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Description of Mathematical Creative Thinking Ability of High School Students viewed from Metacognition Skills

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Abstract: Mathematical creative thinking ability is one of the skills that must be mastered in the 21st century. This study aims to describe the mathematical creative thinking ability of high school students in terms of metacognitive skills. The subjects used were students of class XI MIPA 5 SMA Negeri 3 Purwokerto. The sampling technique used is purposive sampling. The data were obtained from the results of the metacognition skill questionnaire, creative thinking ability test and interviews. Questionnaire data was used to classify students into categories of high, medium and low metacognitive skills. Test and interview data are used to describe mathematical creative thinking skills. The results showed that, students who have high metacognitive skills are able to master all indicators of creative thinking skills: 1) fluency; 2) flexibility; 3) originality; 4) elaboration. Then students with moderate metacognitive skills are able to master 3 indicators of creative thinking skills: 1) fluency; 2) originality; 3) elaboration. Meanwhile, students with low metacognition skills are only able to fulfil 2 indicators, namely originality and elaboration.

Keywords: Mathematical creative thinking ability, metacognition skills, high school students.

Abstrak: *Kemampuan berpikir kreatif matematis merupakan salah satu keterampilan yang harus dikuasai di abad 21. Penelitian ini bertujuan untuk mendeskripsikan kemampuan berpikir kreatif matematis siswa SMA ditinjau dari keterampilan metakognitif. Subyek yang digunakan adalah siswa kelas XI MIPA 5 SMA Negeri 3 Purwokerto. Teknik pengambilan sampel yang digunakan adalah purposive sampling. Data diperoleh dari hasil angket keterampilan metakognisi, tes kemampuan berpikir kreatif dan wawancara. Data angket digunakan untuk mengelompokkan siswa ke dalam kategori keterampilan metakognitif tinggi, sedang dan rendah. Data tes dan wawancara digunakan untuk mendeskripsikan kemampuan berpikir kreatif matematis. Hasil penelitian menunjukkan bahwa, siswa yang memiliki keterampilan metakognitif tinggi mampu menguasai semua indikator keterampilan berpikir kreatif: 1) kelancaran; 2) fleksibilitas; 3) orisinalitas; 4) elaborasi. Kemudian siswa dengan keterampilan metakognitif sedang mampu menguasai 3 indikator keterampilan berpikir kreatif: 1) kefasihan; 2) orisinalitas; 3) elaborasi. Sedangkan siswa dengan kemampuan metakognisi rendah hanya mampu memenuhi 2 indikator yaitu originality dan elaboration.*

Kata kunci: *kemampuan berpikir kreatif matematis, keterampilan metakognitif, siswa SMA.*

▪ INTRODUCTION

One of the skills that must be mastered by students in the 21st century according to Nahdi (2019) is creative thinking (Creative Thinking Skill). Students are encouraged to come up with new ideas for others, to be transparent to change, able to convey ideas and criticisms and able to openly implement different new ideas. Sabbagh (2016) also adds that one of the special skills that must be possessed in the 21st century is creativity as a universal. Sabbagh (2016) defines creativity as a new idea that emerges imaginatively which includes a new discovery or a different solution to a problem. Tatag (2018) argues the same thing, namely creative thinking in mathematics refers to

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the notion of creative thinking in general, namely creative thinking is seen as a unit or combination of logical thinking and divergent thinking to produce something new. By thinking creatively students are also able to find solutions to problems by thinking divergently, logically and generating many ideas (Siswono, 2010). However, the reality in the field is that the ability to think creatively in mathematics is still low, as evidenced by the results of PISA several years ago that the results were not satisfactory. With a score of 375 in 2012 the ability to think creatively increased to 386 in 2015. However, when compared to the overall average, the level of achievement is still below the average, which is around 490 (Rasnawati et al., 2019). Fitriarosah (2016) added that until now, the facts show that students' mathematical creative thinking skills have not developed well in all fields.

This is in line with one of the skills that students must develop, which is related to awareness and monitoring of students' thinking and work results or more specifically related to the mental processes involved in learning, such as making study plans, using appropriate skills and strategies to solve problems or solve problems. we usually know metacognition according to Coutinho, SA (in Danial, 2010). Metacognition skills were first put forward around 1976 when John Flavel was still a student at Stanford University and defined that metacognition skills are a person's monitoring and control of learning activities or when solving a mathematical problem (Chairani, 2016). In this case, students can understand how to learn according to themselves so that they are able to know and understand the material well.

In this case the cognitive process in each individual will certainly be different, the characteristics that can be observed include those expressed by Chairani (2016), namely (1) slow cognitive information processing, (2) difficulty concentrating on task-related problems, (3) lack of functional working memory (4) lack of control over cognitive processes, (5) lack of knowledge base to use in new learning. From some of these things, controlling (monitoring) one's cognitive process is part of the metacognitive process. Ormrod (in Chairani, 2016) reveals that the more students understand their thinking and learning processes, the better their cognitive processes will be, so that it affects the achievements that can be achieved. By having metacognitive skills students can distinguish information that has just been obtained with information that has been studied previously, this is one of the effective ways students can understand and process new information. This is also evidenced by several researchers who are qualified in discussing metacognition, namely Garner and Alexander; Pressley and Ghatala (in Schraw, G. & Dennison, 1994) show that students with high metacognitive skills have better strategies and learning outcomes than students with low metacognitive skills.

▪ METHOD

This study uses a descriptive qualitative research method called descriptive qualitative research, which in this study provides an explanation and description of the condition of natural objects or based on existing facts. This study will also provide an explanation and description of the mathematical creative thinking ability of class XI students of SMA Negeri 3 Purwokerto in terms of metacognition skills. This study involved 32 students consisting of 12 male students and 20 female students. The subjects in this study were taken using a purposive sampling technique which is a method of sampling data sources with certain considerations. The subjects selected in

this study were students of class XI MIPA 5. The researcher took 2 students from skill competencies who had high metacognitive skills, moderate metacognitive skills and low metacognitive skills. This study will describe how students' creative thinking abilities are.

