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E-Module Development of Linear Programs Based on Students' Conceptual Understanding

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Abstract

The purpose of this study is to create an E-Module based on conceptual understanding of linear programming that is valid, practical, and understands the potential effects of E-Modules. The Research and Development (R&D) method was used in this study. This study employs the ADDIE model development procedure, which consists of five stages: analysis, design, development, implementation, and evaluation. The E-Module is declared "valid" based on the assessments given by three validators with four aspects assessed, namely content feasibility, presentation feasibility, language feasibility, and graphic feasibility, with a total percentage of 79.8 percent. The E-Module was regarded "highly practical" based on the results of student response surveys in the small and large groups, which received 83.8 percent and 81.5 percent, respectively. Based on the findings of the teacher response questionnaire, the E-Module was declared "highly practical" with a score of 92 percent. Based on the student learning outcomes test, the e-module is determined to have a "good" potential effect with a score of 66.7 percent.

Abstrak

Penelitian ini bertujuan untuk menghasilkan E-Modul berbasis pemahaman konsep pada materi program linear yang valid, praktis dan mengetahui efek potensial E-Modul. Jenis penelitian ini adalah penelitian Research and Development (R&D). Penelitian ini mengggunakan prosedur pengembangan model ADDIE yang terdiri dari lima tahapan yaitu Analysis, Design, Development, Implementation, dan Evaluation. Hasil dari penelitian ini adalah E-Modul dinyatakan "valid" berdasarkan penilaian yang diberikan oleh tiga validator dengan empat aspek yang dinilai yaitu kelayakan isi, kelayakan penyajian, kelayakan bahasa, dan kelayakan kegrafisan dengan jumlah persentase sebesar 79,8%. E-Modul dinyatakan "sangat praktis" berdasarkan hasil angket respon peserta didik pada kelompok kecil (Small Group) dan kelompok besar yang masing-masing mendapat persentase sebesar 83,8% dan 81,5%. Serta E-Modul dinyatakan "sangat praktis" berdasarkan hasil angket respon guru dengan persentase sebesar 92%. E-modul dinyatakan memiliki efek potensial "baik" berdasarkan tes hasil belajar peserta didik yang dengan persentase sebesar 66,7%.

Keywords: Development; *E-Module*; Linear Programs, Conceptual Understanding

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INTRODUCTION

Mathematics is one of the subjects that is crucial in education, which is why it must be taught from a young age. This is consistent with Suryadi, Yanto, and Mandasari's (2020) view that mathematics is one of the fundamental sciences. Both its thinking and applications are extremely valuable in everyday life and can aid in the rapid advancement of science and technology. The existence of narrative problems relating to mathematics demonstrates one of the areas of mathematics in everyday life. Linear programming is a mathematical problem having applications in everyday life. Sunaryo (2019) mentioned that challenges in linear programming are met in everyday life, such as calculating the highest profit in a corporation or trade, identifying the least quantity of material to be utilized, and so on. Meanwhile, Ahmad, Nurhidayah, and Nurdin (2018) state that issues or forms of linear programming questions are typically in the form of story questions with extensive language.

It has been discovered that linear programming is one of the things that students find difficult to grasp while implementing mathematics learning using linear programming. This is connected to the preparatory content that students must learn as well as the difficulty of pupils in grasping real-world challenges, which can result in low scores (Idris, 2015). Furthermore, according to Fannie and Rohat (2014), linear programming is one of the mathematical topics that involves a high degree of thinking and conceptions to solve issues. Students' difficulty in addressing real-life situations, particularly in choosing the optimum value, demonstrate a lack of knowledge of their principles in linear programming (Andriyani & Ratu, 2018). This is also supported by Suci (2015), who claims that in the submaterial to discover the optimal value, many students make errors in creating mathematical models, calculating corner points, and drawing inferences based on the questions posed.

