Metacognitive experience of mathematics education students in open start problem solving based on intrapersonal intelligence

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Abstract. This research aims to describe metacognitive experience of mathematics education students with strong, average, and weak intrapersonal intelligence in open start problem solving. Type of this research was qualitative research. The research subject was mathematics education students in Muhammadiyah University of Surakarta in academic year 2017/2018. The selected students consisted of 6 students with details of two students in each intrapersonal intelligence category. The research instruments were questionnaire, open start problem solving task, and interview guidelines. Data validity used time triangulation. Data analyses were done through data collection, data reduction, data presentation, and drawing conclusion. Based on findings, subjects with strong intrapersonal intelligence had high self confidence that they were able to solve problem correctly, able to do planning steps and able to solve the problem appropriately. Subjects with average intrapersonal intelligence had high self-assessment that they were able to solve the problem, able to do planning steps appropriately but they had not maximized in carrying out the plan so that it resulted incorrectness answer. Subjects with weak intrapersonal intelligence had high self confidence in capability of solving math problem, lack of precision in taking plans so their task results incorrectness answer.

1. Introduction
Mathematical problem solving is an important thing that should get teacher’s attention, especially to develop students’ ability in their problem solving, either in the real problems or mathematical problems. Mathematical problem solving is a base which determines students’ success in mathematics learning. Problem solving in mathematics learning is important thing and should be carried out by students [9]. That statement has a reason that mathematical problem solving is a medium for students to develop their ability, to build new mathematical knowledge, and to reflect mathematical problem solving process [2].

To get optimal result in problem solving, there are several problem solving steps that should be well-organized used. According to Polya [17] problem solving consists of four steps, (1) understanding the problem; (2) devising the plan; (3) carrying out the plan; and (4) looking back. This systematic problem solving steps or procedures will shape well-structured mindset of individuals in solving problem.

Problem solving is individuals’ activity or effort for finding the right solution of a problem [20]. Problem solving has a connection to thinking process. The process shows the sequence of events that
must be passed. This means that problem solving is carried out by process sequence, such as individuals should think about problem solving strategies and control every action in obtaining the right problem solving. The individuals’ awareness to get the right answer through their way of thinking is the role of metacognitive experience.

Flavel [8] defines that metacognitive experience is individuals’ awareness on strategies related to solve the problem. Metacognitive experience is the important aspect in problem solving. The reason is metacognitive experience helps individuals to devise problem solving strategies until they achieve the right result [6]. The same statement is also explained by Kuzle [13], metacognitive experience assists individuals in identifying the problem that should be solved, in looking back the real problem, and in achieving the goal or solution. Thus, metacognitive experience is individuals’ awareness to do useful things rather than do negative things in solving problems.

Jacob & Paris [12] explain that metacognitive experience includes planning, monitoring and evaluation process. Planning is individuals’ ability to plan their learning activities. The planning activities are choosing the right strategies that can affect the result and the availability of accurate information sources. Monitoring is individuals’ ability to monitor the learning process and matters related to the learning process, such as monitoring the plan steps to get the right answer. Evaluation is individuals’ ability to evaluate the effectiveness of learning strategies, such as modifying the learning strategies or discontinuing their learning activities.

Metacognitive experience in problem solving is important for students. Students who involve their metacognitive experience are more effective solving their problem; the reason is metacognitive experience is a skill that is able to make one’s thinking clearly [15]. Therefore, students should have good understanding about metacognitive experience to use in their problem solving. Anggo [2] explains that there are some factors that can stimulate metacognitive experience in problem solving, i.e. the use of challenging and non-routine mathematical problems. Open start problem is one of the problems that has challenging and non-routine characteristics because it has various ways to solve problems in which the first step in solving the problem shows its vagueness. The characteristic of mathematical problem in open start, is students do not know how to solve the problem directly, there will be hesitation about the questions, time for accomplishing problem solving steps, and time to find out the answers [14].

Problem in analytic geometry of space has the same characteristic with open start problem. The reason is problem in analytic geometry space has a single answer with various ways of solving the problem although it is not automatically known how to accomplish it. Thus, one of the problems that can stimulate metacognitive experience for mathematics education students is open start problem in analytical geometry of space.

