Mathematical connection ability in 7th grade students viewed from self-regulated learning

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Abstract. The purpose of this research is to determine which mathematical connection ability is better; students with high, medium or low self-regulated learning. This research was descriptive quantitative research. The instruments used in this research were questionnaire of self-regulated learning and written test of mathematical connection ability. The research samples consisted of 186 students who were studying at a state Junior High School in Sukoharjo Regency, Indonesia, with heterogeneous abilities. The data analysis technique used was one-way Anova with unbalanced cell and post hoc test using the Scheffe method. The results show that students with high self-regulated learning have better mathematical connection ability than students with medium and low self-regulated learning. Students with medium self-regulated learning have better mathematical connections ability than students with low self-regulated learning. In order to connect to each mathematical problem, students must first remember the problem, while to understand the problem, students must be able to make connections with topics related to the problem so that students' efforts in finding solutions to mathematical problems are through self-regulated learning activities. When students have self-regulated learning, they will significantly improve their mathematical connection ability.

1. Introduction

Mathematics is the gate leading to opportunities. In this changing world, those who understand mathematics will have significantly enhanced opportunities and options for shaping their futures. Mathematical competence opens doors to productive futures, and a lack of mathematical competence keeps those doors closed [1]. This is in line with the Outline of the Teaching Program (GBPP) which states that the general goal of mathematics learning are: (a) preparing students to be able to deal with changing circumstances in an evolving world, through training to act with logical, rational, and critical thinking, careful, honest, effective and efficient, and (b) prepare students to be able to use mathematics and mathematical mindset in daily life and in studying various sciences [2].

Mathematical connection ability is one of essential competencies that must be possessed and developed in junior high school students. The term mathematical connection ability is implied by the same characteristics, namely the relationship between ideas, concepts, principles, processes, mathematical content and theorems, and the relevance of mathematical contents to another study content or everyday problems [3]. Correct connections can build conceptual understanding; the stronger the connection between related concepts, the further it will deepen and enrich the understanding of the concept [4]. From the standard of mathematics teaching, there are three major components of
mathematical connection ability [1], namely (a) recognize and use connections among mathematical ideas, (b) understand how mathematical ideas connect and build one another to produce a coherent understanding, and (c) recognize and apply mathematical knowledge outside Mathematical context.

In more detail, mathematical connection ability can be categorized into four aspects, namely: (a) inter-connection of mathematical topics that link concepts or principles in the same topic, (b) connections between mathematical topics that relate material in certain topics to material in other topics, (c) the connection between matter and science other than mathematics, and (d) connection with everyday life [5]. Based on the similarity of aspects of mathematical connection ability, they can be categorized into two types, namely modeling connections is the relationship between situational problems that arise in the real world or in other scientific disciplines with mathematical representation, whereas mathematical connections are the relationship between two representations that are equivalent and between completion processes from each representation [6]. The mathematical connection ability has two different directions, namely (a) connections within and between Mathematical ideas, and (b) connections of mathematics to the real world or other fields of study outside mathematics [7]. The classification of mathematical connection abilities relating to internal connections including connections between mathematical topics and external connections includes mathematical connections with other subjects or connections with everyday life [8].

A preliminary study was carried out on 27-29 of September 2018 on students at SMP Negeri 1 Mojolaban, SMP Negeri 2 Kartasura, and SMP Negeri 2 Baki. They were given questions containing mathematical connection ability. It was obtained that a percentage of 77.8% students could not answer the questions correctly. In addition, the results of observations and interviews conducted on the mathematics teachers, there were several problems, namely: (a) students are indicated to be less able to use between mathematical concepts and procedures because of lack of prior knowledge or pre-requisite material taught, (b) students are less able to apply mathematical concepts outside the topic of mathematics because they are less accustomed to being given problems different from what the teacher exemplifies but still in the same concept, and (c) learning indicates there is no active involvement of students in compiling their cognitive structures because most teachers record information on the board or explain the material in front of the class while students copy in their notebooks or listen to what the teacher has to say. In accordance with the results of other studies, the level of mathematical ability of junior high school students was relatively low, reaching only an average of 53.8% [5]. The average percentage of connection mastery aspects is 63% of connections between mathematical topics that relate material in a particular topic to material in other topics, 42% for connections between one topic in the same math, 56% for connections between mathematics and other subjects, and 55% for mathematical relationships with everyday life.

Characteristics of students who are suitable to improve mathematical ability are contained in self-regulated learning because one semester consists of six subjects, students cannot rely solely on classroom learning which is only five hours per week. To be successful in the academic challenges they will face, students must go beyond surface-level learning, taking ownership of learning by choosing and using the best resources and strategies for the task, as well as reflecting upon and monitoring their progress toward learning goals [9]. Learning success must imply students’ awareness to learn independently in addition to classroom learning. This new curve of learning, which has become one of the most important topics and interest in education, focused attention on how to empower students to perform learning practices by themselves because self-regulated learning depends heavily on students’ proactive roles in their learning outcomes [10].

