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# STUDENTS'ADAPTIVE REASONING SKILLS IN MATHEMATICAL BASED ON SELF EFFICACY LEVEL: GROUNDED THEORY CODING PARADIGMS

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**Abstract:** Grounded theory coding paradigms is one of the qualitative research techniques that is widely used in today's circles. This study aims to analyze conjectures that correlate students' mathematical adaptive reasoning ability (MARS) and students' level of self efficacy (LSE). This research is a descriptive research with a qualitative approach. The number of respondents used in this study was nine grade VIII students obtained using the purpose sampling technique. The data collection technique was carried out using a test to see the students' MARS and a questionnaire to see the LSE. Based on the analysis of the output of the project map assisted by the N-Vivo 12 pro application, it shows that 1) each conjecture of each level of self-efficacy has seen the achievement of students' MARS, 2) For students' low LSE only achieved two indicators, 3) the LSE of students at the medium level and high level has reached all five indicators than MARS, 4) the LSE of students at the medium level still has one sub-indicator that has not been achieved. Therefore, a stimulus in the form of a model or technique in learning is needed to motivate every student to be able to improve LSE. So that with the increase in LSE, it will also allow students to achieve MARS.

**Keywords:** Mathematics Adaptive Reasoning Skills, Self Efficacy, Grounded Theory, Nvivo Application

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## INTRODUCTION

Adaptive reasoning was first disclosed by the National Research Council (NRC) in 2001 which introduced a reasoning that included induction and deduction capabilities, and was later introduced with the term adaptive reasoning (NCTM, 2020). Adaptive reasoning ability is the ability of students to be able to prove by combining two ways, namely inductive and deductive proof. One form of adaptive reasoning is the ability to justify one's work. Proof is a form of justification, but not all justification is proof. Proof (both formal and informal) must be logically complete, but justification may be more telegraphic, simply showing the source of the reason. Justification and proof are hallmarks of formal mathematics, which are often considered the affairs of older students.

Vol. 2, No. 1, pg. 312 –324
ISSN: 3046-594X

However, as mentioned above, students can begin to learn to justify their mathematical ideas from the earliest grades in elementary school.

NCTM, (2020) stated that adaptive reasoning can be defined as the ability to think logically, the ability to give reasons, explain and the ability to provide solutions to the problems given. Meanwhile, Herman, T. (2007) said that in mathematics, adaptive reasoning is the glue for the integration of various student abilities that are referred to and as a learning guide. A person uses adaptive reasoning to organize various facts, procedures, concepts, and ways and analyze that they are all intertwined in a proper path. Students' mathematical ability is the main goal in mathematics learning (NCTM, 2020). Each student not only understands the concept and then solves the problem, but also the process and thinking skills in solving the problem (Crockett et al., 2011). One of the mathematical abilities referred to by NCTM is reasoning and communication. Especially for reasoning skills, self-control, motivation and self-efficacy are needed. This shows that mathematics adaptive reasoning skills are very, very important for students. Apart from that, with the development of technology and the mathematics learning system which is increasingly leading to technological advancements, students should already have these abilities to be developed and applied in learning and in daily life.

21st century learning focuses on student centers with the aim of providing students with thinking skills including: (1) critical thinking, (2) problem-solving, (3) metacognition, (4) communication, (5) collaboration, (6) innovation and creativity, (7) information literacy [2], (see Figure 1).

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**Figure 1. Students' Thinking Skills in the 21st Century**

Students' thinking skills in the 21st century will be a benchmark for student success in learning as well as teachers' success in teaching. The six skills are interrelated, have different concepts and analyses in their learning. Complicating the process of improving students' thinking skills is the dispute over what content should be taught and how it should be taught (Loveless & Ellis, 2001). Mathematics should be taught primarily by teachers who provide clear and organized explanations of concepts and procedures and then provide opportunities for students to practice those procedures and apply those concepts. Others argue that teachers should devise ways to engage students directly in exploring the meaning of mathematical procedures, rather than

Vol. 2, No. 1, pg. 312 –324
ISSN: 3046-594X

simply showing them how to implement them. However, there are also those who want their students to memorize procedures and develop skills so that understanding can be obtained from these activities (Ball & Chair, 2003).

