THE ROLE OF LINEAR PROGRAMMING LEARNING ACTIVITY USING MATHEMATICAL MODELLING

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Abstract

This research is aimed at figuring out the role of learning activity using mathematical modelling in order to help pupils comprehend the linear programming. This research is conducted to the XI grade students of Xaverius 1 Palembang Senior High School. The learning implementation is conducted in XI Science class, which consists of 38 students. This research involves the mathematics teacher who acts as a model teacher to teach linear programming material. The method used in this research is the design research. The data are collected through video recording, taking picture during the learning process, students activity sheet, observation sheet, interview, and field notes during the learning process. The research result states that learning activity using mathematical modelling is benficial in providing the students opportunity to construct the linear programming knowledge by their own selves. Through independently thinking, students are given opportunity to express their idea about linear programming problem using mathematical modelling learning. Next, by asking the teacher, reading books, doing group discussion, and getting teacher's reinforcement, the students are enable to enlarge the comprehension of linear programming.

INTRODUCTION

Mathematics has an important role in various disciplines and advances of the human mind. Rapid According to [1], mathematics is the science about how to think and manage logic, both quatitatively and qualitatively. The better and more qualified Mathematics learning process at school is compulsory. Many mathematics learning materials have been taught to the students since they were in kindergarten until they are in senior high school, one of which is linear programming material.

Linear programming is a branch of mathematics which is often applied in daily life, among other things, in economic field, industry, and trade. Linear programming is a part of applied mathematics (operational research) with the mathematical modelling consisting of linear equations or linear inequalities, which includes designing program to solve various daily life problems [2].

There are many problems faced by the students in learning the linear programming. According to [3], linear programming is one of the materials which is difficult for the students to understand. It has something to do with the prerequisite materials that have to be matered, such as linear equations and linear inequalities, and the students's difficulty in understanding the story question. [4] adds that the linear programming is difficult to do since it has story questions. It happens as the students are not really understand how to change verbal sentences into mathematical modelling.

According to [5], the difficulty in learning mathematics is due to the mathematics which is not related to the daily life. In every moment, mathematics learning should be started with the problem identification which is related to the situation (contextual problem). Learning linear program concept application in contextual problem needs an aid that can make it easier and faster in solving linear programming problems. The aid addopted in this research is the mathematical modelling steps proposed by [6]. [6] explains that there are seven steps to design question in the form of mathematical modelling, namely (1) constructing the problem given, (2) simplifying/symbolizing, (3) designing mathematical modelling, (4) working mathematically, (5) exploring, (6) validating, (7) exposing/presenting). Blum's seven steps signify that there is an interconnection between real world problems and mathematics in various contexts of daily life.

Mathematical modelling according to [7] is a process of representing real world problems in mathematical in an attempt to find solutions to the problems. Mathematical modelling is one of steps in problem solving. Designing model is an essential step since the model resulted determines the accuracy of the next process and even the result gotten. During constructing model, students learn the meaningfulness of mathematics and skill to apply the perfected mathematics [6] In mathematical modelling, real context is applied in general form and open problem to construct the strength of mathematical modelling which is collaborated, adapted, and applied in other contexts [8].

Linear programming is a part of applied mathematics (operational research) with the mathematical modelling consisting of linear equations or linear inequalities, which includes designing program to solve various daily life problems [3]. Meanwhile, according to [9], linear programming (also called: linear optimization) is a program that can be applied to solve the optimization program.

In conclusion, mathematical modelling can be applied to overcome problem in linear programming materials.

METHODOLOGY

The method adopted in the research is design research method [10]. The procedures used in this research consists of three phases, namely, preparation for the experiment and preliminary design, design experiment, and restropective analysis.

The subjects of this research are 38 XI Science class students of Xaverius 1 Palembang Senior High School. This reserch involves a model teacher to teach the linear programming material using mathematical modelling instructional design. The data collecting technique consists of video recording, pictures documentation, student activity sheet, observation sheet, interview, and field notes.

