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# Metacognitive Profile of Students Who Play Chess in Solving Mathematics Problems

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**ABSTRACT.** Mathematics is the study of patterns, so in chess pattern recognition is very important in problem solving. Chess is a problem-solving instrument and the best way to analyze problem-solving because chess has clear rules in decision making, thus a skilled chess player becomes a good problem solver. Metacognitive activity and problem-solving processes are intimately intertwined. The purpose of this research is to describe the metacognition profiles of students who play chess and students who do not play chess in solving mathematical problems. This research is a qualitative-research. The research subjects in this study were students who could play chess and students who could not play chess. The criteria are students who have participated in chess matches as low as possible at the sub-district level and regularly play chess, while students who cannot play chess are students who do not understand the basics of playing chess. This research carried out in class VIII at a junior high school in Surabaya. The instruments in this study were math ability tests, problem-solving tests and interview guidelines. The data collection procedure was carried out by giving students a math problem-solving test and interviews. The data analysis technique in this study was carried out in the following steps; transcribing the subject's answers, examining the subject's answer data from interviews, data reduction, data categories, analyzing students' metacognition profiles, and drawing conclusions. The results of the study stated that the metacognitive abilities in solving problems of chess students were better than those of non-chess students. The ES subject achieved 80% of metacognitive activity indicators, while the MI subject only achieved 54.25% of metacognitive activity indicators.

**Keywords**: chess; metacognitive; problem-solving

**ABSTRAK.** Matematika adalah ilmu yang mempelajari pola, maka dalam catur pengenalan pola sangat penting dalam pemecahan masalah. Catur adalah instrumen pemecahan masalah dan cara terbaik untuk menganalisis pemecahan masalah karena catur memiliki aturan yang jelas dalam pengambilan keputusan, sehingga pemain catur yang terampil menjadi pemecah masalah yang baik. Proses pemecahan masalah terkait erat dengan aktivitas metakognitif. Tujuan penelitian ini adalah untuk mendeskripsikan profil metakognisi siswa yang bermain catur dan siswa yang tidak bermain catur dalam menyelesaikan masalah matematika. Penelitian ini merupakan penelitian kualitatif. Subjek penelitian dalam penelitian ini adalah siswa yang dapat bermain catur dan siswa yang tidak dapat bermain catur. Kriterianya adalah siswa yang pernah mengikuti pertandingan catur serendah-rendahnya di tingkat kecamatan dan rutin bermain catur, sedangkan siswa yang tidak dapat bermain catur adalah siswa yang tidak memahami dasar-dasar bermain catur. Penelitian ini dilaksanakan di kelas VIII pada salah satu sekolah menengah pertama di Surabaya. Instrumen dalam penelitian ini adalah tes kemampuan matematika, tes pemecahan masalah dan pedoman wawancara. Prosedur pengumpulan data dilakukan dengan memberikan siswa tes pemecahan masalah matematika dan wawancara. Teknik analisis data dalam penelitian ini dilakukan dengan langkah-langkah sebagai berikut; mentranskrip jawaban subjek, mengkaji data jawaban subjek dari wawancara, reduksi data, kategori data, menganalisis profil metakognisi siswa, dan menarik kesimpulan. Hasil penelitian menyatakan bahwa kemampuan metakognitif dalam memecahkan masalah siswa pecatur lebih baik dibandingkan dengan siswa non-pecatur. Subjek ES mencapai 80% indikator aktivitas metakognitif, sedangkan subjek MI hanya mencapai 54,25% indikator aktivitas metakognitif.

**Kata kunci**: catur; metakognisi; pemecahan masalah

## INTRODUCTION

The five process standards highlight the types of mathematical thinking needed from pre-kindergarten through grade 12 to develop understanding: problem-solving, reasoning and proofing, communication, connections and representation (NCTM, 2000). Based on the NCTM statement above, problem-solving is one of the standard components of the mathematics learning process. Furthermore, NCTM states that problem-solving means engaging in a task for which the solution methods are not known in advance. In order to find a solution, students must draw on their knowledge, and through this process, they will often develop new mathematical understandings. Solving a mathematical problem is a complex metal process which requires visualization imagination, analysis, abstraction, and cohesion of ideas (Johnson & Rising, 1972). Therefore, solving a mathematical problem is a task whose method of completion is unknown and in order to find a solution it requires the ability of visualization, imagination, manipulation, analysis, abstraction and unification of ideas.

Through solving mathematical problems, students are directed to develop their abilities, including building new mathematical knowledge, solving problems in various contexts related to mathematics, applying various strategies needed, and reflecting on the process of solving mathematical problems (Pierson, 2008). All of these abilities can be obtained if students are accustomed to carrying out problem-solving according to appropriate procedures, so that the scope of benefits obtained is not only tied to one problem being solved, but can also touch on various other problems and cover broader aspects of mathematical knowledge.

Several studies found that the advantages of chess in education(Ferguson, 1995; Ferreira & Palhares, 2008b; Liptrap, 1998; Thompson, 2003). The results show that chess can advance academic achievement, especially problem-solving strategies, improve memory, focus, IQ test scores, critical thinking and creativity, as well as improve spatial and visual power, and the ability to recognize patterns (Farhad Kazemi, Yektayar, & Abad, 2012). This shows that the abilities needed in solving mathematical problems can be improved through chess games. As an instrument to teach problem-solving and abstract reasoning, chess can be used effectively. Chess promotes academic achievement, especially problem-solving strategies, improves memory, concentration, scores on IQ tests, critical thinking, and develops visual and spatial abilities and the capacity to identify patterns (Ferreira & Palhares, 2008).

Learning how to solve problems is perhaps more important than finding solutions to specific problems. By playing chess, we learn how to evaluate context and end, we must concentrate on the main factors and eliminate distractors so as to find real and imaginative solutions to complete the plan. Chess is clearly a problem-solving instrument and the best possible way to analyze problem-solving and decision-making because it is a closed system with clear and determined rules. This statement explains that chess is a problem-solving instrument and the best way to analyze problem-solving because chess has clear rules and is about decision making.