Referring to figure 1, it shows that one of the thinking skills of students in the 21st century is critical thinking and problem-solving. To develop these skills, MARS students are needed. Student reasoning can be known by giving a problem to students to solve. The problem given must be the type of problem that can provide students with the opportunity to freely use their reasoning skills (Aziz et al., 2013). One type of problem that can be given is open-ended problems, with the relationship between students' problem-solving skills and reasoning skills, so that to establish problem-solving skills requires habits in practicing high reasoning (Rustana & Sumantri, 2019). Mathematics is indeed a difficult subject, solving math problems requires skills, competencies, and abilities in a person (Heryani et al., 2022).

Providing motivation to students will also increase the self-efficacy of the students themselves both in learning, solving problems and in decision-making. says that a person with high self-efficacy believes that they are capable of doing something to change the events around them, while a person with low self-efficacy thinks that they are basically incapable of doing everything around them. In addition, people who have low efficacy mean people who consider themselves helpless, unhappy and unmotivated to act (Flammer, 2015),(Bandura, 1982). Thus, in understanding and solving mathematical problems, self-efficacy and motivation to learn are needed. With self-efficacy, being able to optimize a person in decision-making and make conclusions from the results of one's work (analysis and problem solving).

In fact, there are still many research results that show that students' adaptive reasoning skills are still low. One of the reasons why this happens is because improving students' mathematical adaptive reasoning skills is not as easy as improving other mathematical skills. Mathematical adaptive reasoning skills are not only able to solve problems, but also relate to various other mathematical studies and the ability to think at a higher level. In solving mathematical problems, students do not just solve with the procedure of entering formulas and making substitutions for the specified values. Rather, reasoning skills are needed in solving them, namely students think logically about the relationship between concepts and procedures for solving the problem. This is used so that the results of solving the problem are valid and proven inductively (Kusuma et al., 2020).

Nurfajriyanti & Pradipta, (2021) stated that the factor that can influence students' mathematical ability is the level of student confidence. With high confidence in compiling conjectures and making decisions on the results of solving mathematical problems, it will improve the adaptive reasoning ability of the students themselves. Moreover Bandura, (1994) said that students who doubt their abilities, and avoid difficult tasks that they perceive as a personal threat, have low aspirations, weak commitment and think more about the obstacles they will face than concentrate on how to do it successfully. This will obviously affect the level of self-efficacy of students and the low ability of mathematical adaptive reasoning, because in the ability of mathematical adaptive reasoning, there is a high self-efficacy to adapt from the mathematical proof itself.

This study focuses more on students' mathematical adaptive reasoning skills (MARS) and is analyzed based on the level of self efficacy (LSE). Based on several

Vol. 2, No. 1, pg. 312 –324
ISSN: 3046-594X

problems and the results of previous research, the researcher is interested in conducting a different research from previous researches, namely analyzing students' mathematical adaptive reasoning ability reviewed from the level of self-efficacy carried out on grade VIII students of SMP Negeri 6 Garut.

Based on the background of the problem, we set the goal of this study to describe the achievement of MARS students based on the level of self-efficacy and the difference in the achievement. Furthermore, the research questions from this study are 1) what are the conjectures of students' MARS achievement based on LSE?, 2) how are the differences in students' MARS achievement based on LSE?. Based on the above explanation, we want to conduct qualitative research related to MARS students reviewed from the level of self-efficacy.

