Mathematical resilience and mathematical problem-solving ability in Junior High School

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Abstract. In the process of mathematics learning, every student has different characteristics and attitudes to face adversity that called mathematical resilience. Mathematical resilience is one of the factors that have a role in supporting student achievement. This study investigated the relationship between mathematical resilience with mathematics problem-solving ability among junior high school students. Participants included 100 students at Sragen Region, Central Java Province, Indonesia. The method used in this research is the survey method with the correlation and regression technique. Data sources included the questionnaire of mathematical resilience and written test. Findings revealed a significant, positive correlation between mathematical resilience and student’s mathematical problem-solving ability, with a contribution of 16.30% obtained by the regression model $Y = 14.355 + 0.302X$. The result indicated that positiveness response to learning mathematics, emotion regulation, curiosity, and optimism in mathematical resilience beliefs were associated with mathematical problem-solving ability. Evidence presented to support and contribute to the value of students’ mathematical problem-solving abilities and provides a new approach for encouraging greater student participation and persistence in mathematics.

1. Introduction

The mathematical problem-solving ability is one of the main parts to be achieved to learn mathematics in the 21st-century. Adaptive education and learning innovations to the demands of the times need to be continuously carried out from the elementary school level to the university level, especially in response to the increasingly rapid development of science and information technology. Tien et al. [1] argue that a rapid change in technology, information, and economics increasingly demands skills such as critical thinking skills, problem-solving, making decisions, teamwork, etc. The importance of problem-solving for students to learn is recognized to a rich view of mathematical competence [2,3]. Jader et al. [4] also show that problem-solving as a key to competence in mathematics learning, the problem-solving distinction between student practicing by construction solution and imitation solution.

Problem-solving in mathematics needs to be studied by students so that they can combine elements of knowledge, techniques, rules, skills, and concepts that have been learned beforehand to provide new solutions [5]. There are several studies in Indonesia show that Indonesian students find difficulties in solving mathematical problems [6-8]. The ability to solve mathematical problems is not solely intended to get the right answer but to build knowledge and the process of getting answers rationally.
Sumarmo argues that problem-solving ability is an activity of solving open-ended problems, solving non-routine problems, applying mathematics in real-life problems, and proving conjectures [9]. The development of learning models by integrating creativity processes needs to be explored [10]. Besides, teachers tend to teach learners to apply formulas and give routine problems done and not far from the example of the questions given by teachers [11].

Students’ mathematical solving abilities are still low. This fact is supported by the results of the National Examination for Junior High School students in Sragen Regency [12]. Assessments in the classroom must be familiar with questions that present a variety of applicative problems, complex translations, and non-routine problems that are included in Higher Order Thinking Skills so that children are motivated by their ability to think mathematically. The mathematics learning achievement of students can be seen in the results of the Junior High School National Examination report in Sragen Regency for the last three years shown in Table 1.

**Table 1. The result of the Mathematics National Examination in Sragen Regency.**

| Average Result of Mathematics UNBK in Sragen Regency | 2016 | 2017 | 2018 |
|-----------------------------------------------------|------|------|------|
|                                                     | 44.35| 49.22| 46.08|

Based on Table 1, it is shown the results of the Mathematics National Examination of Junior High Schools in Sragen Regency for the last three years. It can be seen that the results of the national examination score have increased in 2017, then in 2018 the result of national examination scores was decreased. Efforts to improve the quality of education have been carried out by improving the implementation of the learning process. However, the efforts that have been made are not enough to show satisfactory results, mathematics learning so far has not been able to change the cognitive aspects of students such as mathematical problem-solving abilities which are expected to be better. Mathematical learning tends to be oriented towards giving formulas, examples of questions and practice questions [13]. Students are more dominant in practicing working on routine questions whose solutions are using formulas and algorithms. Consequently, if students are given non-routine questions or forms of problem-solving are still considered as complex and rare questions. Besides, in its development at school, mathematics is often seen as one of the difficult subjects for some groups, especially for students.