The research procedure was carried out in three stages, namely: the preparation stage, the implementation stage, and the final stage within a period of 5 months. The initial stage is carrying out observations, determining research subjects, filling out metacognition skills questionnaires, creative thinking skills tests, data validation tests, and finally drawing conclusions. In this study, the data collection techniques used were written tests, questionnaires, interviews and documentation. The questionnaire used to obtain metacognitive data in this research is an open questionnaire and refers to the metacognition Awareness Inventory (MAI) developed by Schraw & Dennison (1994), consisting of 43 question items covering aspects of metacognitive knowledge (metacognitive knowledge) with sub-aspects declarative knowledge, procedural knowledge and conditional knowledge and aspects of metacognitive regulation (metacognitive regulation) consisting of planning, monitoring and evaluation sub-aspects. Etymologically, metacognitive ability is expressed in English as a combination of two words: meta and cognition (cognition). Meta is the prefix of cognition, which means “after” cognition. Dunlosky & Metcalfe (Shahbari et al., 2014) explain that cognition is a mental process that actualizes itself in problem solving, memory and understanding knowledge. Metacognition also refers to "thinking about thinking" or self-awareness about one's inner cognitive abilities, about how a person knows knowledge, abilities or skills and organizes and uses his cognitive abilities (Mahdavi, 2014). Likewise Fisher (1998) states that the concept of metacognition is a turning point in a person's understanding of his thinking.

While the form of the test in this study is in the form of a description that aims to measure students' mathematical creative thinking abilities. The material measured in the test is a polynomial which consists of 3 questions. Sabandar (2009) argues that the ability to think creatively is actually a thinking ability that starts from a person's sensitivity to the situation at hand, such as an identified problem that must be solved. Munandar (2014) creative is a person's ability to combine information and come up with ideas or solutions that reflect fluency, flexibility, and originality in thinking and in seeing or thinking about unusual things. McGregor (2007) argues that creative thinking ability is a thinking process in the realm of gaining new insights, new approaches, new perspectives or new understandings. The ability to create new innovations to solve problems is called the ability to think creatively (Noer, 2019). Mrayyan (2012) revealed that creativity in mathematics is a mental activity which is shown to form a new mathematical relationship that has not been previously known by students. This relationship reflects verbal fluency, flexibility, originality, and the ability of explanations. Ayele (2016) has the characteristics of mathematical creativity in the realm of problem finding, invention, independence and originality and is related to the concepts of fluency, flexibility, and originality. Furthermore, Silver (1997) explains that there are three dimensions related to creativity, namely according to the TTCT (Torrance Tests of Creative Thinking) fluency, flexibility and novelty. Fluency refers to the number of ideas generated in response to a command. You can see the flexibility in changing approaches when responding to commands. And novelty refers to the originality of an idea created in response to it. In addition, Torrance Rachman (2018)

also argues about indicators of creative thinking, namely fluency, flexibility, originality, and elaboration. Furthermore, Siswono (2018) argues about the indicators of creativity in mathematics, namely fluency, flexibility and novelty (novelty). From several indicators of creative thinking ability above, this study uses indicators offluency, flexibility, originality, and elaboration.

This research also uses the interview method, to obtain direct and detailed data about the completeness of the responses from the test method. Interviews in the research focused on students' mathematical creative thinking, the actions they took to solve the given problems and the difficulties they faced in solving these problems. Documentation was carried out during the study as a support for the research. The documentation used includes the results of the mathematical creative thinking ability test answers and the results of the questionnaire.

Data analysis in this study was carried out when the data had been collected. The analysis used in this study is an analytical technique of the Miles and Huberman model. The stages in analyzing the data include: data reduction, data presentation and drawing conclusions. This study uses a validity test or data validity test using triangulation with the aim of testing the suitability of the data. Triangulation in this study is using a triangulation test technique. According to Sugiyono (2018), technical triangulation is a method of data validation for the same subject, but with different techniques. Technical triangulation is done by checking data from the same source, namely to 6 selected students, but using different techniques, namely written tests and Interview. If the data on the results of the written test and the interview are interrelated, then the results are considered valid. Then to discuss the data by analyzing the results of the written test and the results of the interviews conducted.

▪ RESULT AND DISSCUSSION

The results of the metacognition skill questionnaire with the lowest score of 21 and the highest score of 40. Calculations were carried out using descriptive statistics with the help of Microfosft Excel 2016 the mean or average value (M) was 31 and the Standard Deviation (SD) value was 5. The results obtained obtained students are categorized into 3 groups. There are 7 students (12%) in the low category. Then there are 21 students (66%) in the medium category. Furthermore, there are 4 students (12%) are in the high category. It can be concluded that students' metacognition skills are dominated by the moderate category.

The creative thinking ability test consists of 5 questions that contain indicators of mathematical creative thinking skills which include: 1) fluency; 2) flexibility; 3) originality; 4) elaboration.indicator fluency found in questions no. 1a and 2a, the flexibility found in questions no. 1b and 2b, the originality indicator is elaboration contained in all questions, namely 1a, 1b, 2a, 2b, 3. In this section, a description of the test results is carried out according to the indicators. The description is also adjusted to the results of the interview in order to test the suitability of the data. The description of students' test results and interviews regarding mathematical creative thinking skills is as follows:

1. Indicators Fluency and Elaboration

a. ***Question number 1a***

1) High Metacognitive Skills (SKMT) Students

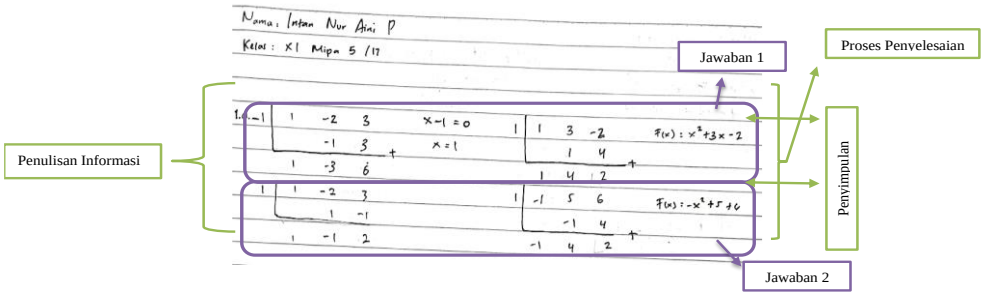


Figure 1. SKMT's answer to question number 1a

Figure 1 shows the KMT subject on the fluency, which is able to give 2 different answers and both are correct. In answering question no. 1a students are able to write 2 polynomials of degree 2 using the Horner method. KTM subjects on the elaboration are able to provide detailed answers. This is evidenced by students being able to write down things that are known in the problem and write conclusions from the results obtained.