The importance of adaptive reasoning skill for reasoning, reflection, explanation and reasoning (Kilpatrick et al., 2001). If students have low mathematical thinking skills, then students can only get information from the teacher's explanations and examples (Agustin et al., 2023). In mathematics, adaptive reasoning is the glue that integrates the various abilities of students who are referred to and as a learning guide (Herman, 2007). One uses adaptive reasoning to organize various facts, procedures, concepts, and ways and analyze that they are all intertwined in a proper path. NCTM (Susilawati et al., 2021) Putting forward standards for mathematical adaptive reasoning is achieved by: (1) Directing mathematical problems; (2) Building students' experience and knowledge; (3) Develop convincing mathematical thinking skills about the validation of certain representations, make guesses, solve problems or assume answers from students; (4) Involving students' intellectuals consisting of directing questions and tasks involving students that are challenging; (5) Developing students' mathematical knowledge and skills; (6) Stimulate students to make decisions, connections and to develop a coherent framework for mathematical ideas; (7) Useful for problem formulation, problem solving, and mathematical reasoning; (8) Encourage the development of all students' abilities in doing mathematical work. The eight bases for achieving mathematical adaptive reasoning according to NCTM are the indicators of achieving mathematical adaptive reasoning ability, Muin et al, (Susilawati et al., 2021) namely: (1) Directing the conjecture; (2) Providing reasons for the answer; (3) Summarizing statements; (4) Checking the validity of an argument; (5) Finding patterns in mathematical problems (Kilpatrick et al., 2001).

Self efficacy is also one of the attitudes that must be possessed by students because with confidence students can be more active in learning activities and students can be confident in their abilities so that students can achieve learning goals well (Pangestu & Sutirna, 2021). The concept of self-efficacy felt by each student is able to regulate their own learning activities by influencing their motivation, achievement and learning outcomes (Mozahem et al., 2021a). Thus, it can be concluded that attention to the level of students' self-efficacy is very important, especially in students' mathematical adaptive reasoning skills. With high self-efficacy, students will be more convinced in solving mathematical problems using adaptive reasoning.

Some of the factors that effect self efficacy according to Bandura, (1997), namely mastery experience, vicarious experience, verbal persuation, and physiological state, these four factors are the basis that determines the development of the level of self-efficacy ability of students in learning. So that the high or low self-efficacy ability of a person depends on how the condition of these four factors interacts in their daily life. In

Vol. 2, No. 1, pg. 312 –324
ISSN: 3046-594X

addition to these four factors, Bandura divides self-efficacy into three dimensions, namely (a) magnitude, namely how students can overcome their learning difficulties; (b) strength, namely how high the student's confidence in overcoming learning difficulties; and (c) generality, which indicates the breadth and level of achievement of successfully completing the task (Bandura, 1997). From the three dimension of self efficacy, self efficacy indicators are describe (Bandura, 1997) which are as follows:

1. Indicators of self-efficacy in the magnitude dimension include: a) Having a great interest in lessons and tasks, and being optimistic in doing them; b) Developing abilities and achievements; c) Seeing difficult tasks as a challenge; and d) Act selectively in achieving its goals.
2. Self-efficacy indicators in the strength dimension include: a) The efforts made can improve performance well; b) Committed and persistent in completing the tasks given; c) Believe and know the advantages they have; d) Have a positive goal in doing various things; and e) Have a good motivation towards himself for his or her own development.
3. Indicators of self-efficacy in the generality dimension include: a) Likes to seek and try new challenges and overcome those challenges effectively; b) Responding well to new challenges; and c) Making experience a path to success.

To assess the level of self-efficacy, an instrument is needed using a Likert scale. The instrument will be analyzed based on modifications to the level of self-efficacy ability of students from the research (Sadewi et al., 2012). The following table 1 is a modification of the level of students' self-efficacy ability to mathematical ability:

**Table 1: The Level of Students' Self Efficacy Ability to Mathematical Ability**

| Interval | Criterion |
|---|---|
| 66 – 100 | High |
| 51 – 65 | Medium |
| 14 – 50 | Low |

## METHOD

This research is a qualitative research case study design with a grounded theory perspective. The researcher analyzed conjectures related to the achievement of students' mathematical adaptive reasoning skills based on the level of self-efficacy. This research was carried out in grade VIII of SMP Negeri 6 Garut for theorema phytagoras and trigonometry material. The data analyzed in this study are in the form of test results and questionnaires. By using the paradigm of open coding category, axial coding, and theoretical coding, conjectures that associate MARS with LSE are obtained.