Based on interviews with several eighth-grade junior high school students in Sragen Regency, in general, that there was still a need to pay attention to students' self-regulation of mathematics and how to hold students facing various challenges in mathematics learning. Through interviews with several students, it is found that there were still many students feel that mathematics is a difficult and unpleasant subject so that the lack of confidence in students and the low resilience of self-regulation to challenges and difficulties required a skill to overcome problems in mathematics but the above causes are also caused by external and internal factors. Factors that influence the decline in academic prescriptions are (1) Internal factors, namely factors originating from within the student itself, namely physiological factors that are acquired and psychological factors that are intellectual and non-intellectual (2) External factors, namely factors that originate from outside the student, for example, curriculum, teacher, method, social factors, cultural factors, and environmental factors [14]. According to Ruseffendi, mathematics is a science that uses deductive principles, namely a principle from general to special reviews [15].

In the other study, Leo et al. [16] predicted the emotions students experienced during problem-solving, the result demonstrated that the most frequently occurring emotions during problem-solving included frustration (24.34%) and confusion (22.63%) in mathematics learning. A teacher usually chooses and implements certain approaches, methods, strategies, or learning models that support the process of thinking systematically, logically, and find a combination of rules learned earlier that are used to solve new problems so that they are expected to foster a positive attitude towards mathematics and learn math. One positive attitude that is the material of the study from this study is mathematical
resilience. One of the soft skills to be achieved in mathematics learning is mathematical resilience [17]. In a learning process of mathematics, mathematical resilience intelligence is needed by students when faced with a problem and asked to solve it. The intended intelligence is the enthusiasm and fighting spirit of students in solving problems, looking for some possible solutions so that they can turn difficulties into a challenge to solve. Mathematics is also considered difficult to master; therefore students need to develop positive adaptive attitudes toward mathematics that will enable them to continue learning [18].

Mathematical resilience contains a firm or persistent attitude in the face of difficulties, working or collaborative learning with peers, having language skills to express mathematical understanding, and mastering mathematics learning theories [19]. Students with strong mathematical resilience, have adaptive attitudes or can adapt to the environment; can face uncertainty, challenge problems; solve problems logically and flexibly; looking for creative solutions to challenges; curious and learn from experience; have self-control ability; aware of his feelings; has a strong and easy social network [20]. Resilience as a process in, capacity for, or the result of an effort to adapt to conditions that are challenging or frightening [20]. More specifically, resilience is a process in which a person can achieve success or success by adopting even though he is in a challenging situation with high risk and a scary atmosphere. In the context of mathematics, mathematical resilience is a quality attitude in learning mathematics which includes: confidence in its success through hard work; show diligence in facing difficulties; wants to discuss, reflect, and research [21]. Besides that, Lee and Johnston Wilder [22] argue that the construct of mathematical resilience allows learners to manage and protect themselves from unhelpful emotions and obstacles that may arise when mathematics becomes difficult to learn.

Some of the positive attitude factors include a value, fighting power or resilience and growth. A strong positive attitude as above will support students to be diligent and persistent in facing difficulties or obstacles, while students who are low in attitude will lose their diligent and persistent attitude or give up when facing difficulties. This study especially designed for investigating the role of mathematical resilience in mathematical problem-solving ability. At least there are two sub-questions need to be answered: (1) Is there any relationship between mathematical resilience and their mathematical problem-solving ability? And (2) how much percentage of mathematical resilience contributes to student’s mathematical problem-solving ability in 8th-grade junior high school?.

2. Method
This research used a survey method with correlation and regression techniques that are looking for abstraction relationships with mathematical resilience and mathematical problem-solving abilities of students. The population in this research was all students of the eighth grade of junior high school in Sragen Region, Central Java, Indonesia. The population was divided into three categories of schools, namely high, medium, and low categories, which are obtained based on the mathematics national examination score in 2018. The data of this research was obtained from 100 students of junior high school in the Sragen Region with heterogeneous abilities, collected using a written test and questionnaire of mathematical resilience. The subject consisted of grade eight students from three schools in Sragen, conducted in the second semester of the academic year 2018/2019.

The student's mathematical resilience ability was measured by using a mathematical resilience scale that consisted of 23 items of statements. Prepared based on its indicators, where each statement had five scale options using a Likert scale. The written test was used to measure the ability of specialization and generalization of mathematical problem-solving. The instrument in this study was validated by six validators, each of which was three validators for tests and three validators from psychology lecturers for questionnaires. Based on the result of the instrument's validity analysis, the result of testing the validity revealed good validity. 23 items of statements of mathematical resilience were greater than 0.3. The assessment for reliability was based on composite reliability. A value of CR ≥ 0.6 is required. The value of CR of this instrument was more than 0.7; specializing mathematical problem-solving=0.7125, generalizing mathematical problem-solving=0.786, and mathematical
resilience=0.7912. The essay topic for the test was about probability (peluang) learning materials. The calculations in this study are assisted by Microsoft Excel and SPSS.