According to Rizki and Linuhung (2017), most students struggle and make mistakes when it comes to comprehending the notion of mathematical modeling in linear programming. Students appear perplexed when defining variables, generating graphs, and seeking for regions of completion in linear programming tasks. These are known as conceptual errors. Students suffer conceptual errors when they use the notion of linear inequality incorrectly, draw graphs incorrectly, or determine the solution area incorrectly, as well as when they apply other concepts in linear programming incorrectly (Sulistiyaningsih & Rakhmawati, 2017). This viewpoint demonstrates that linear programming is a mathematical substance with a high degree of conceptual comprehension. According to Anwar and Abdillah (2016), the notion of linear programming is a high-level mathematical topic that is difficult for students or students to understand since it requires a lot of algebraic operations, graph drawing, and numerical procedures.

It is critical for students to comprehend the notion of material when learning mathematics, particularly linear programming, because the concepts of material in mathematics are connected to each other and must be studied systematically and constantly (Wicaksono, Handayanto & Happy, 2020). According to Mursalina, Marhamah, and Retta (2020), "conceptual skills are one of the basic talents' pupils have that must be mastered by students," which implies that understanding ideas is one of the basic abilities that students must master and possess. Meanwhile, according to Khairani, Roza, and Maimunah (2021), if students grasp the ideas in

studying mathematics, they would be able to comprehend and solve problems in mathematical material more easily. Students' inactivity in the learning process might also lead to a low degree of grasp of their notions. According to Ulia (2016), inactivity of students in the learning process causes students to be unable to comprehend the concept of the material, and eventually, students rely on teachers and peers to solve arithmetic issues.

To actively engage students and stimulate their interest in learning the principles of the content to be taught, it is required to produce new teaching materials in accordance with scientific and technological advancements, one of which is E-Modules. According to Romayanti, Sundaryono, and Handayani (2020), the learning process employing instructional materials in the form of electronic modules (E-Modules) can be more entertaining for students to understand the ideas in the subject matter since it includes pictures and videos. Furthermore, the usage of E-modules in learning can increase student engagement and enhance student learning results (Dewi & Lestari, 2020).

According to the findings of the study "Development of Mathematics E-Modules Based on Contextual Approach Assisted by Powerpoint Media to Improve Students' Understanding of Mathematics Concepts in Linear Program" conducted by Wicaksono, Handayanto, and Happy (2020), using E-Modules in the learning process can increase students' interest, motivation, and activeness in the learning process. Afrianti and Qohar (2019) determined in their study, "Development of Contextual-Based E-Modules in Class XI Linear Program," that their E-Modules are valid and capable of motivating pupils to learn.

Some of the following research and development on linear programming tries to increase idea understanding. In this study, new instructional materials were created in the form of building E-Modules on linear programming, the explanations of which are based on or relate to indications of concept knowledge. Furthermore, the developed E-Module includes learning videos about linear programming material, beginning with prerequisite material, mathematical models, and learning videos on how to graph the area of the resultant solution and determine corner points, which can be a solution to students' difficulties in the linear programming learning process. This research also intends to construct an E-Module based on conceptual knowledge of linear programming material that is valid, practical, and understands the potential effects of the generated E-Module.

METHOD

This is referred to as "research and development." R&D (Research and Development) is the abbreviation for research and development (Setyosari, 2016:276). The study was carried out at SMA Negeri 4 Palembang, and the subjects were students from class XI at SMA Negeri 4 Palembang. The E-Module development design in this study was taken from the ADDIE learning design approach. This design employs five stages of development, which are as follows: 1) Analysis (analysis); three tasks are performed at this stage: needs analysis, curriculum analysis, and software requirements analysis. The purpose of this phase is for researchers to identify difficulties in the area, understand the core skills and fundamental competencies of the applicable curriculum to define learning objectives, and select the software that will be used to construct the E-Module. 2) Design: this stage is carried out with the goal of creating an initial design or storyboard of the E-Modul to be produced, as well as research tools to test the degree of

validity, practicability, and prospective consequences of the E-Modul. 3) Development: this step involves creating an E-Modul based on a storyboard and determining the level of validity of the E-Modul once it has been validated; 4) Implementation: the aim of this step is to determine the reaction of teachers and students to the produced E-Module, as well as whether or not the E-Module is practical; 5) Evaluation: The purpose of this step is to assess the usefulness of the instructor and student response questionnaires. as well as testing student learning outcomes to assess the possible effects of the E-Module. This model was chosen because it is pre-programmed with a structured sequence of activities to tackle learning difficulties connected to learning materials based on students' requirements and characteristics.