RESULT AND DISCUSSION

Preparing for the Experiment and Premlinary Design

In this phase, lesson plan, student activity sheet, teacher instruction, and test sheet are developed. The activity includes: (1) Reviewing literature, namely, content standard of 2013 curriculum for Senior High School, which consists of sylabus, Core Competence, Basic Competence, and Competence Achievement Indicator for linear programming material); (2) Examining the preliminary skill of XI class students who are supposed to be able to differentiate the linear equations and linear inequalities and to be able to draw the linear equations and linear inequalities in the Cartesian plane, which the students need in mastering the linear programming yet deal with difficulty in modelling the story question into mathematics. The students's learning strategy is mostly still dependent to the teacher's assistance. The learning process is mostly teacher-centered. This preliminary situation meets the prerequisite to design the mathematical learning using mathematical modelling, where the learning process is student-centered; and (3) Designing instrumets, namely, student activity sheet, pre-test sheet, and post-test sheet, which is the additional information over the student's comprehension on the linear programming. The power point presentation is used as the learning aid. Learning activity guide and teacher's instruction is used as the learning guide. Observation sheet is used as a guide in observing the learning process during the research and research schdule.

Student Activity Sheet includes three activities, namely, activity 1, which takes modelling step 1 to 3, activity 2, which takes modelling step 3 to 4, activity 3, which takes modelling step 5 to 6. Modelling step 7 is used in every activity since at the end of every activity, presentation is conducted.

The design experiment

Pre-test

The purpose of giving the pre-test is only to figure out the student's preliminary knowledge and skill about mathematical modelling and linear programming. In the pre-test, only 3 students answer the questions. Meanwhile 3 other students do not answer the questions. The answer of student 1 has been complete (drawing graph and determing the maximum and minimum price). Student 1 uses corner point test in determining the maximum and minimum price. Student 2 only answers until constructing the mathematical modelling. The minimum and maximum price have not been determined in the graph. Student 2 has not answered the question from the pre-test. Meanwhile, student 3 only writes the information gotten from the question in the` pre-test. There is no answer to determine the minimum and maximum price of purchasing tablet.

Pilot Experiment

Piloting experiment is conducted towards a group consisting of 6 students whose skills vary. The students considered having superior skill are Jovianto Saputra and Roselin Yosefa; the students considered having mediocre skill are Della Angela and Dona Flora, and the students considered having inferior skill are Bagas Yoga and Febyo Andriano. All these students are from class XI science 8, which is not the experiment class.

This phase consists of three activities. Activity 1 starts with the teacher explains the material that will be learnt and the method that will be used. Students do activity sheet , which has been prepared by the teacher. The students face the difficulty when they do activity sheet 1. In the second step, the students find it difficult in answering question number 1 and number 2. Question "How many adult tickets are sold?", The students answer $x \leq 750$. Then, group discussion takes place. The students discuss and find out the answer from the second step. In the third step for question number 3 and 4, the students answer by assuming the area of an adult spectator and a child spectator. The students's answers vary according to the assumption of each student. According to the finding of the observation, video recording, activity sheet for activity 1, the students are able to determine the mathematical modelling, constraint function, and objective function of the linear programming problem.

Activity 2 starts with the teacher reminds the students of activity 1. Then, the students do activity 2. The students re-determine the mathematical modelling, constraint function, and objective function as they did in activity 1.Next, the students determine the X-intercept and Y-intercept from the constraint function which have been found out in the Cartesian plane. In the step 4 for question number 2, The student named Jovianto is able to draw the graph of the constraint function correctly. The five other students do it, yet it is incorrect and incomplete.

Activity 3 is the apperception of the material which is learnt in the previous activity. The students re-determine the mathematical modelling, constraint function, and the objective function as they did in activity 1. Next, the students determine the X-intercept and Y-intercept of each constraint which has been found as in activity 2. Then, the intercepts of the constraint function which have been found out are drawn in the Cartesian plane. After drawing it, the students determine the feasible region. In activity 3, the students determine the maximum and minimum income and the total tickets sold as well for adult and child spectators. According to the finding of activity 3 in completing the student activity sheet for activity 3, the students are able to comprehend activity 1 and activity 2.

Revision of the instrument

The revision of the student activity sheet for activity 1: the first modelling step (constructing): the initial question is "what information can be infered from the problem above?" after this question is given, the students are given the question "what problems are going to be figured out? The question number 3 in step 1 is omitted since this question is only repetition of question number 1 and number 2. Question 3 makes the students confused to understand the long and repetitive problem sentence. The second modelling step (simplifying/structuring) for qusetion number 1 and number 2: the sentence is changed into "Has the number of adult tickets and children tickets sold been already known?. If the sentence is not changed, the students will find it difficult to apply it in the form of variable the number of the adult and children tickets sold. In the third modelling step(mathematising the students are given an additional question in order that they will not be confused when they assume the problem. The question is "Has the area for an adult spectator and child spectator been known? In the forth modelling step (working mathematically), the students are given a table so that they only fill the information from step 1 to step 3 into the table. If the table hasn't been known, the students will be confused and find it difficult to construct the mathematical modelling.