The researcher conducted the document analysis on semester learning plan of analytic geometry of space subject on Mathematics Education Study Program, Faculty of Teacher Training and Education, at University of Muhammadiyah Surakarta. The analysis result of semester learning plan showed that teachers were more focused on the use of active learning model in carrying out the learning rather than on emphasis of students’ metacognitive experience. The analysis result was strengthened with interview result from lecturer of analytic geometry of space subject who explained that the varied learning model is needed in teaching the material of space analytic geometry. The researcher did further interview about the students’ metacognitive experience in solving the problem of analytic geometry of space, but the lecturer could not answer about it.

The researcher also conducted the document analysis of score on subject of analytic geometry of space in academic year 2016/2017. The result of document analysis showed that 34% of students get score C, D, and E (final score less than 56). These results indicate that many mathematics teacher candidates have not good understanding about metacognitive experience which makes them lack of capability in planning, monitoring, evaluation their own teaching process so that it causes students get low score on the subject of analytic geometry of space.

Furthermore, the researcher conducted a pre-survey activity to know Mathematics Education students’ metacognitive experience at Muhammadiyah University of Surakarta in solving the problem
of analytic geometry of space. The researcher conducted a task-based interview to a student who pursued analytic geometry of space subject. The selected students are those who have quite achievement and activeness, and are able to argue well related to lecturer of analytic geometry of space explanation. Pre-survey result showed that the students had not maximized the evaluation process on carrying out the plan and looking back step, so that their solving tasks result the wrong answer. This matter shows that the evaluation of individuals’ performance is not only due to adequate knowledge, but also the individual’s awareness to organize, carry out and evaluate their knowledge [19]. This awareness arises when individuals can understand themselves well so they can solve the problems effectively and efficiently. The ability of individuals to understand themselves is called intrapersonal intelligence.

Armstrong [3] explains that intrapersonal intelligence is self-knowledge to act adaptively based on the knowledge. Intrapersonal intelligence involves the ability to create accurate and realistic overview of personal strengths and weaknesses, awareness of thinking processes, and the ability to have self-discipline and self-understanding. Hoer, Bogeman, & Wallach [11] states that through strong intrapersonal intelligence individuals will be able to reflect on their own shortcomings to set useful life goals. The same statement is explained by Gangadevi & Ravi [9] that the learning experience of individuals who have strong intrapersonal intelligence tend to be independent, have self-confidence, and able to make important decisions for themselves.

Strengths and weaknesses are important aspects of intrapersonal intelligence. The strengths and weaknesses information of individuals can correct the mistakes [4]. Individuals with average intrapersonal intelligence know their strengths and weaknesses but they have not maximized the strengths and minimize the weaknesses. Habeeb & Fatema [10] explain that individuals with weak intrapersonal intelligence have not been able to reflect themselves from their shortcomings in solving a problem.

Based on the previous explanation, researcher needs to conduct the research related to metacognitive experience in open start problem solving. The aim of this research is to describe metacognitive experience of mathematics education students with strong, average, and weak intrapersonal intelligence in open start problem solving.

2. Research Methods
This research was a qualitative research. The research was conducted in Mathematics Education Study Program of Muhammadiyah University of Surakarta in academic year 2017/2018. The selected subjects were done by purposive sampling with snowball sampling. Creswell [7] explains that the purpose of selection of subjects with purposive sampling is the researchers can choose individuals as subjects of research and understand the phenomenon on their research focus. Snowball sampling is subject recruitment in which the subject can increase as time progressed depending on the research need [5]. Firstly, the selected subjects consisted of 6 students with details of two students in each intrapersonal intelligence category, and then the subjects could be increased depending on the research need. The category of intrapersonal intelligence was obtained based on questionnaire developed by researcher based on aspects and indicators written by Alder [1].

Other instruments in this research were open start problem solving tasks on analytic geometry of space and interview guidelines. The open start problem solving tasks given to the subjects during the interview are as follows.

