



## Analysis of Mathematical Problem Solving Skills using Meta-Cognitive Strategy from The Perspective of Gender-Based Self-Efficacy

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### Abstract

This research aims to analyze the effect improved self-efficacy in students' ability to solve mathematical problems from the gender perspective with the implementation of meta-cognitive strategy for the topic of prism and pyramid. It is a mixed method research using the concurrent embedded model. Subjects involved were students of Class VIII (eighth grade) of MTs Asy-Syarifah Mranggen (Islamic Junior High School of Mranggen). It is found in the field that when students have to deal with applied mathematics concerning everyday life problems of significant difficulty level, they are not confident about their own abilities to solve them. Results show that 1) Self-efficacy greatly influences students' ability in solving mathematical problems; 2) At the same level of self-efficacy, boys and girls undergo the same process and get the same results in terms of mathematical problem solving skills; 3) Students have different levels of ability in solving mathematical problems based on self-efficacy; 4) There has been an increase in self-efficacy prior to and after the implementation of met-cognitive strategy for the topic of prism and pyramid.

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## INTRODUCTION

Mathematical learning at school is usually aimed at instilling problem solving skills in students including the ability to understand the problem, designing a mathematical model, solving the model, and interpreting the solution required. This process of problem solving skills is via practicing making decisions and drawing conclusion of problems based on logical, rational, critical, smart, honest, efficient, and effective thinking. It is expected that the processes involved allow students to be able to solve everyday problems, learn many rational sciences, skillful in applying mathematics, and have self-confidence. According to Didi (2005: 2), in order to develop problem solving skills, mathematical thinking practices are not enough. There also needs to be development of self-confidence at the same time, which will allow students to be able to deal with challenges in real life.

Other the cognitive aspect, which is the ability to solve problems, there is also the need for psychological aspect concerning the attitude of students that will help with their learning success. More specifically, in doing tasks that require solving issues that merit diligence and perseverance. Self-efficacy is a psychological aspect significantly affecting students' success in doing tasks and answering questions properly.

According to Ormrod (2008: 20), self-efficacy is a person's judgment of his/her own ability in performing certain acts or achieving something. In relation to problem solving, self-efficacy functions to value students' success in solving problems.

Betz & Hackett (Pajares & Miller, 1994: 194) mentioned that self-efficacy recently values an individual's ability in solving problems in mathematics and doing mathematical assignments. Then, according to Liu & Koirala (2009: 1), students who are confident think that mathematics is important in their lives and that it will help them solve problems in a fun way, while those who are not confident of their abilities in solving mathematical problems have lower self-efficacy.

Therefore, self-efficacy is an important factor that determines a person's achievement in mathematics, especially in solving problems. Hence, problem solving and self-efficacy are positively related. If a student has the necessary skills in solving mathematical problems that that student has good self-efficacy. Betz & Hackett in 1983 (Pajares, 2002: 194) reported that with high self-efficacy, students will be better able to solve mathematical problems given to them, that the academic achievement reflecting the success of learning will also be higher, compared to students of low self-efficacy.

Field observation revealed that when Eight Graders (VIII B class students) of MTs Asy-Syarifah Mranggen (Islamic Junior High School of Mranggen) has to deal with applied mathematics for daily life issues of significant difficulty, most of them they easily give up, while the others try to solve those problems via discussion with their peers or asking for favors from their teacher. These later students usually able to attain KKM. Other than that, internal factors from the students themselves affect their achievement in learning. Things like their reluctance to ask their smarter friends for help and their meticulousness in studying and finishing the tasks given. Moreover, it is often found that the teaching practiced by teachers does not allow students to construct their own mathematical knowledge. This results in lower response and self-efficacy from and among students that they only listen, pay attention, and try to work out problems. What lacks here is interaction among students and between them and the teacher. This condition inhibits the development of problem solving and self-efficacy in students. The immediate result is unvaried approach in solving problems as students tend to only copy what the teacher is teaching them that the learning process is monotonous. This situation prevents students from getting used to making plans, implementing strategies, and exploring their generalization abilities in solving problems. One of the ways in dealing with that issue is implementing an alternative learning strategy such as the meta-cognitive strategy.

