Metacognitive activities in solving linear programming problems

F Hakim¹, Murtafiah¹, A Muliana¹, and M Y Amar²

¹Universitas Sulawesi Barat, Majene, Indonesia
²Faculty of Economics and Business, Hasanuddin University, Makassar, Indonesia

Email: fauziahhakim@unsulbar.ac.id

Abstract. Linear Programming is mathematical subject that are studied both at the secondary school level and the college level. In linear programming material, students are required to have good problem solving skills and problem solving is closely related to metacognitive activities. This study aims to describe the metacognitive activities of prospective teacher students in solving mathematical problems, especially linear programming. The subjects in this study consisted of two students with high mathematical abilities and good communication skills and expressions of opinion and had completed the Linear Programming course. Based on the results of giving tests and interviews to the subjects, it was concluded that metacognitive activities in the form of planning the thinking process, monitoring the thinking process, and evaluating the processes and results of thinking appear during the process of solving Linear Programming problems conducted by prospective teacher students.

1. Introduction

Consider the problem: “To make transmigration a success in the Province of Q, the government plans to open up new land that can be occupied and used as agricultural land. There are 3 areas that can be cleared, namely regions 1, 2 and 3. Agricultural output of each region is limited by two things, namely the area of land that can be drained from irrigation and the amount of water that can be allocated for irrigation. Areas 1, 2 and 3 have land area (in hectares) and irrigation water allocation (in cubic meters) respectively 400 and 600, 600 and 800, and 300 and 375. The types of plants that can be developed in these areas include sugar cane, cotton, and wheat, which differ from each other in terms of net yield per hectare and the amount of water consumed. In addition, there are provisions of agricultural materials regarding the maximum land allotment that can be used for each type of plant. Namely for each type of sugarcane, cotton, and wheat plants need 600, 500, and 325 for maximum land ration (in hectares), 3, 2, and 1 for water consumption (in cubic meters), and 400, 300, and 100 (thousands per hectare). How many hectares are allocated to the three types of crops so that the government is able to optimize the three lands?” The example problem above is a common problem solved using a Linear Programming. Linear Programming is mathematical subjects that are taught both at the high school and college levels. Linear programming is a way to solve the problem of limited resources among competing activities in the best way possible [1]. Linear programming can minimize deviations between expected and actual demands, which are suitable for real time quasi applications because of low computing costs [2]. The advantage in linear programming is that it can use many variables so that various possibilities for obtaining optimal utilization of resources can be achieved, and the objective function can be flexed according to research objectives or consists of available data [3].
Linear programming is closely related to good problem solving skills. The problem solving process that uses high-level thinking processes requires not only cognitive knowledge, but also mental and metacognitive processes. Arsyad (2016) states that a person's success in solving problems, among others, depends very much on his awareness of what they know and how he does it [4]. It was further revealed that the process of a person learning how to learn and think about their own thinking in order to build cognitive strategies and realize their use in the learning process is called metacognitive. Brown in Rozen and Kramarski (2018) revealed that metacognition enables students to plan and allocate learning resources, monitor their own level of knowledge and skills, and evaluate their own learning levels at various points during learning acquisition [5]. Metacognitive aspects are very important aspects in problem solving because metacognitive abilities are important in decision making [6]. Self-training in metacognitive behavior can improve students' mathematical achievement, especially in terms of problem solving abilities [7–11]. The problem solving ability of students in Indonesia still tends to be low. This can be seen from the results of the PISA which measures the mathematics literacy of students which is very closely related to solving mathematical problems. The PISA results in 2015 placed Indonesian students' mathematical abilities ranked 63 out of 72 countries. The low mathematical ability can also be seen from the Education Assessment Center Data of the Ministry of Education and Culture which shows that the average value of the National Examination for mathematics subjects in the academic year 2017/2018 is the lowest compared to other subjects with an average score of 43.34. Based on the metacognitive linkages with problem-solving abilities and the close ability of problem solving in Linear Programming taught at the secondary or tertiary level, it is important to do a description of the metacognitive activities of prospective teacher students in solving Linear Programming problems.

2. Method

2.1. Research approach
This research is a descriptive study with a qualitative approach that aims to describe the metacognitive activities of prospective teacher students in solving Linear Programming problems.

2.2. Research subjects
This research was conducted on students of the Mathematics Education Class of 2017 of Universitas Sulawesi Barat. The selection was conducted with the consideration that the student must have high mathematical abilities and good communication skills and expressions of opinion and have completed the Linear Programming course. The subjects chosen in this study consisted of 2 students.

2.3. Data collection techniques
Data collection in this study was conducted with two techniques, namely tests and interviews. The test given is a problem solving test that is used to describe or find out the metacognitive activities of students in solving the Linear Programming problems. Interviews are used to explore in-depth information about metacognitive activities of students in problem solving. Interviews were conducted after the research subjects completed the problem solving test.

2.4. Data analysis techniques
Data analysis technique used refers to the model of Miles and Huberman [12], namely: (1) data reduction, (2) data exposure, and (3) drawing conclusions.