Task of open start I problem solving
Given points \( P(0,6,4), Q(0,−1,4), R(−5,0,0), \) and \( S \) lies on the \( x \)-axis. Determine the point \( S \) so that \( QS \) intercrosses perpendicular to \( PR \), and then find the distance between \( QS \) to \( PR \)!

Task of open start II problem solving
Given points \( P(0,6,4), Q(0,−1,4), R(−5,0,0), \) and \( S \) lies on the \( x \)-axis. Determine the point \( S \) so that \( QS \) intercrosses perpendicular to \( PR \), and then find the distance between \( PS \) to \( QR \)!
**Task of open start III problem solving**

Determined points $A(1,2,3)$, $B(0,0,1)$, and $C(x_C, y_C, 7)$ lies on a line $g_1$. Given a line $g_2$ that that passes through the point $P(2,0,0)$ and perpendicular plane $V : 5x - 2y + 3z - 3 = 0$. Determine the distance point $C$ to line $g_2$!

All instruments in this research fulfilled the criteria since they were validated by experts of their fields. Research data were obtained through task-based interview and documentation of students’ work. Data validity used time triangulation. Testing credibility with time triangulation is carried out by collecting data at different times [18]. The researcher conducted two task-based interviews that held at different times. The researcher would add third task-based interviews, if the first task-based interview result found the difference from the second result. Data analyses were done through data collection, data reduction, data presentation, and drawing conclusion. Analysis model of this research used interactive analysis. This means that data reduction, data presentation, and conclusion drawing are reciprocal [5]. The research methods which described above is illustrated by Figure 1 below.

![Flowchart of the research methods](image)

**Figure 1.** Flowchart of the research methods

3. **Research Results**

Researcher conducted task-based interviews on subjects with their intrapersonal intelligence tendency. Task-based interview activities were conducted to determine the metacognitive experience of math education students in solving open start problems. The result of metacognitive experience description of each subject is shown as follows.

3.1. **Metacognitive Experience of Mathematics Education Students with Strong Intrapersonal Intelligence in Open Start Problem Solving**

a. Understanding the problem

The subjects understood the problem by reading the question, writing down coordinate geometry information and the question, and finding the keywords to help them in solving the problem. The interview results with the subjects at understanding the problem are presented as follows ($P =$ researcher; $T =$ subjects with strong intrapersonal intelligence).
Have you understood the given problem?

Yes I have. The problem that should be solved is calculating the distance of line QS to PR.

What do you do to understand the problem?

Reading the question at first, understand the coordinate geometry information and the question, searching for keyword related to the lesson material.

Figure 2. The task result of strong intrapersonal intelligence subjects on understanding the problem

Data T1.1 indicates that the subject understands the problem. How subject understands the problem is shown by data T1.2. The subject understands the problem by writing down coordinate geometry information and the question as seen in Figure 2.

b. Devising a Plan

The subjects devised a plan by thinking the steps through imagination and thinking of formulas to solve the problem. Excerpts of interview with subjects on devising a plan are presented as follows.

P2.1: What are your plans for solving the given problem?
T2.1: Determine the point S at first and then make the plane that passes through QS and crosses perpendicular PR.

P2.2: Why do you plan on it?
T2.2: Because QS and crossing perpendicular PR so it can be found the distance with point space concept to plane.

P2.3: What is on your mind when you devise a plan?
T2.3: Imagining the distance of two perpendicular lines crossing then thinking a usable formula.

Data T2.1 shows the subject knows the steps taken to solve the problem. Why subject choose plan T2.1 is explained by data T2.2. How subject devise the plan is shown by data T2.3.

c. Carrying Out The Plan

Subjects solved the problems which were appropriate with the plan. Subjects carry out a step-by-step plan for solving. Subjects were able to accomplish the tasks correctly, although the subjects did not use effective and efficient strategies as shown in Figure 3.

d. Looking Back

The subjects checked the answer by looking back the task results. This step was taken to convince the correctness of the answers. Excerpts of interviews with the subjects on looking back are presented as follows.

P4.1: What are you doing? (This question was asked when the researcher saw the subject moving the pencil from top to bottom of the answer sheet)
T4.1: Looking back the steps and the calculations in order to make sure the correctness of my answer.
P4.2: Are you sure that the answer that you write is correct?
T4.2: Yes I’m sure that my answer is correct.
P4.3: How do you know your answer is correct?
T4.3: Because the steps are correct, the formula is correct, and the calculation is correct.