The first step in dealing with a problem is to analyze it and assess the problem and perhaps try to find patterns or similarities with previous experiences. Just as mathematics is the study of patterns, so in chess pattern recognition is very important in problem-solving. By recognizing commonalities and patterns we can formulate general strategies for solving possible problems, including developing other options and creative processes. Skilled chess players and good problem solvers already have a number of relevant grand schemes, thus allowing good alternatives in the future. Chess calculates future events based solely on the evaluated solutions.

To solve the problem, it takes steps to solve it systematically so that the problem can be solved optimally. Polya (suggests a number of steps in solving problems, namely, first, we have to understand the problem, we have clearly what is required; second, we have to see how the various are items are connected, how to unknown is linked to the data, in order to obtain the idea of the solution, to make a plan; third, we carry out our plan; fourth we look back at the completed solution, we review and discuss it (Polya, 2014). Based on this opinion, problem-solving can be done in four steps. Among other things, understanding the problem, planning the solution, implementing the plan, re-examining the results and processes. Through these steps, it is possible to carry out systematic problem-solving so that a well-structured mindset is formed in students.

The process of thinking in solving mathematical problems is an important thing that needs to be considered by teachers, especially to help students to be able to develop their abilities in solving mathematical problems. This is in line with the opinion expressed by Lester that the main purpose of teaching problem-solving in mathematics is not only to equip students with a set of skills or processes, but also to enable them to think about what they think (Lester, 1994). Problem-solving capability is a complicated interaction between cognition and meta-cognition(Artzt & Armour-Thomas, 1992). Perhaps the basic source of trouble in problem-solving is that students can not actively watch, check and regulate the cognitive processes they encounter upon solving the problems. Therefore, problem-solving must include students' cognitive and metacognition processes, because in problem-solving individuals must choose a solution strategy and think of alternative strategies for future situations. Maybe the basic source of problems in problem-solving is that students cannot actively observe, examine and organize cognitively. However, cognitive processes such as selecting strategies are not enough to solve mathematical problems, metacognitive monitoring that regulates cognitive activities and monitors the efficiency of implementation is also needed (Goos, Galbraith, Renshaw, & Geiger, 2000). Metacognitive activity and problem-solving processes are intimately intertwined (Rott, 2013). This shows that the performance of a student by only looking at the cognitive aspects and ignoring the metacognitive aspects is not enough. Integration of analysis is needed, both cognitive and metacognitive related to one's performance. The reason is that the success of cognitive work is also determined by the knowledge, awareness, and control over the knowledge they already have.

Starting from the things stated above, it can be said that metacognition has an important role in regulating and controlling one's cognitive processes in learning and thinking, so that learning and thinking done by someone becomes more effective and efficient. Therefore, students' metacognition in solving mathematical problems will be the topic of discussion in this paper. With the provision of abilities such as focus, critical thinking, abstract reasoning, strategic planning, analysis, creativity, evaluation and synthesis obtained by students through chess, students are trained to always design the best strategy in choosing, remembering, recognizing, organizing the information they face, in solving problems. It is also hoped that through chess students will get used to always monitoring, controlling and evaluating what they have done. Based on the descriptions above, the researcher is interested in studying metacognition profiles of students who play chess in solving mathematical problems. The purpose of this research is to describe the metacognition profiles of students who play chess and students who do not play chess in solving mathematical problems.

## METHOD

This research is a qualitative's research. This study reveals the metacognition processes of students who can play chess and students who cannot play chess when solving mathematical problems. Students who can play chess referred to in this study are students who have participated in chess competitions as low as at the sub-district level and regularly play chess, while students who cannot play chess are students who do not understand the basics of playing chess. In solving mathematical problems, the steps taken are according to the steps of solving mathematical problems according to Polya's theory.

Students will be given a problem and asked to work on it. At each step of problem-solving according to the steps of problem-solving according to Polya's theory, students were interviewed and asked to explain the steps taken to solve the problem. This interview was conducted to reveal the description of the process of metacognition. This research carried out in class VIII at a junior high school in Surabaya. Based on Piaget's theory junior high school adolescents whose ages range from 11 years and older are in formal operations, namely teenagers who think abstractly, idealistically and logically (Piaget, 1970). The school chosen is a school which, according to researchers, makes it easier for researchers to conduct research.

The selection of research subjects begins with asking for information from teachers and students about students who play chess and cannot play chess. Furthermore, the same mathematical ability test was carried out in both groups. The selection of subjects is based on the results of the math ability test. The test results were analyzed and grouped into groups of high, medium and low mathematical abilities.

From the test results, based on the criteria above, one student who could play chess and one student who could not play chess was selected from a group of students with high mathematical abilities. To further convince the researcher in selecting the subject, an interview process was also carried out with the subject's subject teacher and the subject's willingness to serve as a research subject. The instruments in this study were math ability tests, problem-solving tests and interview guidelines. The data collection procedure was carried out by giving students a math problem-solving test and interviews. The material used in the problem-solving test is probability material. During the problem-solving process, all activities of the research subjects were observed and asked to express thoughts verbally while writing down everything related to problem-solving. The following are problem-solving questions used in this study.