The data collecting strategies utilized in this study were interviews to identify the initial problem; a validation questionnaire used to establish the level of validity of the E-Module; and a practicality questionnaire comprising of a teacher response questionnaire and student responses. The learning outcomes test instrument, which consists of four essay questions pertaining to indications of concept knowledge, is used to assess students' degree of mastery after learning with E-Modules. It's used to assess the prospective consequences of the newly created E-Module.

The following data analysis approaches were used in this study: 1) Validity data analysis based on the validator's assessment of the validation questionnaire, which included four factors that were assessed: content feasibility, presentation feasibility, language feasibility, and graphic feasibility. 2) The practicality study is based on questionnaire responses from teachers and students. The instructor evaluates three criteria: the content/material of the E-Modul, the look of the E-Modul, and the execution of the E-Modul. The student response questionnaire evaluates four criteria: the beauty of the E-Module, the ease of the E-Module, the support of the students, and the indicators of concept understanding. 3) The possible impacts are evaluated through evaluations of student learning outcomes. Widoyoko's potential impact criteria are used (Zaqiyah, 2020).

RESULTS AND DISCUSSION

Result

The following are the findings of this study, which were based on the ADDIE model:

Analysis

Needs analysis, curriculum analysis, and software requirements analysis are all performed during the analysis stage. According to the requirements analysis conducted at SMA Negeri 4 Palembang, mathematics learning relies solely on printed books given by the school or modules adapted from printed books. There has never been a teacher who has employed electronic teaching materials or E-Modules in the learning process. Furthermore, pupils tend to be less engaged throughout the learning process, and their capacity to grasp their classmates' notions is also quite poor. Students' learning results are influenced by their insufficient conceptual comprehension capacity (Fitri, 2017).

According to the curriculum study, the 2013 curriculum was implemented in SMA Negeri 4 Palembang. The linear program is a required mathematics subject in class XI during the odd semester. Meanwhile, it is known through the study of software requirements that the program

utilized to aid in the development of E-Modules is Flip PDF Professional. Because of its capabilities and different menus, this is one of the most common forms of software used in constructing and developing E-Modules on linear programming material. This may be used to insert learning films, graphics, and animations, as well as which can transform modules into electronic form, or E-Modules.

Design

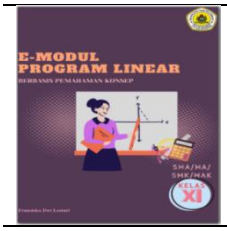
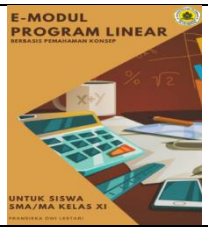
At the design stage, the researcher prepares the necessary components, collects references needed by researchers in developing E-Module teaching materials, and creates research instruments to assess the degree of validity, practicability, and prospective impacts of the developed E-Modules. The storyboard design or basic design of the E-Module will be produced during the design stage to make it easier for researchers to build E-Modules. The storyboard includes the main design as well as the material for the next E-Module. The E-content Modul's is divided into four sections: precondition material, mathematical model, corner point test technique, and line inquiry method.

Development

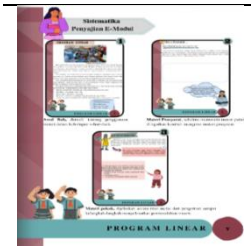
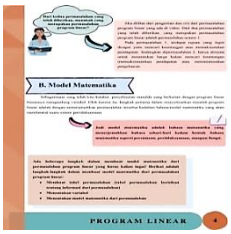
The researcher began developing the E-Module according to the initial design during the development stage. The original product or prototype I E-Module will be validated during this development phase before being tested on students. The original product or prototype I E-Module is created based on the storyboard or basic design created during the design stage. Following the first product production procedure, which results in a prototype E-Module, the researcher verified the E-Module I prototype with three experts, two lecturers and one mathematics instructor. Validators will be experts who evaluate the applicability and validity of the produced E-Module. The researcher handed the validator a validating questionnaire to examine the developed E-Module. The validation questionnaire includes evaluation elements, suggestions, and comments. The validation questionnaire has 39 assertions separated into four assessment categories: content feasibility, presentation feasibility, language feasibility, and visual feasibility.