First, we compiled a questionnaire instrument adopted from Mozahem et al., (2021) to obtain data and information on the level of self-efficacy and test instruments adopted from Suparman et al., (2021) used to obtain data on students' mathematical adaptive reasoning abilities (see Table 2 and Table 3). These instruments have been developed and have a consistency or reliability value measured using Cronbach apha. The reliability test for the test instrument showed an Alpha Cronbach coefficient of 0.66. These findings

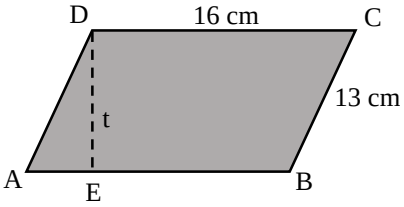
show that the test is reliable and feasible to be used as an instrument to measure mathematical adaptive reasoning ability in this study (Shelby, 2011; Suparman et al., 2021; Vaske et al., 2017). As for the questionnaire instrument, it shows a Cronbach alpha coefficient of 0.86 (Mozahem et al., 2021b; Usher & Pajares, 2009), These findings show that the questionnaire is reliable and feasible to be used as an instrument to measure students' LSE.

**Table 2: Research Questionnaire Instrument Grid**

| No | Dimensi of LSE | | Indicators of LSE | Questionnaire Items | | Number of Items |
|---|---|---|---|---|---|---|
| | | | | Positive | Negative | |
| 1 | *Magnitude* | 1 | There is a great interest in the task and optimism in working on it | 1; 20 | | |
| | | 2 | There is the development of abilities and achievements | 2; 5 | | |
| | | 3 | Seeing difficult tasks as a challenge | 7 | 3 | |
| | | 4 | There is selective action in achieving goals | 1; 8 | | |
| 2 | *Strength* (Levels of strength and confidence) | 1 | The existence of the effort carried out can increase good achievements | 9; 11; 12; 15; | | |
| | | 2 | There is commitment and persistence | 16; 21 | | |
| | | 3 | There is confidence in understanding one's own superiority | 6; 10 | 14 | |
| | | 4 | Positive goals | 17; 20; | 13; 22 | |
| | | 5 | Have good motivation towards yourself | 21 | | |
| 3 | *Generality* (Increase in breadth and achievement of objectives) | 1 | The desire to find and try new challenges and overcome these challenges effectively | 16; 23 | | |
| | | 2 | There is a good disclosure of new challenges | 24; 25 | 4; 18 | |
| | | 3 | Making experience a path to success | | | |

Second, we determined nine research participants who were selected using the purposive sampling technique because of the ease of access to place and time in communicating this research to participants. Then we distributed the research instruments to the nine participants. The distribution of this instrument was carried out for two days. On the first day, we gave a questionnaire instrument to the participants and were given 30 minutes to fill out the questionnaire. Then on the second day, we gave test instruments to the same nine participants and were given 120 minutes to do the test.

**Tabel 3: Kisi-kisi dan Soal Tes Instrumen MARS**

| Item | Problems | Indicators of MARS |
|---|---|---|
| 1 | A triangle with the dimensions of the sides is 3 cm, 4 cm, and 5 cm respectively. Is the triangle a right triangle? Give a reason! | Compile conjectures |
| 2 | Pay attention to the following parallelogram image   What is the Area of BCDE above if the parallelogram height is 10 cm? | Providing reasons or evidence regarding the answers given<br>Finding patterns in a mathematical phenomenon |
| 3 | A freight forwarder must complete the task of delivering goods at two destination points on the same day. If from the warehouse where the goods are stored (let's say point A) delivers the first goods for 8 KM to Point B (east) then from point B delivers the second goods to point C (northbound) for 5 KM. If the courier wants to return to the storage warehouse (Point A) the goods pass the shortest distance or pass through point B (ignore the time), where is the shortest route that the courier will take? Draw a sketch of the courier's path and determine what the shortest distance will be. | Draw conclusions from a statement<br>Checking the validity of an argument |

Third, we analyzed the research data using the *grounded* theory coding paradigm, which describes the conjectures from the coding results of each indicator with the help of the N-Vivo 12 pro application. The coding system in this analysis is carried out with three techniques, namely *open coding category, axial coding*, *selective coding* and *theoretical coding*.