The subjects are looking back the task results. Why subject looks back are shown by data T4.1. Data T4.2 indicates that the subject believes the correctness of the answer. Why the subject believes the correctness of the answer is shown by data T4.3.

3.2. Metacognitive Experience of Mathematic Education Students with Average Intrapersonal Intelligence in Open Start Solving Problem

a. Understanding the problem

The subjects understood the problem by reading the question, writing down coordinate geometry information and the question. The interview results with the subjects on understanding problem are presented as follows (P = researcher; S = subjects with average intrapersonal intelligence).

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Figure 4. Task result of subject with average intrapersonal intelligence on understanding the problem
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Data S1.1 shows that subject understands the given problem. How subject understands the problem is shown by data S1.2. When subjects understand the problem they write coordinate geometry information and the question as seen in Figure 4.

b. Devising a plan

Subjects devised a plan by thinking the steps through imagination and thinking of formulas that could be used to solve the problem. Excerpts of interview with subjects on devising a plan are presented as follows.

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P2.1: What are your plans to solve the given problem?
S2.1: Determine point S and then make a plane that passes through PR and find the distance of QS to the plane.
P2.2: Why do you plan it?
S2.2: Because QS crosses perpendicular to PR.
P2.3: What is on your mind when you devise a plan?
S2.3: Finding ways and thinking about the steps that will be used to solve the problem.
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Data S2.1 shows that subject knows the steps taken to solve the problem. Why subject choose plan S2.1 is explained by data S2.2. How subject devises a plan is shown by data S2.3.

c. Carrying out the plan

Subject solved the problems which were appropriate with the plan. Subjects carried out a step by step plan, it was proved that subjects seemed changing their answers several times because they doubted. Subject believed that their answers were correct although the results were incorrect. The results of subjects’ task on carrying the plan are shown in Figure 5.
d. Looking back

Subjects believed the correctness of the answer by looking back the steps of work results. Excerpts of the interview with subjects on looking back step are presented as follows.

P4.1: Are you sure that your given answer is correct?
S4.1: Yes, I am sure.
P4.2: How do you know that your answer is correct?
S4.2: Because the steps are correct.

The subjects are looking back the work results. Data S4.1 shows that subject believe his answer was correct. Why subject believes the correctness of his answer is shown by data S4.2.

3.3. Metacognitive Experience of Mathematics Education Students with Weak Intrapersonal Intelligence in Solving Open Start Problem

a. Understanding the problem

Subjects understood the problem by reading the question, writing down coordinate geometry information and the question. The interview results with the subjects on understanding the problem are presented as follows (P = researcher; R = weak intrapersonal intelligence subjects).

P1.1: Have you understood the given problem?
R1.1: Yes, I have. The problem that should be solved is calculating the distance of PS line to QR.
P1.2: What do you do to understand the problem?
R1.2: Reading the question at first, understand the coordinate geometry information and the question.

Data R1.1 shows that the subject understand the given problem. How subject understands the problem is shown by data R1.2. The subject understands the problem by writing coordinate geometry information and the question as seen in Figure 6.

b. Devising a plan

The subjects devised a plan by thinking the steps through imagination and thinking of formulas to solve the problem. Excerpts of interview with subjects on devising a plan are presented as follows.

P2.1: What are your plans to solve the given problem?
R2.1: Determine the point S then find the distance PS to QR.
P2.2: Why do you plan it?
R2.2: Because finding distance of PS to QR the coordinate of point S should have been known.
P2.3: What is on your mind when you devise a plan?
R2.3: Thinking about the steps that will be used to solve the problem.

Based on data R2.1, subject knows the steps to solve the problem. Why subject choose plan R2.1 is explained by data R2.2. How the subject devise a plan is shown in data R2.3.
c. Carrying out the plan

Subjects solved the problems which were appropriate with the plan. Subjects carried out a step-by-step plan for the solving. Subjects believed the correctness of his answer, although the answers were still not correct. The subjects’ task results on carrying out the plan are shown in Figure 7.