3. Result and Discussion

The research began with observations in several schools that represent the population in Sragen Regency and found several mathematical problems that were equal with the results of the mathematics national examination in Sragen Regency that still showed a score below the average national examination score. The research population was all junior high school students in Sragen Regency, Central Java, Indonesia. The determination of research subjects was taken from sampling to eighth-grade students from three schools in Sragen Regency. Three schools were selected by cluster random sampling technique. Based on the analysis of the 2018 mathematical national examination scores, there is 49 total from junior high school in Sragen regency. Based on the results of calculations on the average mathematical data of students on the national exam 2017/2018 school year, the combined mean is 46.08 and the combined standard deviation is 18.51. Thus, the group is a group of Sragen Regency State Junior High Schools with a mean score of students’ mathematics on the national exam 2017/2018 for more than 55.34. The middle group is the Sragen Regency Junior High School group with the average mathematics score of students on the national exam 2017/2018 for less than or equal to 55.34 and more than or equal to 36.83. The lower group is the Sragen Regency Junior High School group with the average mathematics score of students on the national exam 2017/2018 for less than 36.83. obtained six schools with high categories, twenty-seven schools with medium categories and sixteen schools with low categories. After categorization, one school from each category was chosen randomly to be used as the sample of this research.

There are two variables resulted from score tests. First, score from the questionnaire of mathematical resilience (MR) and second, score from the test of mathematical problem-solving ability the written-test of mathematics of mathematical problem-solving ability (PS). The summary of standard deviation and mean scores of the participants in MR and PS tests are described in Table 2.

| Variables | Mean | Std.Deviation |
|-----------|------|---------------|
| MR        | 76.64| 9.763         |
| PS        | 37.50| 7.302         |

Based on Table 2, it is shown that the average mathematical resilience is 76.64 and the standard deviation obtained is 9.763. Furthermore, the average mathematical problem-solving abilities of students 37.50 and the standard deviation of 7.302. The vision of Indonesian mathematics education states that mathematics education is devoted to understanding mathematical concepts and ideas which are then applied in routine and non-routine problem solving through reasoning, communication, and connection development inside mathematics and outside mathematics itself [23]. But in fact, out of 100 students of junior high school in Sragen Regency have an average mathematical problem-solving ability and mathematical resilience relatively low. The results of the correlations between mathematical resilience and mathematical problem-solving ability analysis are shown in Table 3.

| Variables | MR   | PS   |
|-----------|------|------|
| MR        | Pearson Correlation | 1    | .404 |
|           | Sig. (2-tailed)     | .000 |      |
| PS        | Pearson Correlation | .404 | 1    |
|           | Sig. (2-tailed)     | .000 |      |
Based on Table 3, it is shown that there is a relationship between mathematical resilience and mathematical problem-solving abilities of students, which is equal to 0.404, which means there is a weak relationship between the two variables. It can be concluded that there is a significant and positive relationship between mathematical problem-solving abilities and mathematical resilience. The results of the regression analysis are shown in Table 4.

| Model  | Unstandardized Coefficients | Standardized Coefficients | T   | Sig. |
|--------|-----------------------------|---------------------------|------|------|
|        | B                           | Std. Error                | Beta |      |
| (Constant) | 14.355                  | 9.770                     | .974 | .332 |
| MR     | .302                       | .115                      | .307 | 4.179| .000 |

From table 4, it can be seen that regression coefficient a = 14.355, b = 0.302, so estimation of the regression model as follows: $Y = 14.355 + 0.302X$. Based on the above equation, the mathematical problem-solving ability will increase by 0.302 times at a constant 14.355. The regression analysis estimates the conditional expectation of the dependent variable given the independent variable, and the average value of the independent variable when the independent variable is fixed.

| Model  | Sum of Squares | Df | Mean Square | F     | Sig. |
|--------|----------------|----|-------------|-------|------|
| Regression | 860.704           | 1  | 860.70      | 19.091| .000 |
| Residual | 4418.29          | 98 | 45.085      |       |      |
| Total   | 5279.00          | 99 |             |       |      |