Meta-cognitive strategy manifests itself in a student's ability to measure his/her own skills

and control them to allow optimum results of whatever he/she attempts to do. Some research carried out by Flavell (1979) show that meta-cognition consists of meta-cognitive knowledge and experience or meta-cognitive directive. Meta-cognitive knowledge in an interaction among; person variable, strategy variable, and task variable. Some researchers also categorize self-efficacy into components of meta-cognitive knowledge, whereas the experience of using cognitive process is categorized into meta-cognitive experience as it triggers awareness of what an individual is thinking about. Meta-cognitive experience is often called meta-cognitive strategy of planning, monitoring, and evaluation of cognitive processes.

Gurian et al. (2009) states that many research suggest that the brains of boys and men are difference in terms of anatomy, hormone, and function to that of girls and women. A research by variable Das and Wilkinson (2011) shows that there is a difference in attitude toward mathematics between boys and girls and from one ethnicity to the next.

The outline of this research is 1) What is the effect of self-efficacy in students' ability to solve mathematical problems from gender-based perspective with the implementation of meta-cognitive learning? 2) Is there a difference between mathematical problem solving skills based on self-efficacy? 3) Is there any improvement in self-efficacy with the implementation of meta-cognitive learning for the topic of prism and pyramid?

This research's aim is 1) Analyzing the effect of improved self-efficacy in students' ability to solve mathematical problems from the gender perspective with the implementation of meta-cognitive strategy for the topic of prism and pyramid. 2) Figuring out differences in mathematical problem solving skills based on self-efficacy. 3) Finding out improvement in self-efficacy with the implementation of meta-cognitive learning for the topic of prism and pyramid.

## METHOD

This research made use of concurrent embedded (imbalanced mix) method that combines both qualitative and quantitative methods by mixing both in an imbalanced manner. It was carried out at MTs Asy-Syarifah Mranggen (Islamic Junior High School of Mranggen) among Eight Graders (VIII B class students). The procedure involved three stages of pre-field, in-field, and data analysis.

The pre-field stage involved observation of daily mathematical learning, filling out of a questionnaire of self-efficacy sources, Mathematical Problem Solving Skills Test (MPSST) for the introduction of the topic of prism and pyramid surface area and volume, and setting out and validation and also testing of learning instrument for MPSST. The in-field work stage included the mathematical learning of prism and pyramid surface area and volume using the problem-based learning founded on meta-cognitive strategy, final MPSST for the topic of surface area and volume of prism and pyramid, and an interview with six sample students. The data analysis stage covered analyses for both qualitative and quantitative data. Quantitative data analysis was carried out to establish the validity of tools and instrument, categorize students into high, medium, and low self-efficacy, and determine whether there is a difference in mathematical problem solving skills among students based on self-efficacy. Qualitative data analysis, which is the point of this research, was carried out to know and analyze mathematical problem solving skills among students from the perspective of gender-based self-efficacy, during learning, whilst checking out individual test results, after mathematical problems were given, and while analyzing interview results concerning difficulties experienced by students.

## RESULT AND DISCUSSION

Levels of self-efficacy among students were set based on results of questionnaire on sources of self-efficacy. The questionnaire itself was set based on the four sources of self-efficacy

(Ormrod, 2008) that include mastery experiences (direct experience), vicarious experience (experience of others), in this case peers and people around students, social persuasion or specific feedback, and level of arousal while dealing with tasks or psychological index while students are dealing with tasks.

Students were categorized into three different groups of high, medium, and low self-efficacy using the limit of standard deviation. From these three groups, 6 students were taken as samples for further investigation using

observation. Students chosen for the High Self-Efficacy (HS) category were those with codes SS-07 and SS-15, for the Medium Self-Efficacy (MS) category were those with codes SS-39 and SS-42, and for the Low Self-Efficacy (LS) category were those with codes SS-33 and SS-36.

