized by subject S-03 and S-04 weakly able to model the problem given, able to write the formula used but less able to perform mathematical operations correctly and less able to complete the modelling which he/she made. On indicator 3, namely confirmation of the answer and process (checking the correctness of the answer), subject S-03 and S-04 are less able to determine the solution of the problem. The subject of S-03 characterized this indicator, and the S-04 subject was able to write conclusions obtained but not by the actual results. This case has happened because of the inadequacy of subject S-03 and subject S-04 in modelling and performing mathematical operations correctly. The following is presented in one of the student's test in Figure 2.

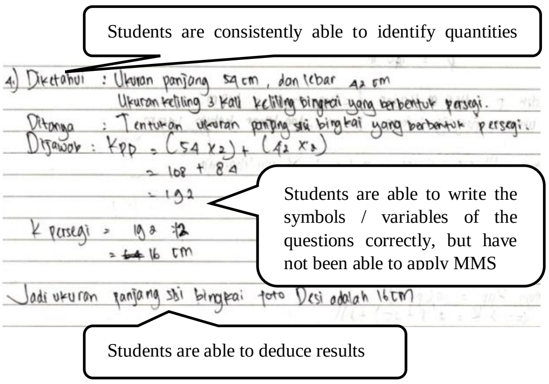


**Figure 2.** Subject test result with problem-solving abilities in the middle self-efficacy.

In the low group self-efficacy, there were two research subjects selected, namely S-05 and S-06. S-05 and S-06 subjects are students who have problem-solving abilities that are classified as low. The following is the result of the qualitative analysis of problem-solving abilities in the low group self-efficacy in Table 7.

**Table 7.** Results of qualitative analysis of the problem solving ability in the low self-efficacy group.

| Research Subject | Question Number | Problem Solving Ability Indicator | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| S-05 | 1 | M | M | M |
| | 2 | M | M | M |
| | 3 | M | NM | M |
| | 4 | M | M | M |
| | 5 | M | NM | NM |
| | 6 | NM | NM | NM |
| | 7 | NM | NM | NM |
| S-06 | 1 | M | M | M |
| | 2 | M | M | M |
| | 3 | NM | NM | NM |
| | 4 | M | M | M |
| | 5 | M | M | M |
| | 6 | NM | NM | NM |
| | 7 | NM | NM | NM |

Note:
Meet (M): It meets the indicators of problem-solving ability, and
Not Meet (NM): It does not meet the indicators of problem-solving ability.

Based on the results of the qualitative analysis of problem-solving abilities in low group self-efficacy, information was obtained that on indicator 1 was reading and understanding problems, the S-05 subject and S-06 subject were consistently able to identify quantities and units correctly, characterized by S-05 subject and S-06 subject were able to write down what was known and asked correctly. On indicator 2, namely organizing strategy and solving the problem (compiling a solution strategy and solving a problem), the S-05 subject and subject S-06 can correctly provide the symbol/variable of the question. The S-05 subject and the S-06 subject were unable to compile a mathematical model based on the controlling law, thus making the S-05 subject and subject S-06 unable to determine the model solution correctly. This is characterized by the S-05 subject, and the S-06 subject can provide the symbol/variable of the question correctly, but they are unable to model the problem given. The S-05 subject and the S-06 subject were able to write the formula used, but they were unable to do mathematical operations correctly and were unable to complete the modelling he made. On indicator 3, namely confirmation of the answer and process (checking the answer correctness), subject S-05 and subject S-06 are not able to determine the solution to the problem, because they are less able to model the problem given. This indicator was characterized by the S-05 subject, and the S-06 subject had not been able to complete the modelling on some of the questions given. The S-05 subject and S-06 subject were able to write conclusions obtained but not by the actual results. This was obtained because the S-05 subject and S-06 subject were inadequate in modelling and performing mathematical operations correctly. The following is presented in one of the student tests result in Figure 3.

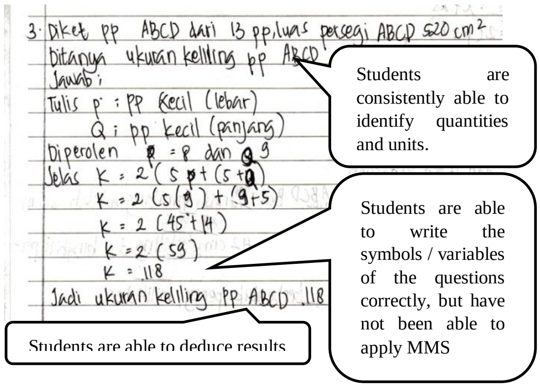


**Figure 3.** Subject test result with problem-solving abilities in the low self-efficacy groups.

## 4. Conclusion

Based on this research, mathematical modelling strategies can be used as an alternative to utilize problem-solving learning. However, the results of the students' test (worksheet) show that from the three indicators of problem solving according to Tambychik (2010), the indicator of organizing strategy and solving the problem is not met at most or in other words students still find the difficulty to form the model and complete the model they made correctly.

The results obtained in this study are (1) problem-solving ability in the application of mathematical modelling strategies in Brain-Based Learning has not achieved in classical mastery learning point of view; (2) the problem-solving ability of the experimental class by applying mathematical modeling strategies to Brain-Based Learning is better than the control class that uses the Problem Based Learning; and (3) two subjects in the high SE category have high PSA, two middle SE subjects currently have middle PSA, and two low SE subjects have a low PSA.

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