2) Intermediate Student Metacognition Skills (SKMS)

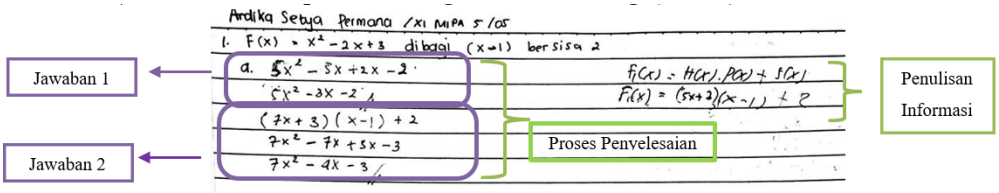


Figure 2 SKMS answers to question number 1a

Looking at Figure 2 above on the fluency KMS subjects were able to answer the question with 2 different answers but there was an error in the final solution. KMS subjects on the elaboration students were able to provide detailed answers but lacked detail. This is evidenced by the fact that students have not been able to write down the information in the questions as a whole, and do not include conclusions from the results obtained.

3) Students with Low Metacognition Skills (SKMR)

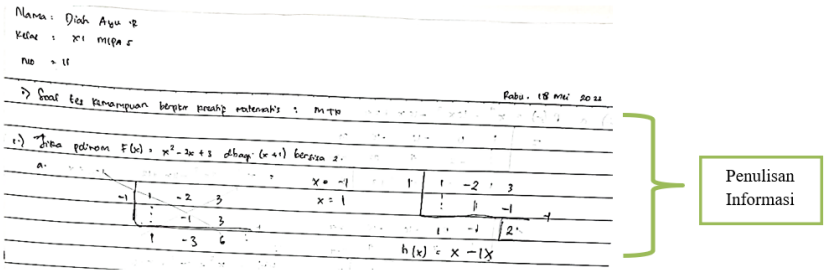


Figure 3 SKMR answers to question number 1a

SKMR1 on the fluency students have not been able to answer correctly. Students only rewrite the known polynomials in the problem. While the elaboration does not write down problem solving, but students write down what is known in the problem.

b. Question number 2a

1) Students with High Metacognition Skills (SKMT)

KMT subjects in Figure 4 show that they are able to meet the fluency indicator, namely being able to answer questions with 2 different answers and both are correct.indicator, elaboration KMT subjects are able to write detailed answers. In addition, students are able to write things that are known but students have not written conclusions from the results obtained.

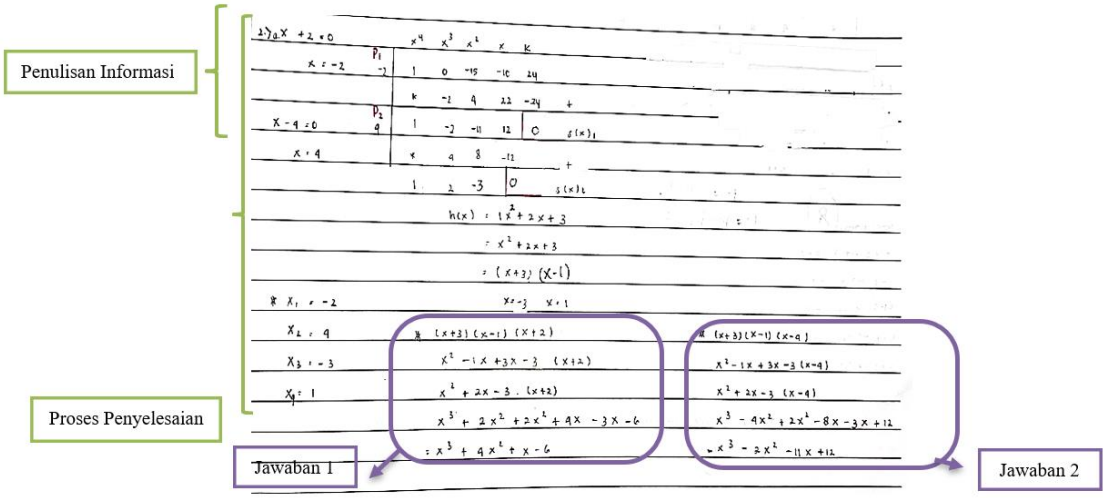


Figure 4 SKMT Answers to Question Number 2a

2) Intermediate Student Metacognition Skills (SKMS)

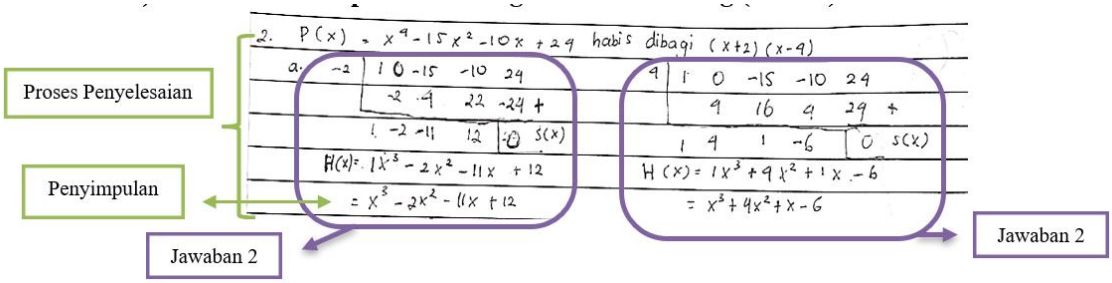


Figure 5 Answers to SKMS1 Question Number 2az

Looking at Figure 4.10 shows the KMS subject on the fluency able to answer questions with 2 different answers and the value is correct. It is proven that students are able to write 2 different polynomials using polynomial roots x= -2 and x=4 in a horner way. On the elaboration KMS subjects are able to write detailed answers. Students only write conclusions from the results obtained, not accompanied by a description of the results obtained.