**Table 1. Problem-Solving Questions**

| | |
|---|---|
| A company manufactures 5000 bicycles. Each of these bicycles is given a serial number from 1 - 5000 but with a note that the bicycle that has the same number is also 1 bicycle and is chosen randomly. What is the probability that the selected bicycle does not contain the number 8? | A magician, he prepares 100 cards. If the cards are numbered 1 to 100, this magician selects a spectator to draw the cards. What is the probability that the spectator's selection does not contain the numbers 5 and 7? |

Furthermore, the following are the stages of problem solving and indicators of metacognitive activity used in this study (Cohors-Fresenborg & Kaune, 2007)

**Table 2. Metacognition Activities in The Problem-Solving Steps**

| Problem-Solving Steps | Metacognitive Activities | Indicators | Code |
|---|---|---|---|
| Understanding the problem | Be aware of the thought process, in developing plans, when understanding problems | • Thinking about how to understand the problem (by reading the questions, making pictures or other representations).<br>• Thinking of prerequisite concepts that will be used in solving problems | UT1<br>UT2 |
| | Be aware of the process and results of thinking, in monitoring the implementation when understanding the problem | • Monitoring the conformity of drawings or other representations made of a given problem<br>• Monitoring the understanding of the problem<br>• Monitoring the suitability of the prerequisite concepts that will be used in solving problems | UM1<br>UM2<br>UM3 |
| | Be aware of the process of thinking, in evaluating actions, when understanding the problem | • Checking the conformity of the drawings or other representations that have been made<br>• Checking understanding of problems.<br>• Checking the truth that is revealed from what is understood<br>• Checking the suitability of the prerequisite concepts that will be used in solving problems | UC1<br>UC2<br>UC3<br>UC4 |
| Thinking of an action plan and building | Be aware of the process and results of thinking, in | • Thinking through the flow of problem-solving<br>• Estimating the time needed to solve the problem<br>• Thinking of the first solution plan | TT1<br>TT2<br>TT3 |

| Problem-Solving Steps | Metacognitive Activities | Indicators | Code |
|---|---|---|---|
| alternative solutions | developing plans, when thinking about plans of action | • Thinking of another solution to the problem | TT4 |
| | Be aware of the process and results of thinking, in monitoring implementation when thinking of action plans | • Monitoring the problem-solving flow plan<br>• Monitoring the formulas that will be used to solve problems<br>• Monitoring other plans for solving problems | TM1<br>TM2<br>TM3 |
| | Be aware of the process and results of thinking, in evaluating actions when thinking of action plans | • Checking the suitability of the problem-solving flow<br>• Checking the suitability of the formula that will be used to solve the problem<br>• Checking the suitability of the estimated time to solve the problem<br>• Checking the suitability of other solutions to the problem | TC1<br>TC2<br>TC3<br>TC4 |
| Implement the action plan by choosing a settlement strategy | Be aware of the process and results of thinking, in developing plans, when making plans of action | • Thinking about what to do first when implementing a problem-solving plan<br>• Thinking about how to implement the problem-solving plan<br>• Thinking of ways of implementing plans other ways of solving problems | IT1<br>IT2<br>IT3 |
| | Be aware of the process and results of thinking, in monitoring implementation when making action plans | • Monitoring the implementation of the problem-solving plan<br>• Monitoring the implementation of other solutions to the problem plan<br>• Monitoring the calculations made | IM1<br>IM2<br>IM3 |
| | Be aware of the process and results of thinking, in evaluating actions, when making action plans | • Checking suitability is the first thing to do when implementing a problem-solving plan<br>• Checking the suitability of the implementation of the first problem-solving plan<br>• Checking the suitability of the implementation of other problem-solving plans | IC1<br>IC2<br>IC3 |
| Evaluate and re-examine how the best solution | Be aware of the process and results of their thinking, in developing plans, when conducting evaluations | • Thinking of ways to check the correctness of the results of problem-solving<br>• Thinking of ways to check the correctness of the results of other ways of solving problems | ET1<br>ET2 |
| | Be aware of the process and results of thinking, in monitoring the implementation during evaluation | • Monitoring the correctness of the results of problem-solving<br>• Monitoring the correctness of the results of other ways of solving problems | EM1<br>EM2 |
| | Be aware of the process and results of thinking, in evaluating actions, when evaluating | • Checking the correctness of the results of the first problem-solving<br>• Checking the correctness of the results of other ways of solving problems | EC1<br>EC2 |

Then students were interviewed based on the results of the recording and the results of written work in solving problems. This is done to find out more deeply and identify the subject's metacognition in solving a given problem. The data analysis technique in this study was carried out in the following steps: 1) transcribing the subject's answers, 2) examining the subject's answer data from interviews, 3) data reduction, 4) data categories, 5) analyzing students' metacognition profiles, and 6) drawing conclusions.

## RESULT AND DISCUSSIONS

From the research that has been done, the researcher found one student who can play chess who has high mathematical ability and one student who cannot play chess who has high mathematical ability. The researcher then gave problem-solving assignments to students, and conducted interviews after the two students had done the problem-solving assignment. Subject 1 was given the initials ES and subject 2 was given the initials MI. The ES subject is a subject who can play chess. The MI subject is a subject who is unable to play chess.

### Subject ES

*Understand the problem by identifying and clarifying the problem*

The metacognitive activities of the ES subject at the understanding the problem stage fulfills the indicator be aware of the thought process, in developing plans, when understanding problems, namely the indicator thinking about how to understand the problem (by reading the questions, making pictures or other representations) and thinking of prerequisite concepts that will be used in solving problems. Furthermore, the ES subject fulfills metacognition activities in the section be aware of the process and results of thinking, in monitoring the implementation when understanding the problem, that is monitoring the understanding of the problem monitoring the suitability of the prerequisite concepts that will be used in solving problems. The next metacognition activity that is fulfilled by ES subjects is be aware of the process of thinking, in evaluating actions, when understanding the problem, namely checking understanding of problems, checking the truth that is revealed from what is understood and checking the suitability of the prerequisite concepts that will be used in solving problems. The following is an excerpt of the researcher's interview with the ES subject at the stage of understanding the problem.

| | | | |
|---|---|---|---|
| R | : | What do you get after reading the questions? | |
| S | : | From this problem there is a company that produces 5000 bicycles and each bicycle is given a serial number from 1-5000 but with a note that there is no serial number that continues to be the same if 1 bicycle is chosen at random. What is the probability that the selected bicycle does not contain the number 8? | UT1, UM2, UC2 |
| R | : | Then what are we looking for from this problem? | |
| S | : | From this problem, we want to find the probability that the selected bicycle does not contain the number 8 | UT1, UM2, UC2 |
| R | : | From what is known and asked, do you think that enough is known here to solve the problem? | |
| S | : | I think that's enough | UC3 |
| R | : | What material do you think this question is related to? | |
| S | : | Hmm, I think this is probability material. | UC4 |