Self-regulated learning is the active process of students setting their main goals in learning, trying to monitor, regulate and control their cognitive, motivational and behavioural abilities to achieve goals in learning [11]. Aspects of self-regulation learning, namely (a) forethought phase includes task analysis (goal setting, strategic planning) and self-motivation beliefs (self-efficacy, goal orientation), (b) performance control that includes self-control (self-instruction, attention focusing, task strategies), and (c) self-reflection that includes self-reflection (self-judgment, self-evaluation) and self-reaction (self-satisfaction) [12,13]. Self-regulated learning to help students become self-regulated learners must have
good self-regulation including: (a) initiative and intrinsic learning motivation, (b) the habit of diagnosing learning needs, (c) set learning goals or targets, (d) monitor, regulate and control learning, (e) view difficulties as challenges, (f) utilize and search for relevant sources, (g) choose, implement learning strategies, (h) evaluating learning processes and results, and (i) self-efficacy or self-concept or self-ability [3]. In addition, self-regulated learning consists of four categories, namely (a) cognitive that includes associated with behaviours and cognitive processes used by students during their learning to complete tasks or achieve academic goals, (b) meta-cognitive that includes planning, monitoring and evaluation that help individuals control and regulate their own cognitive processes, (d) self-management that includes controlling and regulating the time and environment of learning, business, cooperation and seeking help, and (d) motivation that includes intrinsic values, self-efficacy and anxiety in the test stand as the final dimension of self-regulated learning [14].

From some experts, the indicators of mathematical connection ability are mathematical connections between concepts in the same topic, mathematical connections between concepts in certain topics with other topics, mathematical connections in other subject disciplines, and mathematical connections in everyday life. Then, the indicators of self-regulated learning are forethought, performance control, and self-reflection. Therefore, the purpose of this research is to determine which mathematical connection ability is better; the students with high, medium or low self-regulated learning.

2. Method
The type of current research was quantitative descriptive. The population employed in this research were all 7th grade students of State Junior High Schools in Sukoharjo Regency. The samples of this study were obtained by taking three State Junior High Schools in Sukoharjo Regency. Each school represents three categories, namely high, medium and low. Grouping three school categories sorted by the results of the 2018 Mathematics National Examination using the stratified cluster random sampling technique. Based on the results of the school category, it obtained that the school at high category was SMP Negeri 1 Gatak, the medium category school was SMP Negeri 2 Kartasura, and the low category school was SMP Negeri 2 Baki. The total subjects of the study were 186 students consisted of 63 students were taken from the school with high category, 56 students were taken from the school with medium category, 67 students were taken from schools with low category. The study was conducted in the second semester of academic year 2018/2019.

The instruments used in this research were questionnaire of self-regulated learning and written test of mathematical connection ability. The self-regulated learning questionnaire consisted of 30 items. Before the questionnaire was distributed to the research subjects, the content of each questionnaire was validated. Validating the questionnaire was through two expert assessment by psychology lecturers. After the questionnaire instrument was declared valid by the validators, then the questionnaire was tested to students outside the study sample but still included in the study population. This instrument was analysed by using internal consistency tests and reliability tests with the Cronbach Alpha technique. Therefore, the written test was used to measure the ability of internal and external mathematical connection. Validating the written test was through three expert judgment. The written test of mathematical connection ability consisted of 6 items. This written test was analysed by using reliability tests, level of difficulty, and discrimination power. After the trial tests, data analysis techniques in research were by using one-way Anova statistical test with unbalanced cells and based on the acquisition of scores of students’ self-regulated learning, questionnaires were classified into three categories, namely high, medium and low self-regulated learning.

3. Result and discussion
After determining three schools and research subjects, then a questionnaire test which had been validated by two experts were spreaded to 92 students outside the research subject. In the test, self-regulated learning questionnaire consisted of 30 items of statement. The results of the questionnaire trials showed internal consistency tests for each item and stated as good because they met the criteria of $D \geq 0.30$ and the reliability test was obtained at $0.790$. Based on the results of the questionnaire analysis, it obtained
30 items of statement on questionnaire which were ready to be used as research instrument. Before the data were analyzed by using one-way Anova test with unbalanced cells, a prerequisite test was first performed. Table 1 and Table 2 show that three self-regulated learning categories of data have met the requirements of the one-way Anova test with unbalanced cells, namely normality and homogeneity.