3) Students with Low Metacognition Skills (SKMR)

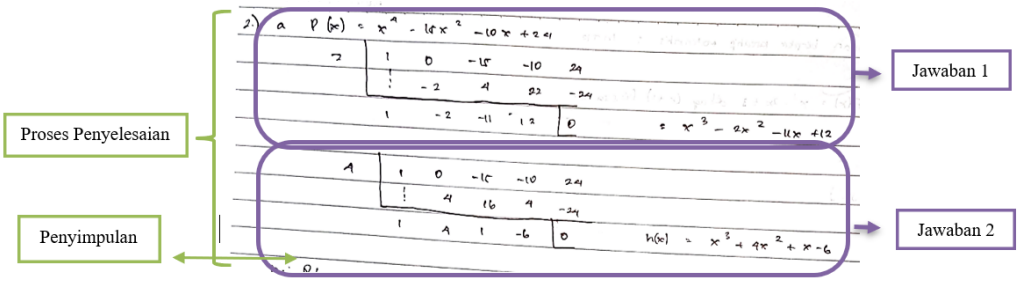


Figure 6 Answers to SKMR Question Number 2a

Looking at Figure 6 above the *fluency* KMR subject is able to answer the question with 2 different answers and the value is correct. The subject of KMR on the *elaboration* students are able to write conclusions from the results obtained, but students do not write down information from the questions, this is reinforced by students writing detailed answers.

1. Indicators Flexibility and Elaboration

a. Question number 1b

1) High Metacognition Skills (SKMT1) Students

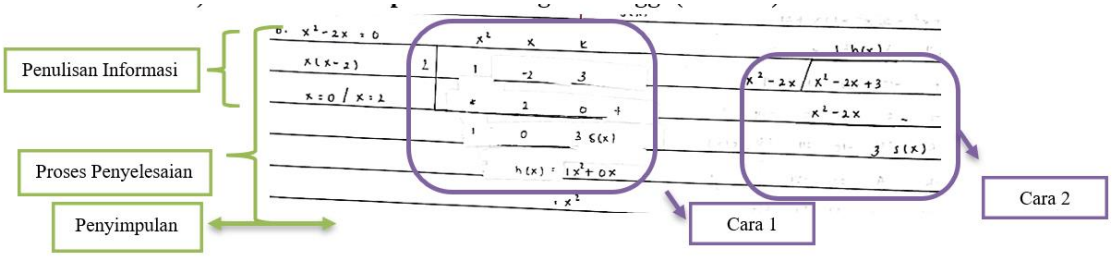


Figure 7 SKMT's answer to Question Number 1b

SKMT in Figure 7 shows that it is able to meet the flexibility. Students are able to answer questions with 2 different methods and the results are correct.indicator, elaboration KMT subjects are able to write detailed answers. In addition, students are able to write down information from the questions and write conclusions about the results obtained but lack detail.

2) Medium Metacognitive Skills (SKMS) Students

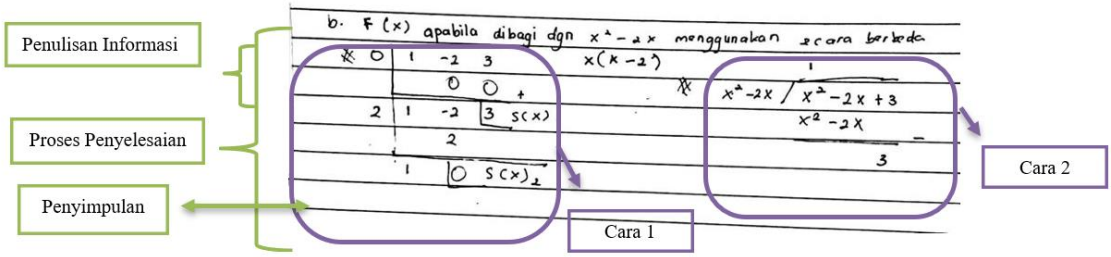


Figure 8 Answers to SKMS Question Number 1b

Looking at Figure 8 above, it shows that on the flexibility students are able to solve problems with 2 methods but one way the students are less thorough in their final writing.indicator is elaboraton able to write detailed answers but lacks detail. This can be seen in Figure 4.16 students write down what they know in the problem but it is not detailed enough. Students in writing conclusions there are errors.

3) Students with Low Metacognition Skills (SKMR)