The validation findings are in the form of ideas and comments that researchers may utilize to improve the prototype E-Module that was produced. Based on the validator's evaluation, it is typically claimed that the E-Module is appropriate for usage with adjustments based on the suggestions and comments provided. The E-Modul is amended in response to the validator's comments and recommendations, and the validator then evaluates the E-Modul using a validation questionnaire sheet. The three validators' average percentage value for the validity criterion is 79.8 percent. As a result, it is possible to infer that the E-Module based on conceptual comprehension of linear programming falls into the "valid" category for usage as a teaching material for students. The results of the revision of the E-Module display based on suggestions and comments given by the validator can be seen in Table 1.

Table 1. The revisions of the E-Module Display

Before	After
	

The evolved E-cover Modul's has been modified. The cover color, picture, and position of the school and class levels on the E-Modul cover have all changed.

Before	After
	
There has been a modification to the E-systematic Module's presentation, which is no longer adequate and has been turned into a description and instructions for the E-Module.	
	
The language and appearance of the E-Modul has been updated to be less neat and incorporate more motion.	
	
The presentation on the learning video is less appealing, and there is no source from the learning video, according to the validator's suggestions and remarks. As a result, the video has been altered to make it more appealing.	

The validator, in addition to editing the E-appearance, Module's also revises the context of the issues used by the E-Module, which receives ideas and comments from the validator to modify the context of the problems used in the context of the problem. The researcher utilized the context of food, clothes, and medicine to frame the problem before it was corrected by the validator. Following the amendment, the researcher updated the problem's context to include Korean POP music, package service, and the usage of internet accounts. The validator additionally revised the indications of comprehending the ideas utilized in the E-Modul because, according to the validator's suggestions and comments, numerous indicators were not in compliance with the linear programming content. Table 2 shows one of the revision's outcomes in terms of difficulties and markers of concept understanding:

Table 2. The revision of the E-Module context and students' understanding indicators

Before	After
Risol and pempek sellers offer their goods in two types of containers: rectangular and square. The rectangular container has a maximum capacity of 14 risol and pempek. While the square-shaped container can hold up to 32 pieces of risol and pempek, the rectangular container cannot. If the trader is currently selling by pouring 6 risol and 1 pempek in a rectangle container and 12 risol and 4 pempek in a square container, what is the greatest profit he will make?	Agam sells two sorts of Givebox record goods from the Korean boyband EXO via a purchasing and selling app. At a cost of Rp. 220,000, Givebox type I comprises four Exodus albums and two Obsession albums. The Givebox type II, which costs Rp. 460,000, comprises two Exodus albums and eight Obsession records. There are just 24 Exodus albums and 18 Ex'act albums in Agam's music collection. So, what is Agam's maximum profit from a single sale?
The researcher used seven indications of idea knowledge prior to the revision: Describe a notion Classify items according to their attributes or concepts Include both examples and non-examples Present ideas using a variety of mathematical representations Establish the necessary or sufficient circumstances for an idea to exist Using, applying, and choosing certain processes or operations Put concepts or algorithms into action	After receiving feedback and ideas from the validator, the researcher reduced the number of markers of concept knowledge from seven to four, namely: Classify items according to their attributes or concepts Present ideas using a variety of mathematical representations Using, applying, and choosing certain processes or operations Put concepts or algorithms into action

Implementation

The expert or expert revised the E-Module and determined it to be valid. The E-Module, which was produced as a teaching tool, was then used, or tested in student learning activities. XI IPA 4, with up to 15 students for small groups (Small Group), and XI IPS 3, with up to 33 students for big group field trials, are the topics of this study (Field Test).