## RESULT AND DISCUSSION

After we obtained the data from the questionnaire and test results, then the analysis of the data was carried out step by step. First, we analyzed the self-efficacy questionnaire, which calculated the average score of the questionnaire based on a predetermined likert scale (see Table 4), then determined the average score of each participant to obtain information from the grouping of the self-efficacy level of each participant. Based on the results of the analysis, information was obtained that there were three people who had low TSE, three people who were medium and three people who were high.

**Table 4: Recapitulation of Questionnaire Results for Students' LSE**

| Respond | Score of Self Efficacy | Criterion |
|---|---|---|
| S1 | 75.2 | High |
| S2 | 80 | High |
| S3 | 81.6 | High |
| S4 | 55.2 | Medium |
| S5 | 59.2 | Medium |
| S7 | 61.6 | Medium |
| S8 | 42.4 | Low |
| S9 | 44 | Low |
| S10 | 47.2 | Low |

Second, we analyzed the MARS test by coding grounded theory on the answer sheets of each participant with the help of N-Vivo 12 pro. MARS analysis was carried out on each answer sheet of students who had worked on the MARS test questions, which can be seen in Figure 2. We input the student's answer sheet into the N-Vivo application targeting students' TSE and then code the results of the student's answer.

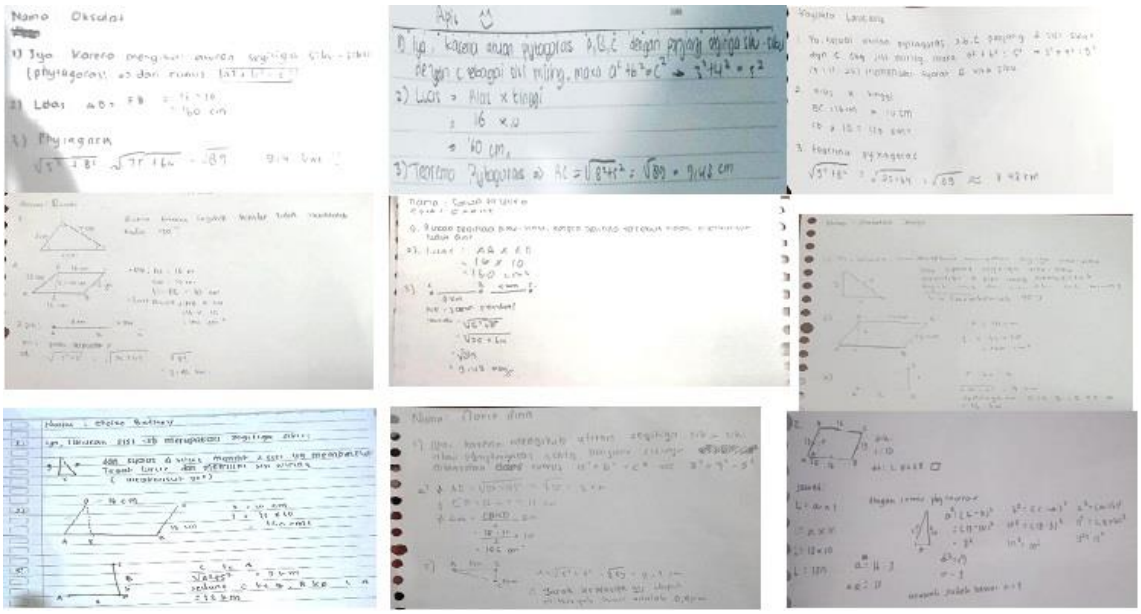


**Figure 2. Test Results of MARS students for each Students' LSE**

The coding technique of gounded theory in the student test results was carried out by open coding category, axial coding, and theoretical coding. First it is done for students who have a low level of self-efficacy, then the medium and finally high ones. In Figure

3, it shows that the coding results are presented in the form of a project map that shows the conjectures of students' MARS achievement in either TSE is low, medium or high.