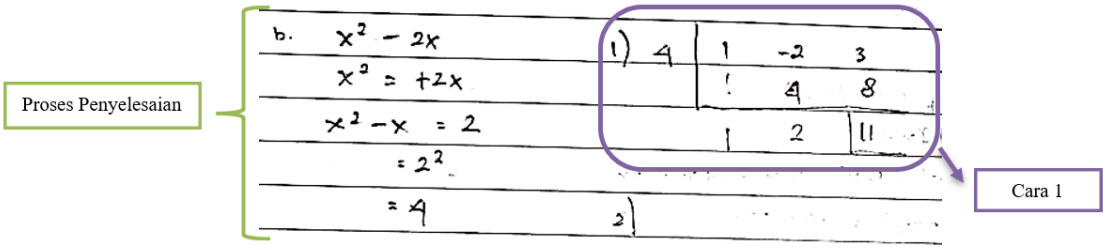
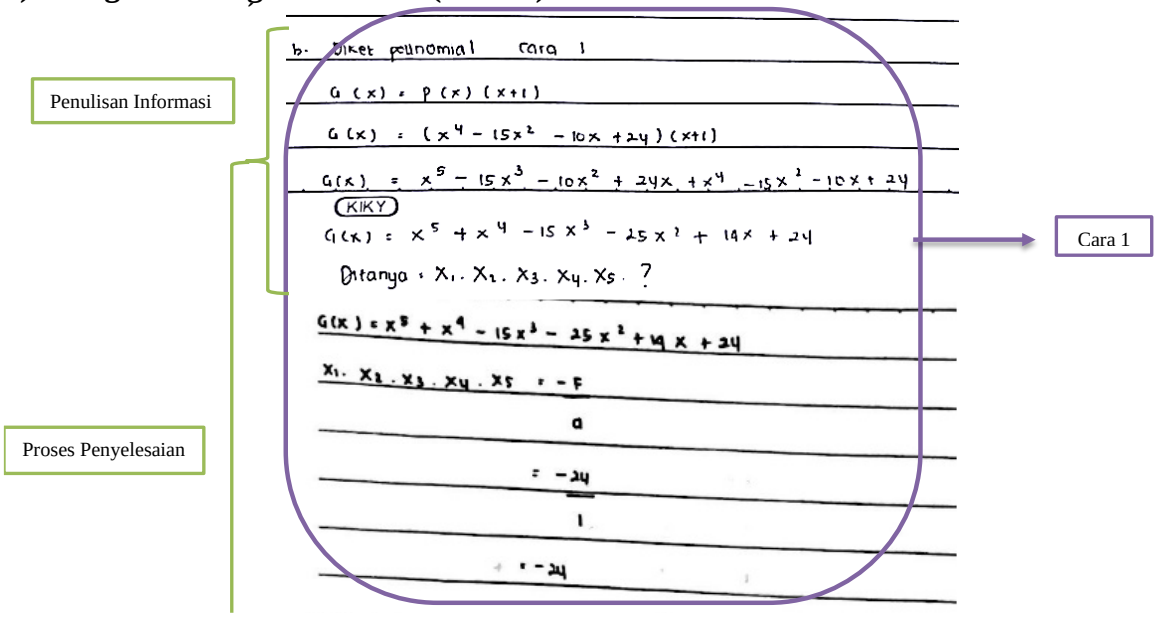


Figure 9 Answers to SKMR Question Number 1b

Figure 9 shows that the KMR subject on the flexibility has not been able to answer the questions correctly. In the picture above, it can be seen that the students answered in the horner way, the process written was correct but there were errors in the completion. On the other hand, the elaboration KMR SubjectStudents only write things that are written in the problem but there are errors in the process. Students also do not write conclusions on the results obtained.

b. Question number 2b

1) High Metacognitive Skills (SKMT) Students



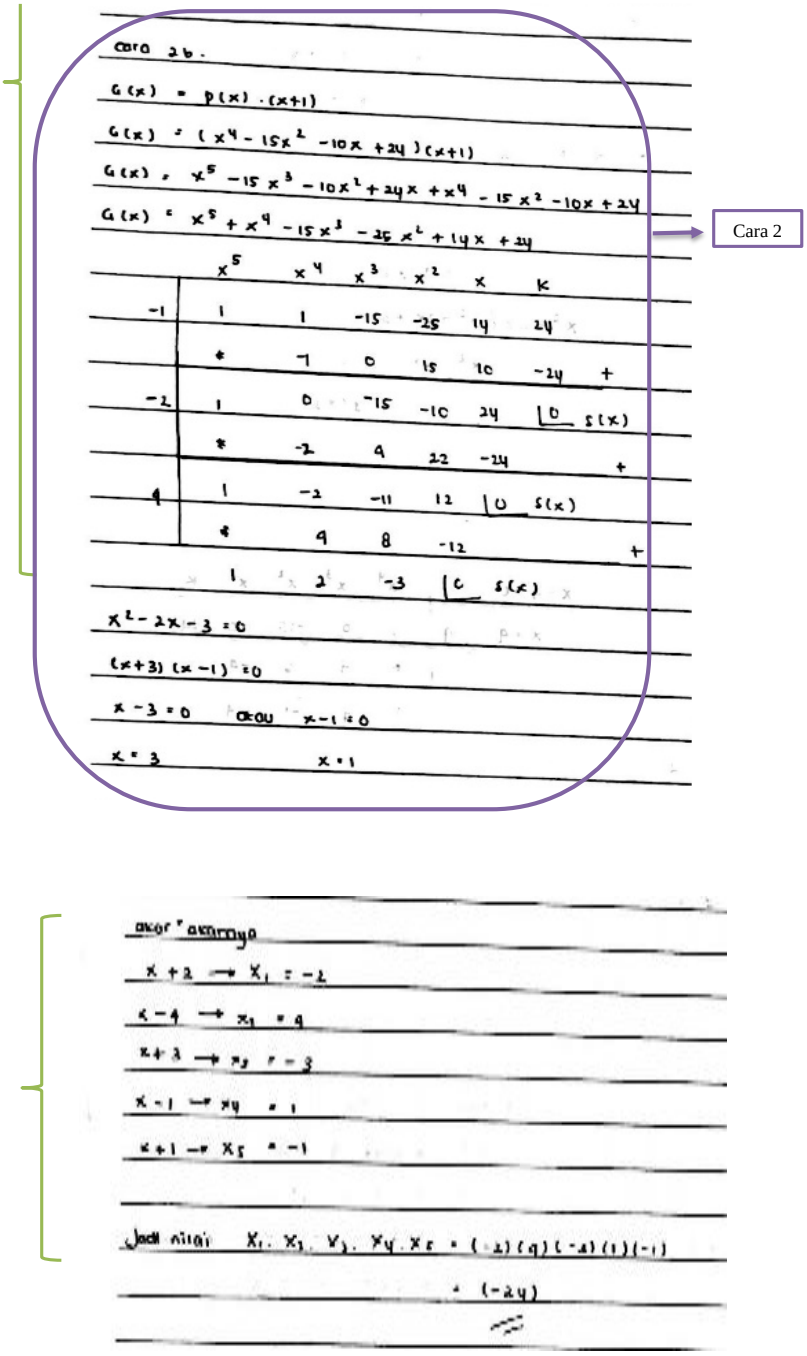


Figure 10 Answers to SKMT question number 2b

Indicator flexibility are able to solve problems in 2 different ways and have the correct value. Students answer problems using the Horner method and the concept of dividing polynomials by linear form.indicator, elaboration KMT subjects are able to write detailed answers. Students are able to write things that are known in the problem. Students are also able to write conclusions from the results obtained.