There is some data to be collected at this stage of deployment, such as a practicality assessment of the produced E-Module and test result data from students after they have completed learning using the E-Module. For E-module students in the learning process, the practicality evaluation is acquired by filling out instructor response questionnaires and student response questionnaires. While the test result data is derived from students' responses to learning outcomes test questions that refer to indicators of concept understanding, researchers have prepared the necessary materials such as lesson plans, student response questionnaires, and learning outcomes test questions that have been validated by the validator prior to conducting student trials. The following is an explanation of the findings of the researcher's e-module trial: *(1) Small Group.* The purpose of this small group experiment is to assess the usefulness of the designed E-Module. At SMA Negeri 4 Palembang, small group trials were conducted on 15 students in class XI IPA 4. Researchers implement learning activities in accordance with lesson plans. Students are also requested to fill out a student response form at the end of the course to express their thoughts on the E-Module; *(2) Field Test.* The learning method was built on grasping the notion of linear programming content as teaching material during the field test, which lasted three meetings. In addition, 30 students from SMA Negeri 4 Palembang's class XI IPS 3 participated in the field experiment. Researchers take out learning activities in accordance with lesson plans designed to be like those used in small groups. The researchers supplied answer questionnaires to students and learning outcomes test questions to students during the third meeting of the field test in a large group, and they also gave reaction questionnaires to teachers.

Evaluation

At this last stage, the researcher evaluates the E-Module based on conceptual understanding on linear programming material that has been developed based. The evaluation are include the practicallity and the potential effect. The following are the evaluation's findings:

Evaluation: The Practicallity data analysis

The instructor response data analysis and the student response questionnaire data analysis are both included in this practicality data analysis. The following are the findings of the data analysis:

Student response questionnaire data analysis. The next step is to compute the overall score of the student response questionnaire in the small group based on the findings of the assessment on the response questionnaire sheet that has been filled out by students. All responders in the small sample scored 83.8 percent on the practicality criteria, placed them in the **"very practical"** category. With a total of 83.8 percent, the overall score for the student answer questionnaire in the large group acquired the percentage value of the practicality criteria of all respondents in the large group, which was included in the **"very practical"** category. The E-Module, which is based on comprehending the idea of linear programming, may be

employed in the learning process based on the outcomes of the presentation of the practicality value.

Data analysis on teacher response questionnaires. The researcher determines the teacher's response questionnaire assessment score based on the findings of the assessment on the response questionnaire sheet that was filled out by the mathematics subject instructor. The teacher response questionnaire has 20 statements, with the highest score in the questionnaire being the highest score in the questionnaire (maximum score is 100). The assessment score for the produced E-Module is 92, and the practicality percentage value of the teacher response questionnaire findings is 92 percent, according to the results of the teacher response questionnaire. As a result, the percentage of criteria scores for the level of practicality of E-Module teaching materials based on conceptual understanding of linear programming materials based on teacher response questionnaires is 92 percent, putting them in the "very practical" category for use as student teaching materials.

Evaluation: Potential Effects Data Analysis

The outcomes of student learning exams can be used to examine the potential effects of E-Modules. Students take a learning outcomes test that consists of four essay questions about signs of topic understanding. The goal of this potential impact evaluation is to see if the generated E-Module has a learning effect or not. If the pupils' score on a test result larger than 77 is more than 61 percent, the E-Modul effects potential requirement is met. According to the criteria for potential effects, the proportion of score tests collected from large groups is 66.7 percent, which is rated as **"good"**.

The percentage value of each indication of concept knowledge is derived using the learning outcomes exam administered to students during the field test phase. The results of the calculations can be seen in Table 3.

Table 3. The results of the student's concept understanding indicator test

Aspect	Score
Classify items according to their attributes or concepts	100%
Present ideass using a variety of mathematical representations	68,2 %
Using, applying, and choosing certain processes or operations	60,6 %
Put concepts or algorithms into action	51,5 %

Table 3 presents that the indicators that provide examples and non-examples indicate that the average value of the students' right responses is 100%, implying that 33 students can answer properly. The indicators that offer concepts in multiple forms of mathematical representation have a score of 68.2 percent, which means that 23 out of 33 students can properly answer these indications. Furthermore, the indications of employing, using, and selecting certain processes or operations receive an average of 60.6 percent, implying that 20 out of 33 students can properly answer this indicator. Finally, they had the lowest average of 51.5 percent on the indication of applying problem-solving principles and methods, implying that only 17 out of 33 students can properly answer this indicator.