*Thinking of an action plan and building alternative solutions*

The metacognitive activities that are fulfilled in the thinking of an action plan and building alternative solutions stage are thinking of the first solution plan and thinking of another solution to the problem. ES subjects are able to think of other solutions to the problems given, this will be proven later in the interview excerpts. The next metacognition activity that is fulfilled by the ES subject is being aware of the process and results of thinking, in monitoring implementation when thinking of action plans, namely monitoring the problem-solving flow plan, monitoring the formula that will be used to solve problems and monitoring other plans for solving problems. Then the metacognitive activities that are fulfilled by ES subjects in the section be aware of the process and results of thinking, in evaluating actions when thinking of action plans, namely checking the suitability of the formula that will be used to solve the problem and checking the suitability of other solutions to the problem. The following is an excerpt of the researcher's interview with the ES subject at the stage of thinking of an action plan and building alternative solutions.

| | | | |
|---|---|---|---|
| R | : | So, if you want to try to solve it, what method do you use? | |
| S | : | If I study probability this means we have to find the sample space | TT3 |
| R | : | Which sample space? | |
| S | : | The sample space of the serial number and the serial number writing | TT3 |
| R | : | Serial numbers of all the bikes? | |
| S | : | The serial number of the 5000 bicycles | |
| R | : | Then, what else? | |
| S | : | This can also be done by counting the number of bikes with the serial number 8 and subtracting that from the total number of bikes | TT4, TM 1, TM2, TM3, TC2, TC4 |
| R | : | How? | |
| S | : | Hmm, looks like we need to find the pattern of the number 8 in each digit between the numbers 1-5000 | TT4, TM1, TM2, TM3, TC2, TC4 |
| R | : | Fine, please do it | |

*Implement the action plan by choosing a settlement strategy*

At the stage of solving the problem of implementing the action plan by choosing a settlement strategy, the metacognitive activity that is fulfilled by ES subjects is being aware of the process and results of thinking, in developing plans, when making plans of action. The indicators that are fulfilled are thinking about what to do first when implementing a problem-solving plan, thinking about how to implement the problem-solving plan and thinking of ways of implementing plans other ways of solving problems. The next metacognition activity that is fulfilled by ES subjects is being aware of the process and results of thinking, in monitoring implementation when making action plans, namely monitoring the implementation of the problem-solving plan, monitoring the implementation of other solutions to the problem plan and monitoring the calculations made. Furthermore, the ES subject also achieves metacognition activity in the section be aware of the process and results of thinking, in evaluating actions, when making action plans. In this section, the indicators that are fulfilled are checking suitability is the first thing to do when implementing a problem-solving plan, checking the suitability of the implementation of the first problem-solving plan and checking the suitability of the implementation of other problem-solving plans. The following is an excerpt of the researcher's interview with the ES subject at the stage of implement the action plan by choosing a settlement strategy.

| | | | |
|---|---|---|---|
| R | : | How to do it? | |
| S | : | I made it into 5 digits. For the first digit, numbers from 1-999 will have 1 digit 8, the 8 itself. So, there are 1x9x9 = 81 bicycles with serial numbers that have 8 in the first digit. | IT1, IT2, IT3, IM1, IM2, IM3, IC1, IC2, IC3 |
| R | : | Ok, so there are 81 bikes with serial numbers that have 8 in the first digit? | |
| S | : | Yes | |

| | | | |
|---|---|---|---|
| R | : | What are you doing next? | |
| S | : | Then I determined the second digit, i.e. 800-899 will have 1 digit 8 in the 2nd digit. So, there are as many as 100 bicycles with serial number 8 in the 2nd digit. | IT1, IT2, IT3, IM1, IM2, IM3, IC1, IC2, IC3 |
| R | : | Then? | |
| S | : | Then the third digit in the hundreds form. The number of bicycles that have the digit 8 in the 2nd and 3rd digits is 10x10 = 100. | IT1, IT2, IT3, IM1, IM2, IM3, IC1, IC2, IC3 |
| R | : | You mean there are 100 bikes that have a serial number of 8 in the 2nd and 3rd digits? | |
| S | : | Yes | |
| R | : | Ok, what's next? | |
| S | : | Still there, in the fourth digit which is in the form of tens digits, the result is the same as the second digit, 100 bicycles that have serial number 8. | IT1, IT2, IT3, IM1, IM2, IM3, IC1, IC2, IC3 |
| R | : | Ok, then? | |
| S | : | Finally, the fifth digit in the form of a unit number, this is the same as the first digit, there are 81 bicycles that have serial number 8 in the fifth digit. | IT1, IT2, IT3, IM1, IM2, IM3, IC1, IC2, IC3 |
| R | : | What next? Is it done? | |
| S | : | Not yet | |
| R | : | What's not finished yet? | |
| S | : | Counts the number of bicycles that have a serial number of 8 and subtracts them from the total number of bicycles | IT1, IT2, IT3, IM1, IM2, IM3, IC1, IC2, IC3 |
| R | : | Ok, so how many total bicycles have a serial number with the number 8? | |
| S | : | The number of bicycles that have a serial number with the number 8 is 81 + 100 + 100 + 100 + 81 = 462 Then, the number of bicycles that do not have the serial number 8 is reduced, so it will be 5000 – 462 = 4538 | IT1, IT2, IT3, IM1, IM3, IC1, IC2, IC3 |
| R | : | Ok, so the number of bicycles that do not have the serial number 8 is 4538. What's next? Have you found the probability yet? | |
| S | : | Not yet.<br><br>So the probability that the bicycle chosen does not contain the number 8 is 4538/5000 | IT1, IT2, IT3, IM1, IM3, IC1, IC2, IC3 |
| R | : | It means the probability that the bicycle selected and does not contain the number 8 is 4538/5000? | |
| S | : | Yes | |