Based on Table 5, it can be seen that the calculated F value is 19.091 and sig.value is 0.000. Because the significance value is 0.000 which is the sig value, < 0.05, in conclusion, mathematical resilience affects students' mathematical problem-solving abilities. Significance of the correlation coefficient test is shown in Table 7, it can be seen that the correlation coefficient $(r_{xy}) = 0.404$ and $F_{\text{hit}}$ $(F_{\text{change}}) = 19.091$, with $p$-value = 0.000<0.05, means that the correlation coefficient of mathematical resilience and mathematical problem-solving ability is significant.

| Model  | R Square | Adjusted R | Std. The Error of the Estimate |
|--------|----------|------------|-------------------------------|
|        | .163     | .040       | .155                         | 6.715 |

Based on Table 6, it was found that the value of R was 0.404 so that the value of its determination coefficient was 0.163. This means that the contribution of mathematical resilience to students' mathematical problem-solving abilities was 16.30% and 83.70% influenced by other variables. Based on the results of the above research, there is a positive and significant relationship between mathematical resilience and mathematical problem-solving abilities in the essay topic for the test was about linear programming. The mathematical resilience contribution to students' ability to solve mathematical problems is including in the low category. This is due to mathematical resilience can be developed in people who have experienced previous mathematical exclusion or stress, through a strategic and explicit focus on the culture of learning mathematics within both formal and informal learning environments. People who were mathematics-avoidant can become curious and increasingly aware of their feelings; they develop an internal locus of control and a strong social learning network, they learn to seek and give help. We propose that valued mathematics experiences, together with a language for awareness and management of risk, can help learners develop risk-taking and
management processes in their learning of mathematics so that they spend increased time in their mathematical growth zone [24]. Whereas according to Ashcraft, mathematical resilience is a part of resilience that allows students to overcome certain forms of anxiety that attach to mathematics and student learning. Anxiety here means feeling tense, anxious, or afraid that interferes with the mathematical performance [25].

Students who have high mathematical resilience, have high motivation and perseverance even though they are in difficult conditions, they tend to be happy when given something challenging related to mathematics learning. Mathematical resilience as a positive adaptive attitude towards mathematics that allows students to continue solving mathematical problems despite facing difficulties [20]. A strong positive attitude as above will support students to be diligent and persistent in facing difficulties or obstacles, while students who are low in attitude will lose their diligent and persistent attitude or give up when facing difficulties. In other words, mathematical resilience is a series of attitudes that give a positive response to learning mathematics. For someone to have high resilience, the strategy that must be done for someone between the ages of 13 and 19 is to have a strong social support network, namely: (1) The presence of parents or parents who unconditionally always support what the child is doing (2) There is a committed mentor or other people from outside the family. (3) Positive experience in the previous school. (4) Having confidence and trying to make changes (5) Participation in various extra-curricular activities. (6) The ability to reframe difficulties so that they are useful and acknowledge the benefits of these difficulties. (7) Ability to 'make a difference' by helping others or through part-time work. (8) Don't take refuge from difficult situations, but develop skills to overcome these difficulties [21]. Resilience is the capacity of individuals to confront and respond positively to unpleasant conditions that are inevitable and to take advantage of those unpleasant conditions into an opportunity for personal self-development [26][27]. Moreover, this study related to Cousins et al. [28], the research found that the students overcame their emotional barriers to learning mathematics support from any factors, there are sensitive support from others, specific teaching and learning strategies, and by increasing their mathematical resilience.

4. Conclusion

Based on the result, there is a positive and significant relationship between mathematical resilience and students' mathematical problem-solving abilities. That is, mathematical resilience can be used to predict the level of students' ability to solve mathematical problems. The research gives an overview based on the statistical analysis of the test that gives an overview based on the statistical analysis of the test that mathematical resilience contributes 16.30% to students' mathematical problem-solving abilities and 83.70% is influenced by other variables. The results of statistical calculations are similar to those of research [14]. Besides, the conclusion from the findings obtained in this study is mathematical resilience can be used to predict the level of students' mathematical problem-solving abilities so that it is expected for other researchers to examine the contribution of mathematical resilience to other mathematical abilities.

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