Figure 7. Task result of subject with weak intrapersonal intelligence on carrying out the plan

Subject make the plane passing through PS. The task result of the subject is shown in Figure 7 which shows use of formula and step to make the plane that passes through PR are not correct. This result shows that subject has not carried out the solving steps correctly.

d. Looking back

The subjects checked the answer by looking back the work results. Excerpts of interviews with the subjects on looking back step are presented as follows.

P4.1: Are you sure that your answer is correct?
R4.1: Yes, I am sure my answer is correct, although the distance is zero
P4.2: How do you know that your answer is correct?
R4.2: Because the steps and the formula are correct.

Subjects look back the result of their works. Data R4.1 shows that subject believes his answer is correct. Why subject believes his answer is shown by data R4.2.

4. Discussion

The research result toward the subjects with strong intrapersonal intelligence showed that subjects carried out planning, monitoring, and evaluation process on understanding problem step. This was proved that the result of data aimed to know the correctness of core question and the statement sentence related to the question. In devising a plan step, subjects did appropriately planning, monitoring, and evaluation process. It was shown that students were able to plan the steps, able to choose the formulas and their initial knowledge to solve the problem. In carrying out the plan, subjects did planning process appropriately but they had not yet maximize the process of monitoring and evaluation. This was proved that the result of subjects’ tasks used less effective and efficient strategy, although the final answers of the task were correct. In looking back step, subjects did planning, monitoring, and evaluation process well. It was applied by subjects to make sure their answers were correct.

Based on the result, subjects with strong intrapersonal intelligence had high self confidence that they were able to solve problem correctly, able to do planning steps and able to solve the problem appropriately. This is appropriate with Gangadevi & Ravi [9] statement. They state that individual learning experience who have strong intrapersonal intelligence tend to be independent, have self-confidence, and able to make important decisions for themselves.

The result on subjects with average intrapersonal intelligence showed that subjects did planning, monitoring, and evaluation process appropriately on understanding the problem step. It could be seen from the data obtained showing that the coordinate geometry information and the question were correct, as well as the statement sentence was in accordance with the question. In devising a plan step, subjects carried out the process of planning, monitoring, and evaluation appropriately. This was proved that subjects were able to decide the formula and initial knowledge used to solve the problem. In carrying out the plan, subjects had not carried out the planning process correctly and maximized the monitoring and evaluation process. It was shown that subjects were not aware of an error so they did not make improvements. The subjects had not carried out well the planning, monitoring and evaluation
process on looking back step. This was shown that the subjects only looked back the steps to do without looking back the calculation and the formula used so that their final answers were incorrect.

Based on the result, subjects with average intrapersonal intelligence had high self-assessment that they were able to solve the problem, able to do planning steps appropriately but they had not maximized in carrying out the plan so that it resulted incorrectness answer. It was proved that subjects with average intrapersonal intelligence had not yet maximized their strength and minimized their weakness so they could not maximized their solving plan. Strength and weakness are important aspects of intrapersonal intelligence; through those aspects person can correct the mistake [4]. The reason is intrapersonal intelligence is the ability to understand and apply self-discipline in order to develop the problem-solving strategies based on their limitations [16].

The result of the subjects on weak intrapersonal intelligence showed that subjects did planning, monitoring, and evaluation process appropriately on understanding problem step. It was shown that data obtained contained about coordinate geometry information and statement sentence which were appropriate with the question. In devising a plan, subjects had not carried out planning process correctly. In addition, subjects had not maximized yet monitoring and evaluation process. It was shown that subjects were incapable to give reason why those planning were chosen. In carrying out the plan step, subjects solved the problem based on the previous plan. In looking back step, subjects checked the answer by looking back the task results. Subjects believed the correctness of their answer, although their answers were incorrect and very out of appropriateness with the question.

Based on result above, subjects with weak intrapersonal intelligence had high self confidence in capability of solving math problem, lack of precision in taking plans so their task results incorrectness answer. The result has in accordance with Habeeb & Fatema’s statements [10], individuals who have weak intrapersonal intelligence have not been able to reflect themselves from their weaknesses in problem solving.