*Evaluate and re-examine how the best solution*

Furthermore, in the stage of problem-solving be aware of the process and results of their thinking, in developing plans, when conducting evaluations, ES subjects achieve metacognitive activity be aware of the process and results of their thinking, in developing plans, when conducting evaluations on the thinking indicator of ways to check the correctness of the results of problem-solving. Furthermore, the metacognition activity achieved by ES subjects in the activity of being aware of the process and results of thinking, in monitoring the implementation during evaluation meets the indicator of monitoring the correctness of the results of problem-solving. Then, the metacognition activity that is fulfilled by the ES subject in the activity be aware of the process and results of thinking, in evaluating actions, when evaluating namely checking the correctness of the results of other ways of solving problems. ES did all the work on the questions correctly. The following is an excerpt of the researcher's interview with the ES subject at the stage of evaluate and re-examine how the best solution.

| | | | |
|---|---|---|---|
| R | : | Are you sure about your answer? | |
| S | : | Yes | ET1, EM1, EC2 |
| R | : | Would you like to check again? | |
| S | : | Ok, I will check again (while checking the problem again by reading) | ET1, EM1, EC2 |
| R | : | How? Are you done? | |
| S | : | Already, I'm sure this is how it's done, I've checked again. | ET1, EM1, EC2 |
| R | : | Ok, that means you are sure that the result is 4538/5000? | |
| S | : | Yes, I am sure. | |

**Subject MI**

*Understanding the problem*

The MI subject's metacognitive activity in the section be aware of the thought process, in developing plans, when understanding problems, only fulfills 1 indicator, namely the indicator thinking about how to understand the problem (by reading the questions, making pictures or other representations). Furthermore, the MI subject's metacognition activity in the section on being aware of the process and results of thinking, in monitoring the implementation when understanding the problem, only achieves 1 indicator, namely monitoring the understanding of the problem. Then, the metacognitive activities achieved by MI subjects fulfill the three indicators in the part of being aware of the process of thinking, in evaluating actions, when understanding the problem, namely checking the understanding of problems, checking the truth that is revealed from what is understood and checking the suitability of the prerequisite concepts that will be used in solving problems. The following is an excerpt of the researcher's interview with the MI subject at the stage of understand the problem by identifying and clarifying the problem.

| | | | |
|---|---|---|---|
| R | : | What do you get after reading the questions? | |
| S | : | There was a magician, he prepared 100 cards. Now if the cards are numbered 1 to 100 then this magician chooses the audience to take the cards. What is the probability that the spectator's selection does not contain the numbers 5 and 7? | UT1, UM2, UC2 |
| R | : | Do you understand this question? | |
| S | : | I see, so there's a magician, these 100 cards, what's the probability of choosing a card that doesn't contain the numbers 5 and 7? | UT1, UM2, UC2 |
| R | : | Well, that's something that is known and asked. So, from what is known, can you answer what is being asked? Or maybe something is still missing? | |
| S | : | Right here, what is known is that there are 100 cards, then they are numbered from 1 to 100, the question is how many chances does he have to take that does not contain the numbers 5 and 7, from what I know I think I can | UC3 |
| R | : | What material do you think this question is related to? | |
| S | : | Probability it seems | UC4 |

*Thinking of an action plan and building alternative solutions*

The indicators of metacognitive activity in the be aware of the process and results of thinking, in developing plans, when thinking about plans of action which are fulfilled by MI subjects are only two indicators, namely thinking through the flow of problem-solving and thinking of the first solution plan. Furthermore, in the metacognitive activity of being aware of the process and results of thinking, in monitoring implementation when thinking of action plans, MI subjects achieve two indicators, namely monitoring the problem-solving flow plan and monitoring the formulas that will be used to solve problems. Furthermore, in the metacognitive activity be aware of the process and results of thinking, in evaluating actions when thinking of action plans, the MI subject only fulfills 1 indicator, namely checking the suitability of the formula that will be used to solve the problem. The following is an excerpt of the researcher's interview with the MI subject at the stage of thinking of an action plan and building alternative solutions.

| | | | |
|---|---|---|---|
| R | : | Well, now you can know what is known and what is being asked. After you find out what is known and what is asked, what is the next step? | |
| S | : | The steps are, there are 100 numbers, from 1 to 100, I will make 3 digits to determine the number of sample spaces. | TT1, TT3, TM1, TM2, TC2 |
| R | : | Next? | |
| S | : | After that, the probability formula is the number of events per sample space, because here the conditions are not allowed to contain numbers 5 and 7, we first find the probability that does not contain numbers 5 and 7. | TT1, TT3, TM1, TM2, TC2 |
| R | : | Then? | |
| S | : | Just reduce it later | TC2 |
| R | : | Ok, now try to do it | |

*Implement the action plan by choosing a settlement strategy*

The indicators of metacognitive activity in the section be aware of the process and results of thinking, in developing plans, when making plans of action achieved by MI subjects consist of two indicators, namely thinking about what to do first when implementing a problem-solving plan and thinking about how to implement the problem-solving plan. Besides that, the indicators of metacognitive activity in the section be aware of the process and results of thinking, in monitoring implementation when making action plans achieved by MI subjects consist of two indicators, namely monitoring the implementation of the problem-solving plan and monitoring the calculations made. Furthermore, the indicators of metacognitive activity in the be aware of the process and results of thinking, in evaluating actions, when making action plans achieved by MI subjects consist of two indicators, namely checking suitability is the first thing to do when implementing a problem-solving plan and checking the suitability of the implementation of the first problem-solving plan. The following is an excerpt of the researcher's interview with the MI subject at the stage of implement the action plan by choosing a settlement strategy.