The revision on the student activity sheet for activity 2 is on question number 2, number 3, and number 4. They are combined in order that the students do not find the difficulty in determining the answer: "Draw on the Cartesian plane the intercepts which have been made on number 1, determine the feasible region of the graph, and label the points at the corner of the feasible region.

The revision of the learning activity is the apperception and to remind the students of the learning time spent, namely, using mathematical modelling, the students get the information about how to complete the student activity sheet 3. Next, the students do activity sheet 3 which has been revised, which is started with the guidance to construct the mathematical modelling, determine the constraint function and objective function, draw the graph function, and determine the feasible region, and eventually determine the maximum and minimum value.

Teaching Experiment

The learning implementation is conducted through the learning activities. The learning activity uses mathematical modelling. Each activity has different modelling steps. Activity 1(step 1 to step 4, and step 7), activity 2 (step 4 and step 7), and activity 3 (step 5 to step 7).

Activity 1 aims at understanding mathematical modelling, objective function, and constraint function of the linear programming using the first modelling step to the forth modelling step. In step 3 for problem number 4 and number 5, the students have different answers. The answers to question number 4 and number 5 are in accordance with the the assumption of each student.

The students are able to measure and associate themselves as spectators so that they are able to determine the area needed by an adult spectator and a child spectator, as shown in the picture below.

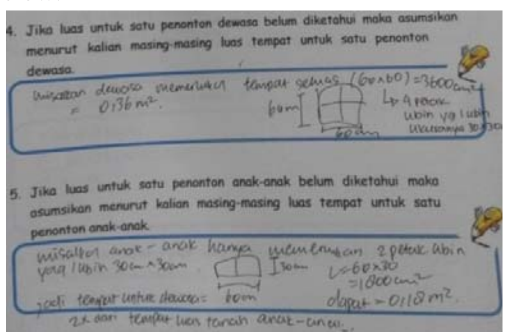

Figure 1. The students's answer to step 3 number 4 and 5

However, some students have different answers. Christalia assumes that the area for an adult spectator is 60 cm X 60 cm, whereas the area for a child spectator is 60 cm X 60 cm. The students have different answers, however, they have the same problem solving, namely, using mathematical modelling.

The instrusctional objective of activity 2 is that the students are able to draw function graph of the objective function, then the feasible region of the linear programming problem. The achievement of this objective is seen through modelling step 4 (working mathematically).

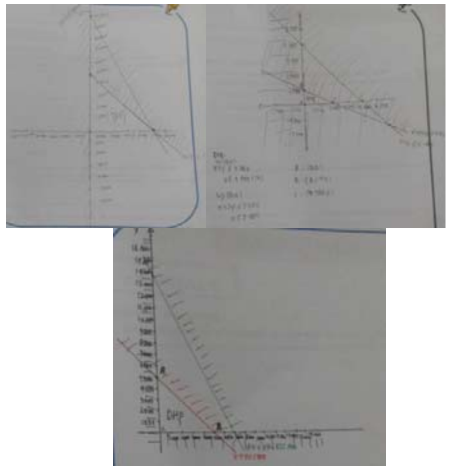

Figure 2. Student’s answer to step 3 number 5

For the problem number 5, the students are able to answer it well. The students are able to determine the intercepts in the feasible region.

The instructional objective of activity 3 is that the students are able to determine the maximum and minimum value. The students determine the constraint function and the corner points of the feasible region. The corner points gotten is substituted on the constraint function. In step 5, the student does not face a difficulty, as shown in the following picture.

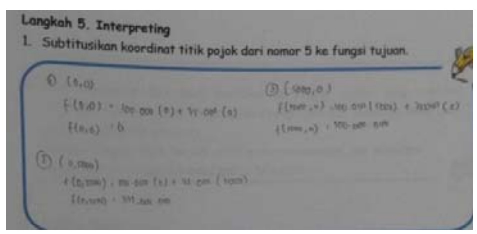

Figure 3. The student answer to step 5

In step 6, the students answer the question from the finding of step 5. The students determine the maximum and minimum income of the ticket sale and the number of adult spectators and child spectators so that the sale can be achieved.