**Table 1. Normality requirements of variance analysis.**

| Requirements | NE Results Category | Total |
|--------------|---------------------|-------|
|              | High | Medium | Low |       |
| \( n_j \)    | 49   | 88     | 49  | 186   |
| Mean         | 53.7755 | 37.9930 | 28.9118 | 120.681 |
| Sd Dev       | 10.02085 | 13.66534 | 12.93541 | 36.6216 |
| \( \text{Var} \left( S_j^2 \right) \) | 100.4170 | 186.7412 | 167.3091 | 454.467 |
| \( L_{\text{max}} \) | 0.11739 | 0.08755 | 0.10159 | 0.30653 |
| \( L_{\text{table}} \) | 0.11739 | 0.08755 | 0.10159 | 0.30653 |

Based on Table 1, the normality test using the Lilliefors method shows that \( L_{\text{max}} < L_{\text{table}} \). This means that each group comes from a normal distributed population. And based on Table 2, the homogeneity test using Barlett method, it is obtained that \( \chi^2_{\text{obs}} < \chi^2_{\text{table}} \). This means that all three populations have the same variance.

**Table 2. Homogenity requirements of variance analysis.**

| RKG | 186 |
|---|---|
| \( f \log \text{RKG} \) | 402.857 |
| \( C \) | 0.995 |
| \( \chi^2_{\text{obs}} \) | 5.650 |
| \( \chi^2_{\text{table}} \) | 5.991 |

Based on Table 1, the normality test using the Lilliefors method shows that \( L_{\text{max}} < L_{\text{table}} \). This means that each group comes from a normal distributed population. And based on Table 2, the homogeneity test using Barlett method, it is obtained that \( \chi^2_{\text{obs}} < \chi^2_{\text{table}} \). This means that all three populations have the same variance.

Table 3 shows the results of the mathematical connections ability distribution of self-regulated learning questionnaire which is used to find out the number of students who are high, medium, and low in each school.

**Table 3. Data distribution of self-regulated learning.**

| Category Self-Regulated Learning | School Category | Total |
|---|---|---|
| | High | Medium | Low |       |
| High | 23 | 14 | 12 | 49 |
| Medium | 29 | 22 | 37 | 88 |
| Low | 11 | 20 | 18 | 49 |
| Total | 63 | 56 | 67 | 186 |

Based on Table 3, students with self-regulated learning category shown 49 students with high category, 88 students with medium category, and 49 students with the low category. From the results of the analysis, it can be seen that students with medium self-regulated learning are more than those of the other two categories, it appears that there are very significant differences. This means that many students were still less aware of the necessity of self-regulated learning.

Table 4 shows the descriptive data of mathematical connection abilities of each category of self-regulated learning, namely high, medium and low. This study uses a one-way Anova test with unbalanced cells because the sample size is different for each school.
Table 4. Descriptive data of self-regulated learning.

| Self-Regulated Learning Category | n   | Mean    | Deviation Standard | Minimum Score | Maximum Score |
|---------------------------------|-----|---------|--------------------|---------------|---------------|
| High                            | 49  | 53.7759 | 10.02085           | 40.00         | 73.33         |
| Medium                          | 88  | 37.9930 | 13.66534           | 13.33         | 73.33         |
| Low                             | 49  | 28.9118 | 12.93541           | 13.33         | 61.67         |
| Total                           | 186 | 120.681 | 36.6216            |               |               |

Based on Table 4, the mean score of the mathematical connection ability viewed from self-regulated learning is 53.7759 for the high category, 37.9930 for the medium category, and 28.9118 for the low category. From the results of the analysis, it can be seen that mean of the high self-regulated learning category resulted better than the medium and low. This is relevant to previous researches which showed that students with high self-regulated learning will maximize their opportunities and abilities in learning [15]. The high self-regulated learning students are usually acquainted with themselves, the subject to be studied, and subject applications to be studied [16]. They know why they learn, so they do and choose something is encouragement from themselves, and it is not controlled by others [17].

Table 5 shows a summary of the results of anova statistical tests, the pair of hypotheses tested is that there are no differences in the three categories of self-regulated learning that have the same effect on students' mathematical connection abilities (H₀) or at least two categories do not have the same mean on students' mathematical connections using anova test statistics (H₁).

Table 5. Anova summary.

|                | Sum of Squares | df | Mean Square | F₀bs | Fₐ  | sig.  | p    |
|----------------|----------------|----|-------------|------|-----|-------|------|
| Between Groups | 15667.077      | 2  | 7833.539    | 49.266 | 3.05| 0.000 | < 0.05 |
| Within Groups  | 29098.143      | 183| 159.006     |       |     |       |      |
| Total          | 44765.220      | 185|              |       |     |       |      |

Based on Table 5, anova test results with unbalanced cells shows the critical region with \( F \geq F_{0.05;2;183} = 3.05 \) and F₀bs = 49.266 \( \in \) critical region, so H₀ is rejected. The conclusion is that it is not true that the three categories of self-regulated learning have the same effect on students' mathematical connection abilities. This is relevant to previous researches which showed there are statistically significant differences among the self-regulation learning levels in the three categories [11,18].