| | | | |
|---|---|---|---|
| R | : | How is it done? | |
| S | : | There are 3 digits, I created 3 digits to find the number of sample spaces | IT1, IT2, IM1, IM3, IC1 |
| R | : | Then, what does this one mean? | |
| S | : | 1 means the number of possibilities in the first digit that can be written is 0 | IC2 |
| R | : | Next? | |
| S | : | The number of digits 0 to 9 | IC2 |

| | | | |
|---|---|---|---|
| R | : | Is that the second digit? | |
| S | : | Yes, the second and third digits are the same | IC2 |
| R | : | Why is the first digit only 0? Why aren't there 1, 2 just like the second, third digits? | |
| S | : | Ooh yeah, there should be a 1 in the first digit | IC2 |
| R | : | Yes, that means there must be 1 in the first digit | |
| S | : | But if there is 1 in the first digit, it means that in the second digit there is 9, the third digit is 9, it means 199, but here you are only told to write 1 to 100 | IM3, IC2 |
| R | : | So? There must be 1 here? | |
| S | : | There should be, but if there is, then there will be more. | |
| R | : | So, how is it? | |
| S | : | So I just enter 0, because if it's 0 it fulfills the number from 1 to 100, 1x10x10 | IM3, IC2 |
| R | : | It means that the area..... 1, 0, 0 doesn't exist, right? | |
| S | : | I still think this answer | |
| R | : | So the answer is 100 is it true or not? | |
| S | : | If the number of samples should be 100 | IC2 |
| R | : | Why does it have to be 100? | |
| S | : | Because it has to be numbered 1 to 100, if for example you give 1 in front, it will be more, it could be 200 | IM3, IC2 |
| R | : | If it's 200 maybe not? | |
| S | : | It's written from number 1 to 100, if it's 200 it's impossible | IC2 |
| R | : | Ooh, so it's impossible? It has to be 1 to 100. Then after getting the sample space, what are you looking for? | |
| S | : | Then look for those that don't contain numbers 5 and 7, this means 3 digits that don't contain numbers 5 and 7, so the chance that the second digit number 5 doesn't appear, there are 8 possibilities, then the third digit is also the same, there are 8 possibilities then I multiply | IT2, IM3, IC2 |
| R | : | How do you multiply it? | |
| S | : | I multiply the probability of the first digit, hmm, the probability of the first digit, the probability of the second digit, the probability of the third digit | IT2, IM3, IC2 |
| R | : | Next? | |
| S | : | The probability is 64, the probability is the number of events per sample space, 64/100 | IC2 |

*Evaluate and re-examine how the best solution*

At this stage, the indicators of metacognitive activity in the be aware of the process and results of their thinking, in developing plans, when conducting evaluations, MI subject only achieve one indicator, namely thinking of ways to check the correctness of the results of problem-solving. Furthermore, the indicators of metacognitive activity in the section be aware of the process and results of thinking, in monitoring the implementation during evaluation, MI subjects also only achieve one indicator, namely monitoring the correctness of the results of problem-solving. Then, the indicators of metacognitive activity in the section be aware of the process and results of thinking, in evaluating actions, when evaluating, MI subjects also only achieve one indicator, namely checking the correctness of the results of the first problem-solving. However, actually in working on the questions that were done by the MI subject, the MI subject hesitated so he made a mistake, the answer to the problem should have been 63/100, but the MI subject answered 64/100. The following is an excerpt of the researcher's interview with the MI subject at the stage of evaluate and re-examine how the best solution.

| | | | |
|---|---|---|---|
| R | : | Are you sure that the answer is right? | |
| S | : | Hmm, sure | |
| R | : | How can you be sure? | |
| S | : | Yes, if the answer is correct, I don't know either, but if you look at the formula, it's already fulfilled | ET1 |
| R | : | What is the formula for finding probability? | |
| S | : | The number of possibilities divided by the number of sample spaces | ET1, EM1, EC1 |
| R | : | Many possibilities of? | |
| S | : | Many possibilities of not loading 5 and 7 | ET1, EM1 |
| R | : | So, the number of possibilities that do not contain 5 and 7 divided by the sample space.<br><br>Are you sure that the answer to this question is like this, 64/100? Are you sure about this? | |
| S | : | Let me check first | EM1, EC1 |
| R | : | How do you check? | |
| S | : | I re-read first | EM1, EC1 |
| R | : | Next? | |
| S | : | I re-read the question first (read the question). Hmm, done. | EM1, EC1 |
| R | : | Well, how is it? | |
| S | : | I'm sure | |
| R | : | So are you sure? Nothing changed? | |
| S | : | Yes, I'm sure, because it fits what you're looking for | EM1, EC1 |

However, there are differences in the metacognition activity of MI subjects who are not chess players compared to ES subjects who are chess players. From the results of research that has been done, ES subjects almost fulfill all indicators of metacognitive activity at each stage of problem-solving. The subject of ES is the subject of a chess player. In the stage of solving the problem understanding the problem, indicators of metacognitive activity that are not fulfilled by ES subjects in the section be aware of the process and results of thinking, in monitoring the implementation when understanding the problem, namely monitoring the conformity of drawings or other representations made of a given problem. Furthermore, indicators of metacognitive activity that are not achieved in the section on being aware of the process of thinking, in evaluating actions, when understanding the problem, namely checking the conformity of the drawings or other representations that have been made. In contrast to MI subjects, at the understand the problem by identifying and clarifying the problem-solving stage, MI subjects do not fulfill 4 indicators of metacognitive activity, namely thinking of prerequisite concepts that will be used in solving problems, monitoring the conformity of drawings or other representations made of a given problem, monitoring the suitability of the prerequisite concepts that will be used in solving problems and checking the conformity of the drawings or other representations that have been made.