The aspects observed for students' self-efficacy include endurance, reliability/resourcefulness, curiosity, and self-reliance. The followings are details of students' self-efficacy for each category.

**Table 1.** Attainment of Self-Efficacy for Each Category

Category	Endurance	Reliability/ Resourcefulness	Curiosity	Self- Reliance	Average
High Self-Efficacy for Boys (SS-15)	3.960	4.200	4.133	4.150	4.111
High Self-Efficacy for Girls (SS-07)	4.040	3.867	4.333	4.550	4.198
Medium Self- Efficacy for Boys (SS-39)	3.720	3.533	3.933	3.550	3.684
Medium Self- Efficacy for Girls (SS-42)	3.200	3.233	3.333	3.300	3.267
Low Self-Efficacy for Boys (SS-33)	3.000	2.967	3.267	3.000	3.058
Low Self-Efficacy for Girls (SS-36)	2.960	2.800	2.800	2.700	2.815

The SS-15 group has relatively low endurance. Despite their high self-efficacy, the students belong here are still not confident enough to communicate their knowledge to the others. The SS-07 group is strongest in terms of self-reliance. Students belonging here feel more comfortable in stating ideas, asking questions, or making opinions, that when they get response they feel confident about what they are doing. The SS-09 group has courage to explain their ideas or opinions before the class. However, they have low self-reliance as students belonging here tend to be less confident about what they know, despite their eagerness to state ideas and opinions. The SS-42 group has the tendency to confirm their answers first prior to stating them before the class. The SS-33 group is known to have very high curiosity. This group is really

affected by their surroundings. During the second research session, for instance, students observed were challenged by the mathematical problems presented to them that they tried to solve some problems from the Students' Worksheet eagerly. They even asked some questions to the researchers despite the fact that they were not interested in solving those problems during the first session, as they think they are not capable enough in mathematics. However, their spirit seemed to have waned during the third session that they finally got lower scores in reliability/resourcefulness. The SS-36 group feels weak in mathematics that they were not trying that hard in solving mathematical problems. Nonetheless, they seemed to try to improve their self-belief in mathematics marked with significantly improved

endurance. In fact, they scored highest endurance during the final session.

Problems in mathematical methods were used to measure the skills in mathematical problem solving skills (MPSS). These problems cover aspects of understanding problems, designing plans, carrying out plans, and

checking solutions. Once solutions to mathematical problems from the Students' Worksheet or TKPM, the skills of VIII B class students were classified into high, medium, and low. In general, students' classification is given in Table 2.

**Table 2.** Classification of VIII B class students' skills in solving mathematical problems.

Category	Number of Student	Ratio to class (%)	Ratio to MPSS category (%)	Ratio to gender (%)
High MPSS for boys	4	9.52	33.33	20.00
High MPSS for girls	8	19.05	66.67	36.36
Medium MPSS for boys	10	23.81	55.56	50.00
Medium MPSS for girls	8	19.05	44.44	36.36
Low MPSS for boys	6	14.29	50.00	30.00
Low MPSS for girls	6	14.29	50.00	27.27

It can be seen in the table that four boys (9.52%) of all students involved belong to the high MPSS category. Compared to the number of students in high MPSS category (12 students), the percentage of boys is 33.33%, and compared to the number of boys in the class, the percentage is 20.00%. The number of girls in the high MPSS category is more than that of boys (19.05%) of all students. Compared to the number of students in high MPSS category, the percentage of girls is 66.67%, and compared to the number of girls in the class, the percentage is 36.36%.

Ten boys belong to the medium MPSS category (23.81%). Compared to the number of students in medium MPSS category, the percentage of is boys 55.56%, and compared to the number of girls in the class, the percentage is 50.00%. Eight girls belong to the medium MPSS category (19.05%). Compared to the number of students in medium MPSS category, the percentage of girls is 44.44%, and compared to the number of girls in the class, the percentage is 36.36%.