Table 6 shows the post hoc test after anova because H₀ of test decision was rejected. This research uses the Scheffe method to find out which mathematical connection ability is better, between students with high, medium or low self-regulated learning.

Table 6. Multiple comparisons with scheffe method.

| (I) Self-Regulated Learning | (J) Self-Regulated Learning | Mean Difference (I-J) | F₀bs | Fₐ  | sig.  | p    |
|-----------------------------|-----------------------------|-----------------------|------|-----|-------|------|
| High                        | Medium                      | 15.78296              | 49.309 | 6.10 | 0.000 | < 0.05 |
| Low                         |                             |                       |       |     |       |      |
| Medium                      | High                        | -15.78296             | 122.37 | 6.10 | 0.000 | < 0.05 |
| Low                         |                             |                       |       |     |       |      |
| Low                         | High                        | -24.86408             | 16.323 | 6.10 | 0.000 | < 0.05 |
| Medium                      |                             |                       |       |     |       |      |

Based on Table 6, the results of the mean comparison between students with high self-regulated learning and students with medium self-regulated learning are F₀bs = 49.309. If the critical region is \( F \geq (k-1) \)
1) \( F_{(k-1),N} \) with \( 2F_{0.05;2,183} = 6.10 \in \text{critical region}, \) so Ho is rejected. This means that students with high self-regulated learning are giving significant differences than students with medium self-regulated learning. Due to the mean results for students with medium self-regulated learning is lower than students with high self-regulated learning, the conclusion is that students who have high self-regulated learning have better mathematical connection ability than students with medium self-regulated learning. Likewise, the results of the mean comparison between students with high self-regulated learning and students with low self-regulated learning are \( F_{\text{obs}} = 122.37. \) If the critical region is \( \{F|F > (k-1) \frac{F_{(k-1),N}}{k}\} \) with \( 2F_{0.05;2,183} = 6.10 \in \text{critical region}, \) so Ho is rejected. This means that students with high self-regulated learning are giving significant differences than students with low self-regulated learning. Because of the mean results for students with high self-regulated learning higher than students with low self-regulated learning, the conclusion is that students who have high self-regulated learning have better mathematical connection ability than students with low self-regulated learning. Furthermore, the results of the mean comparison between students with medium self-regulated learning and students with low self-regulated learning are \( F_{\text{obs}} = 16.323. \) If the critical region is \( \{F|F > (k-1) \frac{F_{(k-1),N}}{k}\} \) with \( 2F_{0.05;2,183} = 6.10 \in \text{critical region}, \) so Ho is rejected. This means that students with medium self-regulated learning are giving a significant difference than students with low self-regulated. Because of the mean results for students with medium self-regulated learning are higher than students with low self-regulated learning, the conclusion is that students who have medium self-regulated learning have better mathematical connection ability than students with low self-regulated learning.

This is relevant to previous researches which showed that the better the self-regulated learning, the fewer students make mistakes in solving mathematical connection ability [19]. The most important role to the learning process is self-regulated learning where students no longer depend on the teacher's detailed explanation in each material, but it is hoped that students can create their own learning activities to achieve learning goals [20]. When students have self-regulated learning, such as goal setting, planning learning, analysing tasks, monitoring their learning progress or seeking help from the teacher, they will significantly improve their academic ability [21]. Self-regulated learning needs to be developed in individuals who study mathematics, because of the implications of the mathematical nature in which mathematics learning is directed at developing mathematical thinking ability, one of which is mathematical connection ability [22]. In order to connect to each mathematical problem, students must first remember the problem, while to understand the problem, students must be able to make connections with topics related to the problem so that students’ efforts in finding solutions to mathematical problems are through self-regulated learning activities [23].

4. Conclusion

Based on the results of the research and discussion, it can be concluded that the three categories of self-regulated learning have a different effect on students’ mathematical connection ability. Students with high self-regulated learning have better mathematical connection ability than students with medium and low self-regulated learning. Students with medium self-regulated learning have better mathematical connections ability than students with low self-regulated learning. Thus, high mathematical connection ability is owned by students with high self-regulated learning, because according to the characteristics of students with high self-regulated learning; they tend to be with better preparation when facing learning in the classroom and they look for various relevant sources to support their learning outside the classroom.

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