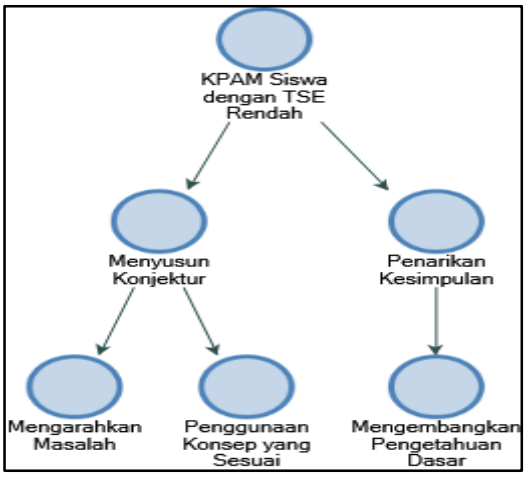



**Figure 3. Projec Map Coding Test of MARS students for students with low LSE**

Students with low levels of self-efficacy have been able to achieve two MARS indicators that are confident in compiling conjectures and drawing conclusions as well as sub-indicators of each of these indicators, namely directing problems, using appropriate concepts and developing basic knowledge. In addition, there are still several indicators and sub-indicators that have not been achieved, namely providing reasons and evidence, determining patterns and checking the validity. However, the conjecture of students' MARS achievement for low self-efficacy levels has shown its representation in solving mathematical problems (see Figure 4).

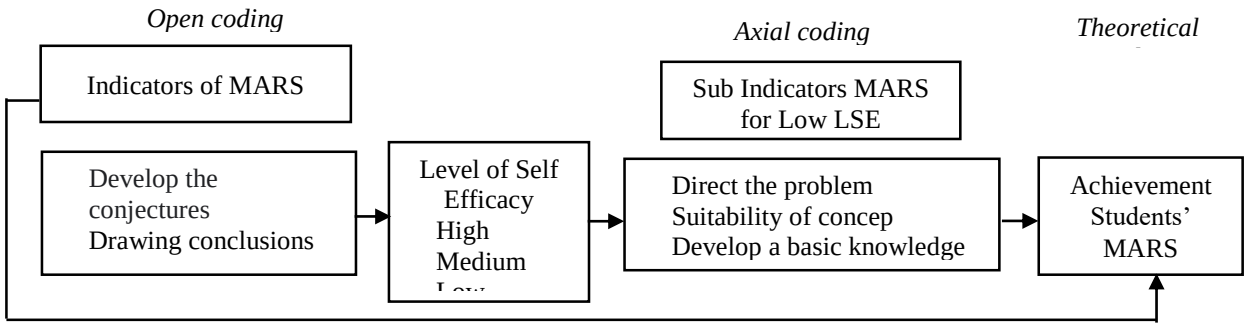



**Figure 4. Conjecture of MARS Achievement of students with Lows' LSE**

Students at a low level of self-efficacy certainly have various obstacles in solving mathematical problems, especially with MARS questions that require a high level of confidence. So that every student can develop thinking skills, make decisions (Susilawati et al., 2021), and responsibility for the problems resolved. Furthermore, for the results of the coding analysis of the results of the MARS test of students who have a level of self-efficacy, it is being presented in the form of an N-Vivo output project map (See Figure 5). The output of N-Vivo in the form of a project map from the coding of grounded theory

shows that the conjecture of students' MARS achievement at the level of moderate self-efficacy has reached the five indicators of MARS (Figure 6). Although the five indicators of MARS have been achieved for students with a moderate level of self-efficacy, there is one indicator where the sub-indicator has not been achieved optimally, namely the indicator of checking the validity of the data. In this indicator, students have been able to develop arguments but have not reached the re-examination stage. If we juxtapose it with the results of a questionnaire from students at a low level of self-efficacy, this shows that the dimension of students' self-efficacy for strength is still low.