2) Intermediate Metacognitive Skills (SKMS) Students

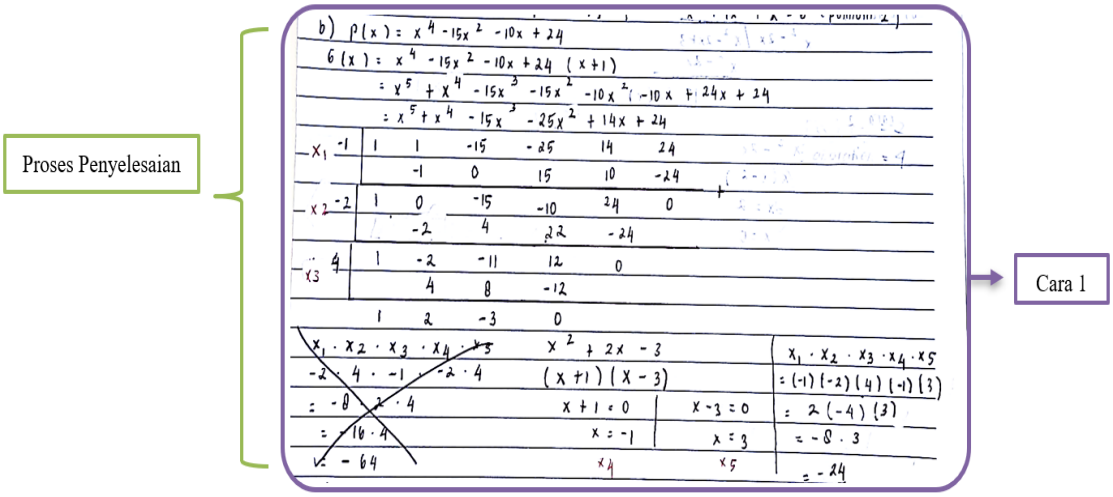


Figure 11 Answers to SKMS question number 2b

Looking at Figure 11 above, the KMS subject on the flexibility only answers the question in 1 way and has the correct value. Students have not been able to write 2 answers with different methods. KMS subjects on the elaboration are able to write detailed answers. Students write down what they know in the problem. But looking at picture 11, the conclusions from the final results were not written by the students.

3) Students with Low Metacognition Skills (SKMR)

The KMR subject on the flexibility has not answered correctly using two different ways. The subject only writes down what is known in the problem. Students have not written the steps to find the roots of the polynomial of G(x) = P(x)(x+1).indicator elaboration has not been able to provide detailed answers. Students only write down what is listed in the problem.

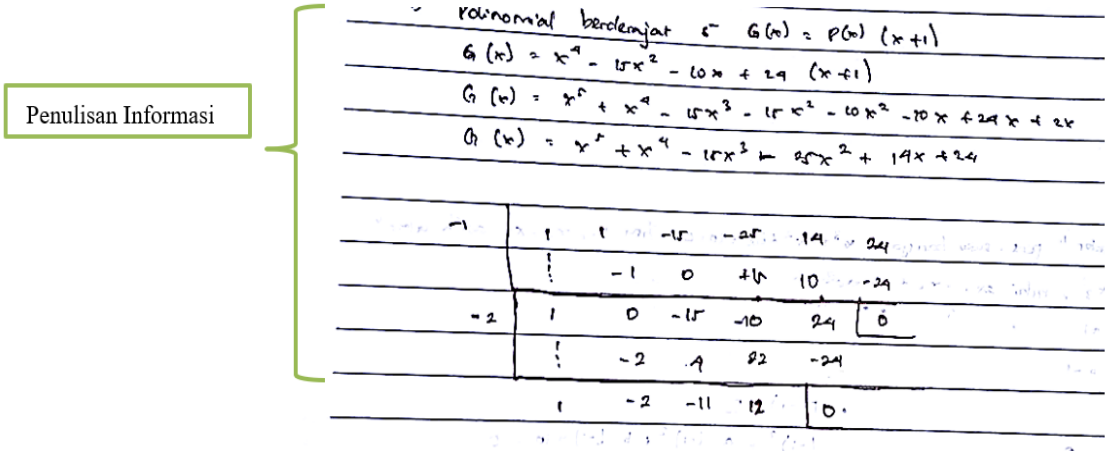


Figure 12 Answers to SKMR1 question number 2b.