Furthermore, ES subject at the stage of solving the problem of thinking of an action plan and building alternative solutions, indicators of metacognitive activity that are not achieved in the be aware of the process and results of thinking, in developing plans, when thinking about plans of action are estimating the time needed to solve the problem. Then, in the section on being aware of the process and results of thinking, in evaluating actions when thinking of action plans, the indicator that is not achieved is checking the suitability of the estimated time to solve the problem. Meanwhile, MI subjects at the thinking of an action plan and building alternative solutions problem-solving stage, there are 6 indicators of metacognitive activity that are not fulfilled by MI subjects, namely estimating the time needed to solve the problem, thinking of another solution to the problem, monitoring other plans for solving problems, checking the suitability of the problem-solving flow, checking the suitability of the estimated time to solve the problem and checking the suitability of other solutions to the problem. However, the most unique difference is that ES subjects are able to think of other solutions to a given problem, while MI subjects are not yet able to. This is consistent with the statement chess-training students have a greater capacity to apply their understanding of a problem's structure to other problems that are comparable in order to solve them more quickly. They are also better at categorizing problems and organizing information by developing a coherent representation of a problem (C Meloni & Fanari, 2019).

ES subject at the stage of solving the problem of implementing the action plan by choosing a settlement strategy, the ES subject achieves all the indicators in the three metacognition activities. However, MI subject at the problem-solving stage implement the action plan by choosing a settlement strategy, MI subjects do not fulfill 3 indicators of metacognitive activity, namely thinking of ways of implementing plans other ways of solving problems, monitoring the implementation of other solutions to the problem plan and checking the suitability of the implementation of other problem-solving plans. A chess player must carefully gather the information (if one piece or square is overlooked, the combination could fail), choose the pertinent information (not all pieces may be involved), plan the combination while taking into account the opponent's chances of defending, and demonstrate the validity of his deduction (Sala, Gorini, & Pravettoni, 2015).

Lastly, ES subject at the evaluate and re-examine how the best solution problem-solving stage, only three indicators of metacognitive activity were not achieved, namely thinking of ways to check the correctness of the results of other ways of solving problems, monitoring the correctness of the results of other ways of solving problems, and checking the correctness of the results of other ways of solving problems. Nevertheless, MI subject at the problem-solving stage evaluate and re-examine how the best solution, MI subject do not fulfill 3 indicators of metacognitive activity, namely thinking of ways to check the correctness of the results of other ways of solving problems, monitoring the correctness of the results of other ways of solving problems and checking the correctness of the results of other ways of solving problems. At this stage, the MI subject was different from the ES subject, the ES subject answered correctly the problem given, while the MI subject had an error in determining the final probability, even though the checking stages had been carried out by the MI subject. Chess players are skilled in drawing spatial visualization-spatial perception, part-whole perception, argumentation, and proving in the areas of problem sensitivity (Burján, 2016).

Chess players have the greatest impact on acquiring or growing metacognitive skills. When compared to other students who weren't chess players or the control group, the chess players demonstrated higher accomplishment in meta-cognitive skills and mathematical problem-solving ability (Farhad Kazemi dkk, 2012). The findings indicate that students who had not played chess had higher mean scores in areas like peer learning and help seeking than those who had (F Kazemi, 2022). Chess training enhanced not only cognitive abilities but also socioemotional abilities, particularly the capacity for self-evaluation (Aciego, García, & Betancort, 2012). Chess practice can help elementary school students improve their capacity for self-evaluation and mathematical problem-solving (Carla Meloni & Fanari, 2019). Students who played chess (the experimental group) progressed more than non-chess players (the control group) on the mathematics problem-solving final exam (posttest). Therefore, taking a chess training session helps fifth graders at a primary school become better at solving mathematics problems (Rezvani & Fadaee, 2014). According to other research, the experimental group's (chess players) proficiency in mathematics is significantly higher than that of the control group (non-chess player) (Mel, 2021). From that statement, in this study the ES subject was superior to the MI subject.

Chess appears to be a useful technique for improving students' capacity to solve mathematical problems in elementary school (Trinchero & Sala, 2016). Chess helps to make abstract math concepts more comprehensible because math and chess are isomorphic domains. A chess player needs to have high-level abilities such as planning, abstract cognition, computation of variants, strategy monitoring, and mathematical capabilities (Sala dkk, 2015). Another study discovered a strong impact of playing chess on both mathematical and metacognitive skills. This result supports the claim that chess encourages students to regulate their own thought processes in order to accomplish objectives like figuring out checkmate combinations and resolving mathematical problems. Chess may be able to help students develop their metacognitive abilities, which in turn may help them become better at solving mathematical problems (Desoete, Roeyers, & De Clercq, 2003; Kramarski & Mevarech, 2003; Veenman, Van Hout-Wolters, & Afflerbach, 2006). Chess instruction enhances the use of metacognition by both teachers and students to help students' mathematical achievement (Tachie & Ramathe, 2022). Chess may increase mental skills including reasoning, memory, thinking, focus, and problem-solving, and that improvement may help advance students' metacognitive and cognitive processes (Atashafrouz, 2019). In this study, ES subject met 28 indicators of metacognitive activity out of a total of 35 indicators of metacognitive activity. This means that ES subject achieved 80% of metacognitive activity indicators. Meanwhile, MI subject only met 19 indicators of metacognitive activity, which means MI subject only achieved 54.25% of metacognitive activity indicators. Therefore, this is evidence that the metacognitive activity in solving the problems of chess students is better than non- chess students.

## CONCLUSION

Based on the results of the research and discussion, the researcher concluded that the metacognitive abilities in solving problems of chess students were better than those of non- chess students. This is evidenced by the ES subject achieved 80% of metacognitive activity indicators, while the MI subject only achieved 54.25% of metacognitive activity indicators. This study was limited to a few research subjects considering that there were quite a lot of indicators of metacognition in problem solving, so the researchers suggested further research on metacognition in problem solving with a larger number of chess students and non-player students as research subjects. Researchers also suggest that schools should also hold chess classes or training to train students' problem-solving skills and metacognition.