5. Conclusion
Students with strong intrapersonal intelligence had high self confidence that they were able to solve problem correctly, able to do planning steps and able to solve the problem appropriately. Students with average intrapersonal intelligence had high self-assessment that they were able to solve the problem, able to do planning steps appropriately but they had not maximized in carrying out the plan so that it resulted incorrectness answer. Students with weak intrapersonal intelligence had high self confidence in capability of solving math problem, lack of precision in taking plans so their task results incorrectness answer.

Educators are expected to have a good understanding of metacognitive experience because metacognitive experience is important for students. Students who involved their metacognitive experience are more effective solving their problem and able to solve the problem appropriately.

6. Open Problem
Mathematics teacher are expected to create learning that can enhance metacognitive experience of students. Can Android media enhance students metacognition?

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References
[1] Alder H 2001 Boost Your Intelligence (Jakarta: Erlangga)
[2] Anggo M 2011 Pelibatan Metakognisi dalam Pemecahan Masalah Matematika Edumatica 1 25-32
[3] Armstrong T 2009 *Multiple Intelligences in the Classroom* (USA: Alexandria)

[4] Azid N H & Yaacob A 2016 Enriching Orphans’ Potentials through Interpersonal and Intrapersonal Intelligence Enrichment Activities *International Journal of Instruction* 9 17-32

[5] Budiyono 2017 *Pengantar Metodologi Penelitian Pendidikan* (Surakarta: UNS Press)

[6] Chimuna L L & Johnson I. D 2016 Assessing Students’ Use of Metacognition during Mathematical Problem Solving Using Smartpens *Educational Research: Theory & Practice* 28 22-36

[7] Creswell J W 2012 *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research* (Upper Saddle River: Pearson Education, Inc)

[8] Flavell J H 1979 Metacognition and Cognitive Monitoring: A new Area of Cognitive E-Developmental Inquiry *American Psychological* 31 906-911

[9] Gangadevi S & Ravi 2014 Multiple Intelligence Based Curriculum to Enhance Inclusive Education to Bring Out Human Potential *International Journal of Advanced Research* 2 619-626

[10] Habeeb K T & Fatema M 2016 Affect of Intrapersonal and Interpersonal Awareness Dimensions of Emotional Intelligence on Stress Management of Adolescents *International Journal of Applied Research* 2 589-59

[11] Hoer T R Bogeman S & Wallach C 2010 *Celebrating Every Learner* (San Francisco: Jossey Bass)

[12] Jacob J E & Paris S G 1987 Children’s Metacognition About Reading: Issues in Definition, Measurement, and Instruction *Educational Psychologist* 22 255-278

[13] Kuzle A 2013 Patterns of Metacognitive Behavior during Mathematics Problem Solving in a Dynamic Geometry Envoronment *International Electronic Journal of Mathematics Education* 8 20-40

[14] Monaghan J, Pool P, Roper T and Threlfall J 2009 Open-Start Mathematics Problems: An Approach to Assesing Problem Solving *Oxford University Press on behalf of The Institute of Mathematics and Its Application* 28 21-31

[15] Ozsoy G and Ataman A 2009 The Effect of Metacognitive Strategy Training on Mathematical Problem Solving Achievement *International Electronic Journal of Elementary Education* 1 68-83

[16] Perez M M P and Ruz N R 2014 Intrapersonal Intelligence and Motivation in Foreign Language Learning *European Scientific Journal* 10 142-150

[17] Polya G 1973 *How to Solve It* (Princeton, New Jersey : Princeton University Press)

[18] Satori D and Komariah A 2013 *Metode Penelitian Kualitatif* (Bandung: Alfabeta)

[19] Telaumbanua Y N, Sinaga B, Mukhtar and Surya E 2017 Development of Mathematics Module Based on Metacognitive Strategy in Improving Students’ Mathematical Problem Solving Ability at High School *Journal of Educational and Practice* 8 73-80

[20] Wismath S L 2015 Collaborative Learning in Problem Solving: A Case Study in Metacognitive Learning *The Canadian Journal for the Scholarship of Teaching and Learning* 6 1-17