3. Results and Discussion
Based on the data analysis, the results show that the three metacognitive activities appear in the process of solving Linear Programming problems at each stage of problem solving based on Polya's opinion.
3.1. Planning the thinking process
In the stage of understanding the problem, the two subjects carry out planning activities by first reading the problem given to understand what information is known from the problem. Subject Ms read the problem once to understand the problem while the subject Mn read the problem given twice to understand the problem. At the stage of devising a plan, planning activities can be seen when the two subjects think of what techniques will be used in solving problems, think of the flow plan of resolution, and the time needed to solve the problem. Both subjects planned to use graphical techniques to solve problems. The intended flow plan is to think about how to draw a graph of each constraint function written and determine the intersection of the graph. At the stage of carrying out the plan, planning activities are carried out by the two subjects when thinking of making an inequality form of each obstacle function, then the subject will think of describing each such equation in a Cartesian diagram and determining the intersection of the graphs. Based on these intersection points, the two subjects plan to insert intersection points into the objective function equation to determine the intended maximum and minimum values. At the stage of looking back, planning activities are carried out when the subject thinks to double check the compatibility between the information provided and what is asked with the completion steps undertaken.

3.2. Monitoring the thinking process
In the stage of understanding the problem, monitoring activities of the research subjects in understanding the problem can be seen when the subjects write information that they know exactly on the answer sheet provided, this is then validated from the results of the interview. At the stage of devising a plan, the monitoring activities of the two subjects are carried out by checking the possibility of no intersection of the inequality of the existing constraint functions. At the stage of carrying out the plan, monitoring activities can be seen when both subjects write each completion plan carefully. Subjects describe each constraint function carefully in a Cartesian diagram then determine the cut point from each graph. To determine the cut point, Subject Ms used substitution elimination methods, whereas subject Mn used substitution techniques. After finding the point of intersection, both subjects substitute their value to the objective function to get the maximum benefit. In the looking back stage, monitoring activities are carried out by both subjects checking the compatibility between what was requested and the answers obtained and monitoring each step of the completion of the apparatus has been done correctly.

3.3. Evaluating the processes and results of thinking
In the stage of understanding the problem, the evaluation activities of the two subjects are carried out by re-checking the suitability of the information that has been written/disclosed with the information available on the given problem. At the stage of devising a plan, the evaluation activity can be seen when both subjects look back at the problem when investigating the suitability of the problem-solving flow plan and say that the problem-solving flow plan is appropriate. At the stage of carrying out the plan, the evaluation activities are carried out by checking again whether the calculations carried out in the completion are correct. In the looking back stage, evaluation activities are carried out by checking again whether the steps taken in solving the problem are correct.

4. Conclusion
Based on the results of the research described in the previous section, it can be concluded that the three metacognitive activities, that are planning the thinking process, monitoring the thinking process, and evaluating the process and results of thinking appear in each stage of problem solving in the Linear Program conducted by prospective teacher students.

Acknowledgments
The authors would like to acknowledge Universitas Sulawesi Barat, especially for Faculty of Teacher Training and Education and Study Program of Mathematics Education for their support.
References

[1] Heizer J and Render B 2005 Manajemen Operasi (Terjemahan) *Salemba Empat, Jakarta*

[2] Soares F J, Almeida P M R and Lopes J A P 2014 Quasi-real-time management of Electric Vehicles charging *Electr. Power Syst. Res.* **108** 293–303

[3] Supriyadi S, Muslimat A, Pratama R and Ramayanti G 2017 Implementasi Linear Programming Untuk Memaksimalkan Keuntungan *Prosiding Seminar Nasional Riset Terapan| SENASSET* pp 183–9

[4] Arsyad N 2016 Model Pembelajaran Menumbuhkembangkan Kemampuan Metakognitif *Makassar Pustaka Refleks.*

[5] Tzohar-Rozen M and Kramarski B 2014 Metacognition, motivation and emotions: Contribution of self-regulated learning to solving mathematical problems *Glob. Educ. Rev.* **1**

[6] Du Toit S D and Du Toit G F 2013 Learner metacognition and mathematics achievement during problem-solving in a mathematics classroom *TDJ. Transdiscipl. Res. South. Africa* **9** 505–18

[7] Barbacena L B and Sy N R 2015 Metacognitive model in mathematical problem solving *BU Fac. e-Journal* **12** 16–22

[8] Izzati L R and Mahmudi A 2018 The influence of metacognition in mathematical problem solving *Journal of Physics: Conference Series* vol 1097 (IOP Publishing) p 12107

[9] Kramarski B, Mevarech Z R and Arami M 2002 The effects of metacognitive instruction on solving mathematical authentic tasks *Educ. Stud. Math.* **49** 225–50

[10] Özsoy G and Ataman A 2017 The effect of metacognitive strategy training on mathematical problem solving achievement *Int. Electron. J. Elem. Educ.* **1** 67–82

[11] Nancarrow M 2004 Exploration of metacognition and non-routine problem based mathematics instruction on undergraduate student problem solving success

[12] Sugiyono 2015 *Metode Penelitian Kuantitatif Kualitatif dan R&D* (Bandung: Penerbit Alfabeta)