## REFERENSI

Aciego, R., García, L., & Betancort, M. (2012). The Benefits of Chess for The Intellectual and Social-Emotional Enrichment in Schoolchildren. *The Spanish Journal of Psychology*, *15*(2), 551–559. https://doi.org/10.5209/rev_SJOP.2012.v15.n2.38866

Artzt, A. F., & Armour-Thomas, E. (1992). Development of a Cognitive-Metacognitive Framework for Protocol Analysis of Mathematical Problem Solving in Small Groups. *Cognition and Instruction*, *9*(2), 137–175. https://doi.org/10.1207/S1532690XCI0902_3

Atashafrouz, A. (2019). The Effectiveness of Chess on Problem-Solving, Working Memory, and Concentration of Male High School Students. *ranian Evolutionary and Educational Psychology Journal*, *1*(4), 249–258. https://doi.org/10.29252/ieepj.1.4.2

Burján, A. (2016). The Effects of Chess Eucation on Mathematical Problem Solving Performance. *Teaching Mathematics and Computer Science*, *14*(2), 153–168. https://doi.org/10.5485/TMCS.2016.0421

Cohors-Fresenborg, E., & Kaune, C. (2007). Modelling Classroom Discussions and Categorising Discursive and Metacognitive Activities. *Proceedings of CERME*, 1180–1189.

Desoete, A., Roeyers, H., & De Clercq, A. (2003). Can Offline Metacognition Enhance Mathematical Problem Solving? *Journal of Educational Psychology*, *95*(1), 188–200. https://doi.org/10.1037/0022-0663.95.1.188

Ferguson, R. (1995). Chess in Education: Research Summary. *A Wise Move' Conference*.

Ferreira, D., & Palhares, P. (2008a). Chess and Problem Solving Involving Patterns. *The Mathematics Enthusiast*, *5*(2), 249–256. https://doi.org/10.54870/1551-3440.1105

Ferreira, D., & Palhares, P. (2008b). *Let us know how access to this document benefits you . Chess and problem solving involving patterns*. *5*(2).

Goos, M., Galbraith, P., Renshaw, P., & Geiger, V. (2000). Reshaping Teacher and Student Roles in technology-Enriched Classrooms. *Mathematics Education Research Journal*, *12*(3), 303–320. https://doi.org/10.1007/BF03217091

Johnson, D. A., & Rising, G. R. (1972). *Guidelines for Teaching Mathematics*. Wadsworth Publishing Company.

Kazemi, F. (2022). The Effect of Chess Instruction on Mathematics Motivational Strategies for Learning and Error Model of Students' Problem Solving Based on Newman Model. *Journal of Algebraic Statistics*, *13*(2), 2698–2716.

Kazemi, Farhad, Yektayar, M., & Abad, A. M. B. (2012). Investigation The Impact of Chess Play on Developing Meta-Cognitive Ability and Math Problem-Solving Power of Students at Different Levels of Education. *Procedia - Social and Behavioral Sciences*, *32*(Iccs 2011), 372–379. https://doi.org/10.1016/j.sbspro.2012.01.056

Kramarski, B., & Mevarech, Z. (2003). Enhancing Mathematical Reasoning in The Classroom: The Effects of Cooperative Learning and Metacognitive Taining. *American Educational Research Journal*, *40*(1), 281–310. https://doi.org/10.3102/00028312040001281

Lester, F. (1994). Musings About Mathematical Problem-Solving Research: 1970-1994. *National Council of Teachers of Mathematics*, *25*(6), 660–675. https://doi.org/10.2307/749578

Liptrap, J. M. (1998). Chess and standard test scores. *Chess Life*, *14*.

Mel, B. (2021). Does playing chess improve mathematics scores? An experimental study among co-curricular chess students in Politeknic Kuching Sarawak. *International Journal of Advanced Research in Education and Society*, *13*(2), 9–17.

Meloni, C, & Fanari, R. (2019). Chess Training Effect on Meta-Cognitive Processes and Academic Performance. *Eric*, 387–393. https://doi.org/10.33965/celda2019_201911L048

Meloni, Carla, & Fanari, R. (2019). Chess Training Effect on Meta-Cognitive. *16th International Conference on Cognition and Exploratory Learning in Digital Age*, (Celda), 387–393. https://doi.org/10.33965/celda2019

NCTM. (2000). National Council of Teachers of Mathematics.(2000). *Principles and standards for school mathematics. Reston, VA: National Council of Teachers of Mathematics*.

Piaget, J. (1970). *Piaget's theory* (Vol. 1). Wiley New York.

Pierson, J. L. (2008). *The Relationship Between Patterns of Classroom Discourse and Mathematics Learning*. The University of Texas at Austin.

Polya, G. (2014). *How to Solve It: A New Aspect of Mathematical Method*. Princeton University Press.

Rezvani, M. A., & Fadaee, M. R. (2014). *Effect of Chess Training on Math Problem-Solving Ability of Elementary School Students*. *4*(5), 240–244.

Rott, B. (2013). Process Regulation in The Problem-Solving Processes of Fifth Graders. *Center for Educational Policy Studies Journal*, *3*(4), 25–39. https://doi.org/10.15488/1849

Sala, G., Gorini, A., & Pravettoni, G. (2015). Mathematical Problem-Solving Abilities and Chess: An Experimental Study on Young Pupils. *Sage Journals*, *5*(3), 1–9. https://doi.org/10.1177/2158244015596050

Tachie, S. A., & Ramathe, J. (2022). Metacognition Application: The Use of Chess as a Strategy to Improve the Teaching and Learning of Mathematics. *Education Research International*, 1–13. https://doi.org/10.1155/2022/6257414

Thompson, M. (2003). Does The Playing of Chess Lead to Improved Scholastic Achievement? *Issues In Educational Research*, *13*(2), 13–26. Diambil dari http://www.iier.org.au/iier13/thompson.html

Trinchero, R., & Sala, G. (2016). Chess Training and Mathematical Problem-Solving: The Role of Teaching Heuristics in Transfer of Learning. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(3), 655–668. https://doi.org/10.12973/eurasia.2016.1255a

Veenman, M. V. J., Van Hout-Wolters, B. H. A. M., & Afflerbach, P. (2006). Metacognition and Learning: Conceptual and Methodological Considerations. *Metacognition and Learning*, *1*(1), 3–14. https://doi.org/10.1007/S11409-006-6893-0