Six boys belong to the low MPSS category (14.29%). Compared to the number of students in low MPSS category, the percentage of is boys 50.00%, and compared to the number of boys in the class, the percentage is 30.00%. Six girls

belong to the low MPSS category (14.29%). Compared to the number of students in low MPSS category, the percentage of girls is 50.00%, and compared to the number of girls in the class, the percentage is 27.27%.

The skills to solve mathematical problems for each student category differs. For the same category, for example, that of high mathematical problem solving skills, both boys and girls undergo almost the same process. There is only little differences and tendencies at certain stages. However, these differences become more evident for different levels of mathematical problem solving skills groups.

The Kruskal-Wallis test resulted in values of sign = 0.000 to sign < 0.05. It can be concluded that there is significant difference in mathematical problem solving skills for groups of high, medium, and low self-efficacy. Hence, self-efficacy is the defining parameter that sets their mathematical problem solving skills apart.

Meta-cognitive learning provides a way for students to come forward with mathematical ideas and to have discussion in groups. Meta-cognitive activities allow interactions among individuals to talk a problem through. Students with adequate self-efficacy will be active in discussions and as questions are asked, students learn new things.

Calculation for improvement of self-efficacy made use of the Gain test. Data from questionnaire and observational data of initial self-efficacy were compared to those of final self-

efficacy. The gain index of initial and final self-efficacy from 6 sample students is given in Table 3.

**Table 3.** Normalized gain index of self-efficacy.

NO	SAMPLE STUDENT	GAIN TEST					AVERAGE
		TASK 1 & 2	TASK 2 & 3	TASK 3 & 4	TASK 4 & 5	TASK 1 & 5	
1	SS-07	0.26	0.18	0.29	0.40	0.74	0.37
2	SS-15	0.33	0.17	0.13	0.38	0.70	0.34
3	SS-39	0.19	0.17	0.16	0.19	0.54	0.25
4	SS-42	0.18	0.13	0.04	0.30	0.51	0.23
5	SS-33	0.29	0.06	0.12	0.14	0.49	0.22
6	SS-36	0.14	0.07	0.18	0.13	0.43	0.19
AVERAGE		0.23	0.13	0.15	0.26	0.57	0.27

The Gain test revealed that the six sample subjects experienced improved self-efficacy after joining the problem-based learning using meta-cognitive strategy. This is in line with the results of a research by Prabawanto (2012) stating that self-efficacy can be improved via students' personality. In this realm, students are taught on how to increase their self-efficacy that they are able to know their true and independent personality. This way, students become complete persons of strong emotion and intellectual abilities. Students know themselves better, are able to consistently control themselves. Students also have empathy and sensitivity toward problems that they and the others are dealing with. That idea is also supported by Gilar (2017) who stated that the use of non-routine problem solving skills in essay problems is believed to add new knowledge and introduces students to ways to think, to be accustomed to being diligent and having high curiosity. It also helps to improve confidence in dealing with unusual situations that will certainly prepare students to deal with many other issues, not only in mathematics.

## CONCLUSION

The differing aspect of self-efficacy among the high, medium, and low self-efficacy groups is self-reliant for the high category group. This aspect represents a person's ability in carrying out tasks

without the help of others. For the medium category group, the dominant aspect is endurance. It relates to a person's ability to try to work out mathematical problems. People with this quality tend to survive difficulties and are actually challenged by them. Meanwhile, the low category group is strongest in the aspect of curiosity, which is a description of a person's willingness to understand new things, including the material a teacher tries to convey. Other than that, it was also found that boys and girls undergo the same process in dealing with mathematical problems, if they are from the same category group. Moreover, students experienced improved self-efficacy after joining the problem-based learning model using meta-cognitive strategy. It has been proven that mathematical problem solving skills differ among groups of different self-efficacy levels.

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