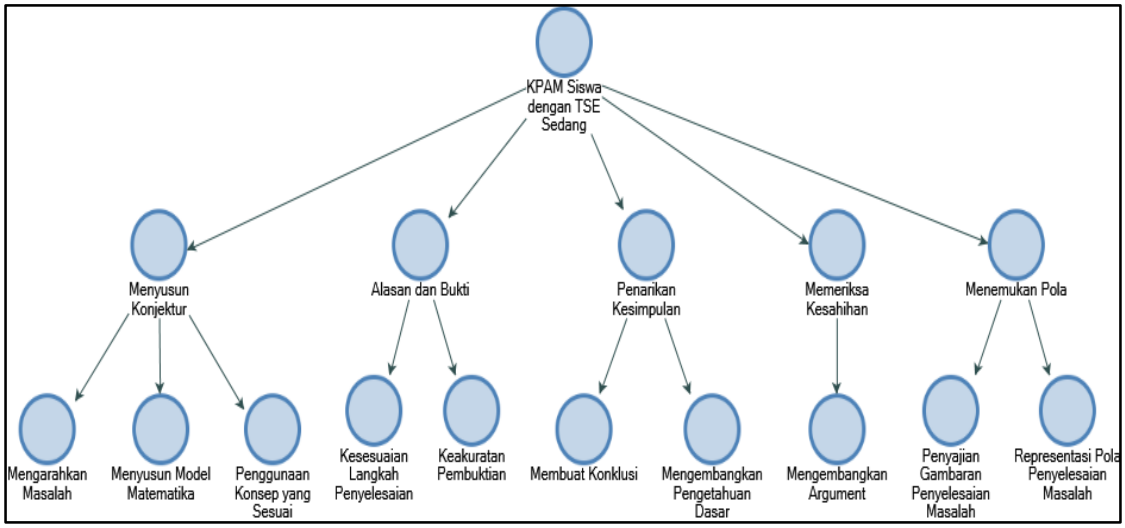



**Figure 5. Test Coding Map Project of MARS students with Moderate LSE**

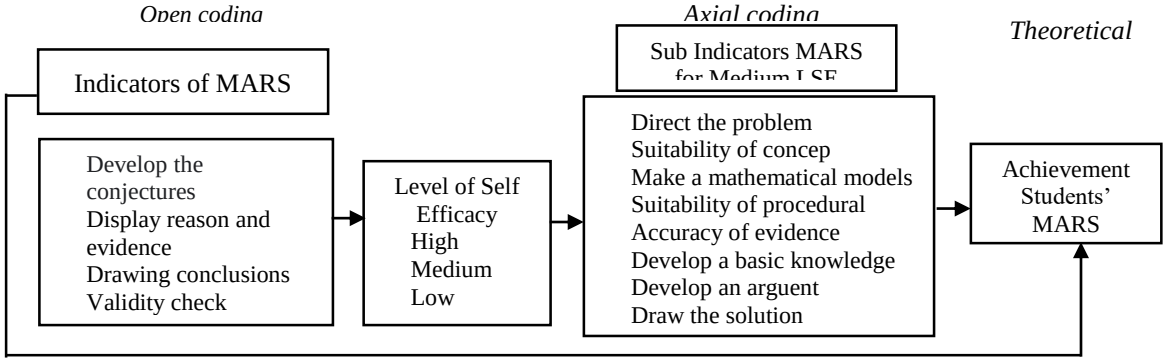



**Figure 6. Conjecture of MARS Achievement of students with Moderate LSE**

Furthermore, for the analysis of the coding of the results of the test of MARS students who have a high level of self-efficacy presented in the form of an N-Vivo output project map, the output can be seen in Figure 7 in the form of a project map, showing that the conjecture of students' MARS achievement at the medium level of self-efficacy has reached the five indicators of MARS and each of its sub-indicators. This shows that the conjecture on students' MARS achievement is fully fulfilled (See Figure 8).