3. Indicators Originality and Elaboration
a. High Metacognition Skills Student (SKMT1)

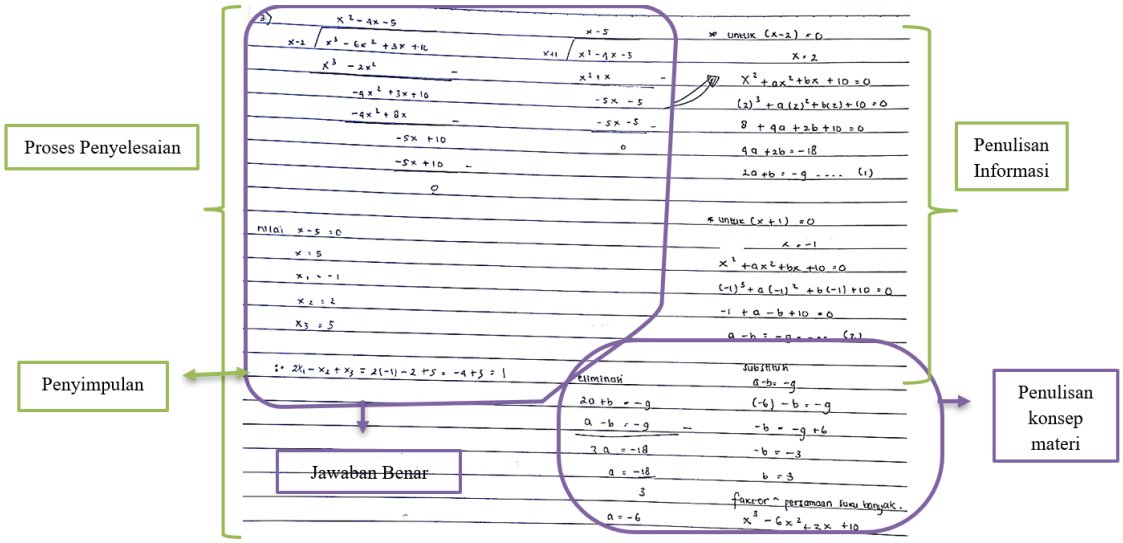


Figure 13 Answers to SKMT Question Number 3

Based on Figure 13 above, KMT subjects were able to solve the questions correctly. In solving problems, students are able to relate concepts to the previous material, namely the spldv material. KMT subjects on the elaboration are able to provide answers with detailed steps. Students are able to write down the information that is known from the problem. In Figure 13 it can also be seen that students have written conclusions from the results obtained.

b. Students with Medium Metacognition Skills (SKMS)

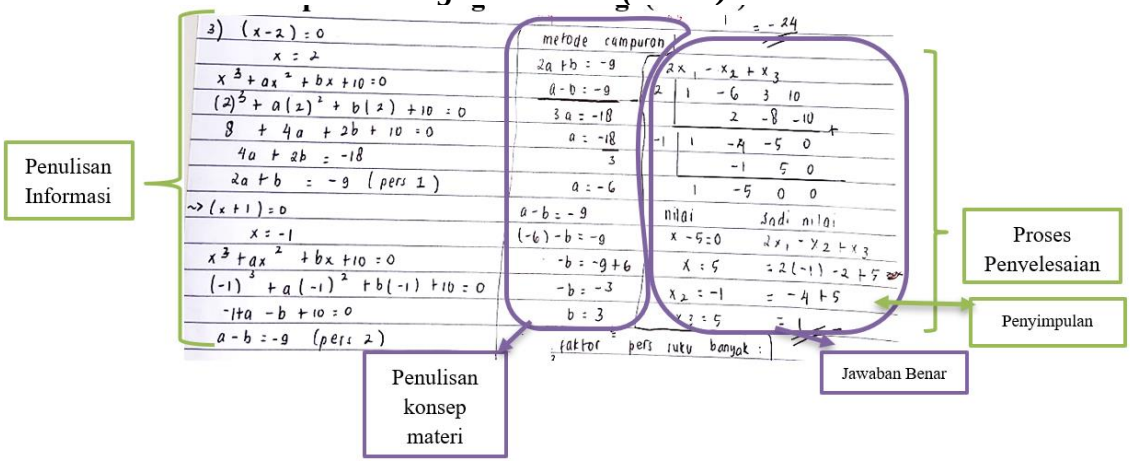


Figure 14 Answers to SKMR1 question number 3

Based on Figure 14 above, students' SKMS are able to meet the originality indicator. KMS subjects can solve problems correctly and students are able to use concepts from the previous material regarding spldv. KMS subjects on the elaboration students are able to provide detailed answers. Students are able to write down things

that are known in the problem and students also write conclusions from the results obtained.

c. Students with Low Metacognition Skills 1 (SKMR1)

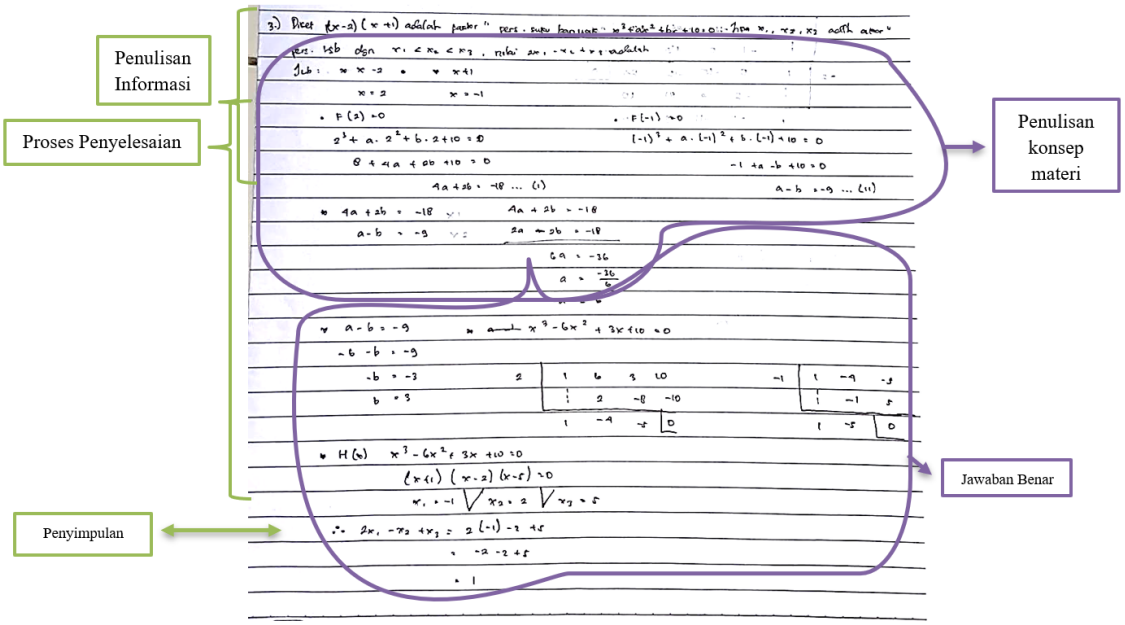


Figure 15 Answers to SKMR1 question number 3

Looking at Figure 15. KMR subjects are able to solve problems correctly and students are able to use concepts from the previous material regarding spldv. SKMR on the elaboration students are able to provide detailed answers. Students write down things that are known in the problem and write conclusions from what is asked in the problem.