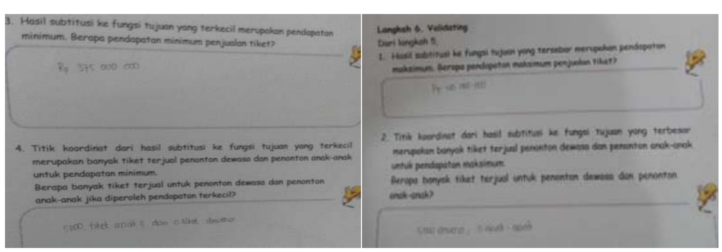

Figure 4. The student’s answer to step 6

From the finding, the students are able to understand and complete activity 3 well.

Post-test

There 30 students out of 38 who answer the question correctly; they area able to determine the mathematical modelling, constraint function, objective function, and draw constraint function graph, determine the feasible region, and determine the maximum and minimum value of the linear pragramming problem. Meanwhile, 8 students answer the question, yet they are wrong. The mistake happens when they construct the mathematical modelling of the linear programming problem.

The retrospective analysis

Pre-test

The test given contains the linear programming problem in the context of seeing a doctor. It is expected that the students expose themselves in the situation in the linear programming problem. Yet, 3 students do not answer the question given, a student answers correctly, a student answers but it's incorrect and incomplete, and a student only writes the information of the problem.

The absence of answer and only a student answer show that the students's preliminary situation has not been enough to understand the real context and its relation as well.

The students have not been able to determine mathematical modelling, constraint function, objective function, graph function of the constraint function, feasible region of the graph, and the maximum and minimum value of the linear programming problem.

Thus, in general the achievement indicator of the linear programming has not been met. In other words, the preliminary knowledge of the studnets on the linear programming is low, especially if it is related to the real context, for instance, seeing a doctor.

Pilot Experiment

Activity 1: The instruction in the student activity sheet needs to be revised so that it is easy for the students to comprehend what is meant by that instruction. Step 1 needs to be revised; Question number 1 exchange the place with the question number 2. Step 2: both question number 1 and number 2 are changed into "Has the number of the adult tickets sold been already known?". In step 4, it is necessary to design a table so that the students are able to understand the instruction of the problem.

In activity 2, Jovianto's answer has been correct, yet his friends's answers haven't. Thus, it is necessary to conduct the apperception in activity 2 in order to remind the students of constructing the function graph and determining the feasible region.

In activity 3, there is no difficulty found when the students do the student activity sheet 3. The students are able to complete step 5 and 6 correctly. The students are able to understand the instruction so that the student activity sheet for activity 3 does not need to be revised.

Teaching Experiment

In activity 1, step 1, the students are able to understand the mathematical modelling well. The students are able to complete step 1. The students find it difficult in associating it into variable the number of adult and child tickets sold. In step 3 for number 1, 2, and 3, all students are able to answer them correctly. There is a group discussion for number 4 and number 5. In group, the students determine the area for the adult and child spectators. Each student has different assumption in accordance with their experience when they watch the circus. In step 4, the students answer the question correctly. All the tables are filled in with the information gotten from step 1 to step 3. The students are able to determine the mathematical modelling of question number 1. The instruction for number 3 and number 4 can be understood well by the students so that they are able to determine the constraint function and objective function.

In general, activity 2: drawing function graph of the constraint function and determining the feasible region can be conducted well. Some students face difficulty. Yet, through group discussion, the students are able to understand the instruction of the problem and answer it.

In activity 3, step 6: the students are able to answer the question in accordance with the answer gotten from step 5. The students are able to determine the maximum and minimum income of the linear programming problem. From the minimum and maximum income, the students are able to determine the number of tickets sold for the adult and child spectators.

Post-test

The students (30 students) mostly answer the question in accordance with the mathematical modelling steps. However, the mathematical modelling steps are not written as in the student activity sheet (activity 1,2, and 3).

CONCLUSION

Learning activity using mathematical modelling plays an important role in giving opportunity for the students to construct their own konwledge of linear programming in accordance with their learning style and skill.

Acknowledgements

Reseacher would like to say thank you to all that support this research. Thank you to Dr. Yusuf Hartono as the first advisor and Dr. Hapizah, M.T. as the second advisor, to Asri Nurdayani, M. Pd. as the model teacher, to SMA Xaverius 1 Palembang, to all my friends in mathematics programs in Sriwijaya University, and my beloved family, and also thanks to SULE-IC 2018 that gives a chance to publish this article on Proceeding of SULE-IC 2018 and/or Journal of Physics: Conference Series (JPCS).

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