Vol. 2, No. 1, pg. 312 –324
ISSN: 3046-594X

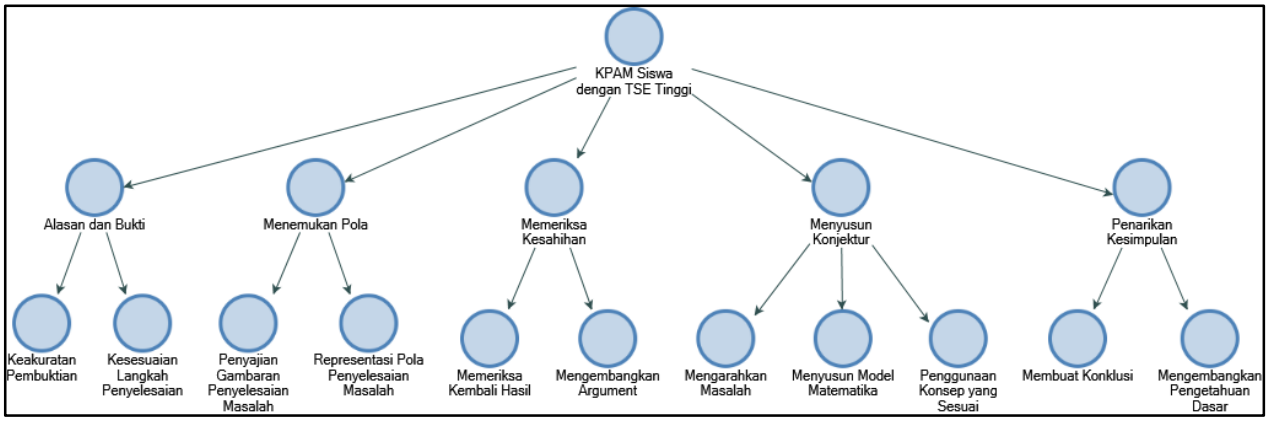



**Figure 7. Test Coding Map Projec of MARS students with High LSE**

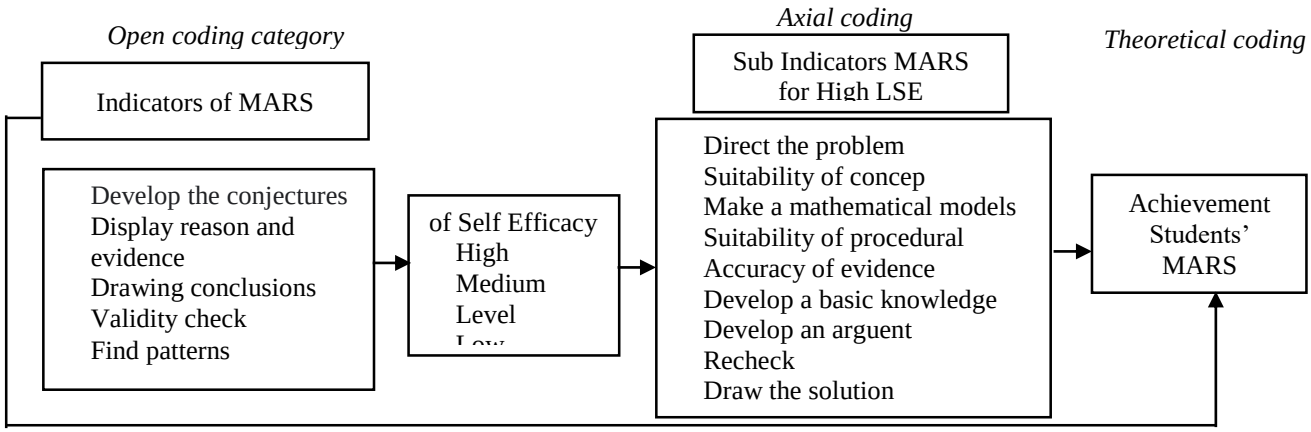



**Figure 8. Conjecture of MARS Achievement of students with High LSE**

Third, we describe the findings of this study based on the coding results of the three levels of student self-efficacy. Based on the findings from data analysis, the achievement of MARS indicators from each LSE is different both in terms of indicators and MARS sub-indicators. Therefore, the role of teachers is needed in motivating and improving students' LSE through learning in the classroom and outside the classroom (in the form of appeals to parents).

## CONCLUSION

This study concluded that students who had low LSE were not able to achieve all five MARS indicators despite trying their best to do MARS questions. From the results of the analysis of each student's answer sheet, it can be seen that the low learning experience and high hesitation in solving math problems related to MARS can be seen. As for medium LSE and High LSE, they almost have similarities in the achievement of MARS, although there is a slight shortcoming from students' TSE, namely in one of the sub-indicators that has not been achieved.

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