The results of the data above are described about the ability to think mathematically creative in terms of metacognition skills. The following is the explanation: Students with high metacognitive skills are able to master all indicators of mathematical creative thinking skills, namely fluency, flexibility, originality, elaboration. This is supported by students with metacognitive skills category capable of mastering 6 aspects. In the aspect of Declarative Knowledge , it is related to the ability to think creatively mathematically on the originality. Students are able to know various knowledge in solving problems, and students also know about thinking strategies. This is evidenced by students being able to answer correctly on the test, students also linking concepts to the previous material. In the aspect of Procedural Knowledge, the indicator of creative thinking ability that is interrelated with this aspect is originality. Students are able to complete the creative thinking ability test correctly and are able to relate it to the concept of the previous material. This is in line with the procedural knowledge aspect, namely students are able to apply their knowledge to solve problems. Students can also use strategies or ways of thinking in solving problems. In the aspect of Conditional Knowledge , it can be related to the indicator of creative thinking ability, namely fluency. Shiva can choose the right knowledge/information to solve the problem.

Students can also choose the right strategy to solve the statement problem. This can be proven by students being able to solve test questions with different or varied answers and the results are worth correct. Planning is characterized by students being able to understand the given problem so that they can determine the right way or strategy to use. Students can also identify important information in a problem. This is in line with the indicator of creative thinking ability, namely flexibility. Students are able to give 2 different ways and the result is correct. Monitoring is related to flexibility and elaboration indicators. Flexibility students are able to get the same results in 2 different ways, meaning that students are able to monitor the results of their work. While on the elaboration students can write answers in detail, by writing down the information contained in the questions. This shows that students are able to re-check the results of their work. Evaluation is related to mathematical creative thinking ability on elaboration. Students are able to write detailed answers, write down things that are known in the problem, and are able to write conclusions. This is in line with students' skills in the evaluation, namely students can evaluate the results of their work, students re-check the results of their work and can draw conclusions.

Students with moderate metacognition skills are able to master the indicators of mathematical creative thinking skills, namely fluency, originality, and elaboration. This is supported by students in the metacognitive skill category who are able to master 4 aspects. Students' abilities in the Declarative Knowledge are related to the originality. Originality students are able to solve problems correctly. Students are also able to relate to the concept of the previous material. This shows that students are able to know a variety of knowledge, and know about thinking strategies. The Procedural Knowledge is related to the ability to think creatively on the originality. This aspect explains that students are able to apply their knowledge to solve problems. This is in line with the students' ability to complete the test by being able to relate the previous material concepts. The indicator of creative thinking ability which is interrelated with the Conditional Knowledge is fluency. Students are able to solve with 2 different answers but there is an error in the final result. This is continuous with students' skills in choosing the right knowledge or information to solve problems. And the right strategy to solve the problem. As in the test results using the remainder theorem formula. Monitoring is related to flexibility and elaboration indicators. indicator flexibility students have not been able to solve problems in 2 different ways. This means that in this aspect students have not monitored the results of their work. Elaboration students is able to write detailed answers but lacks detail. Some students do not write down the information contained in the problem or vice versa students only write conclusions from the results. This shows that students have not been able to re-check the results of their work. Evaluation is related to mathematical creative thinking ability on elaboration. Students are able to write answers in detail but lack detail, students only write down information from the questions or only make inferences. This shows that in the evaluation students do not re-check their work.

Students with low metacognition skills are only able to master 2 indicators, namely originality and elaboration. However, on the elaboration students do not master all criteria. This is supported by students with the category of metacognitive skills that have not been able to master the 6 aspects. The Declarative Knowledge is related to the ability to think creatively mathematically on the originality. Students are able to know

various knowledge in solving problems, and students also know about thinking strategies. This is evidenced by students being able to answer with on the math test, students also relate concepts to the previous material. Indicators of creative thinking skills that are interrelated with aspects of Procedural Knowledge are originality. Students are able to complete the creative thinking ability test correctly and are able to relate it to the concept of the previous material. This is in line with the procedural knowledge aspect, namely students are able to apply their knowledge to solve problems. Students can also use strategies or ways of thinking in solving problems. In the aspect of Conditional Knowledge, it can be related to the indicator of creative thinking ability, namely fluency. Shiva has not been able to choose the right knowledge/information to solve the problem. Students also have not been able to choose the right strategy to solve the problem. This can be proven by the students on the indicator have not been able to solve the problem with 2 different answers and the value is correct. Students only write 1 answer and the result is wrong. Planning is characterized by students being able to understand the given problem so that they can determine the right way or strategy to use. Students can also identify important information in a problem. However, in this aspect the students are at a moderate level. This is in line with the indicator of creative thinking ability, namely flexibility. Students have not been able to give 2 different ways and the results are correct. Monitoring is related to flexibility and elaboration indicators. Flexibility students have not been able to get the same results in 2 different ways, students only use 1 method and there is an error in the final result, meaning that students have not been able to monitor the results of their work. While on the elaboration students have not written detailed answers. Students are only able to write down information from the questions or only write conclusions from the final results. This shows that students have not been able to re-check the results of their work. Evaluation is related to mathematical creative thinking ability on elaboration. Students have not been able to write answers in detail, students are also not able to write conclusions from the final results. However, students are able to write down things that are known in the problem. This is in line with student skills in the evaluation aspect, namely students can evaluate the results of their work, students re-check the results of their work and can draw conclusions.

▪ CONCLUSION

Students with high metacognitive skills have a level of creative thinking ability in the very creative category. Subjects with high metacognitive skills can master all indicators, namely indicators of fluency or fluency, indicators of flexibility or flexibility, indicators of originality or originality and indicators of elaboration or elaboration. Students with moderate metacognitive skills have the ability to think creatively in the category of creative and quite creative. Subjects with moderate metacognitive skills were able to master 3 indicators, namely fluency or fluency indicators and originality indicators and elaboration indicators. Students with low metacognition skills have the ability to think creatively in the category of less creative and not creative. Subjects with low metacognition skills are able to master 2 indicators, namely originality or originality and elaboration. However, the students' elaboration indicators did not meet all of them.

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