According to the above description, the E-Module based on conceptual knowledge of linear programming content can affect student learning outcomes whose questions pertain to indicators of conceptual understanding of the ideas utilized in the constructed E-Module.

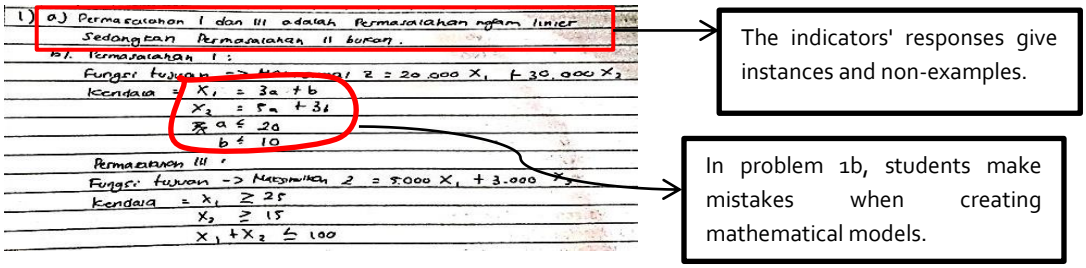


Figure 1. *Students' answers to question number 1*

Discussion

The E-Modul teaching materials based on conceptual comprehension of linear programming content have been pronounced "valid" and "extremely practical" based on the findings of the validation and field trials that have been conducted. This is in keeping with the researcher's objective, which is to create an E-Module based on a sound and practical grasp of linear programming. This is in keeping with Sintiya, Astuti, and Purwoko's (2020) assertion that a product is valid and practical if the average validity, student and teacher replies, and other positive criteria, such as valid and practical, are incorporated. If the final outcomes of producing E-Modules fulfill the minimal standards of excellent or valid (Nafi'ah & Suparman, 2019), they are eligible for usage in the learning process. If the E-Module developed is of sufficient quality, it can be utilized as a substitute learning medium and resource (Priwantoro et al., 2018). Furthermore, using media to communicate content may make learning more attractive, fostering interest, motivation, and curiosity in pupils (Wicaksono, et al., 2020).

At the large group field test stage, the researcher tested learning results to see if the concept-based E-Module had any influence on linear programming content. The researcher administered a test that comprised of four essay questions about signs of concept knowledge. Many students still do not comprehend the processes for completing questions that contain signs of knowing the idea as outlined by the researcher in the E-Module for the four essay problems offered. When it comes to the line of inquiry strategy, students continue to make several errors when working on question 4. Figure 1, Figure 2, and Figure 3 show students' responses to learning outcomes exam question.

Figure 1 shows the responses of students who successfully answered question 1.a, which includes signs of concept mastery, such as presenting instances and non-examples of linear programming problems, however there are student mistakes when answering question 1. b).

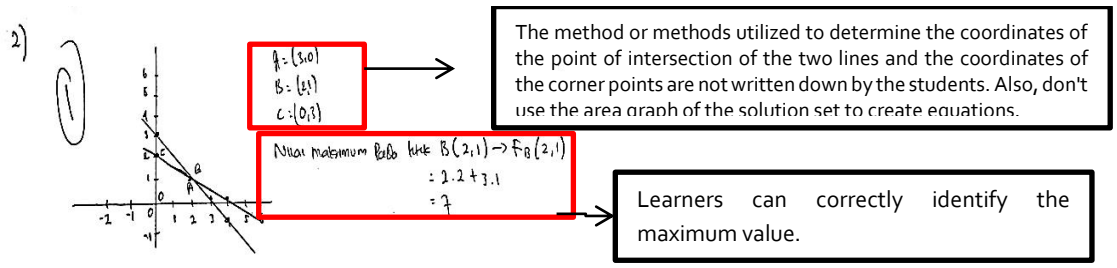


Figure 2. *Students' answers to question number 2*

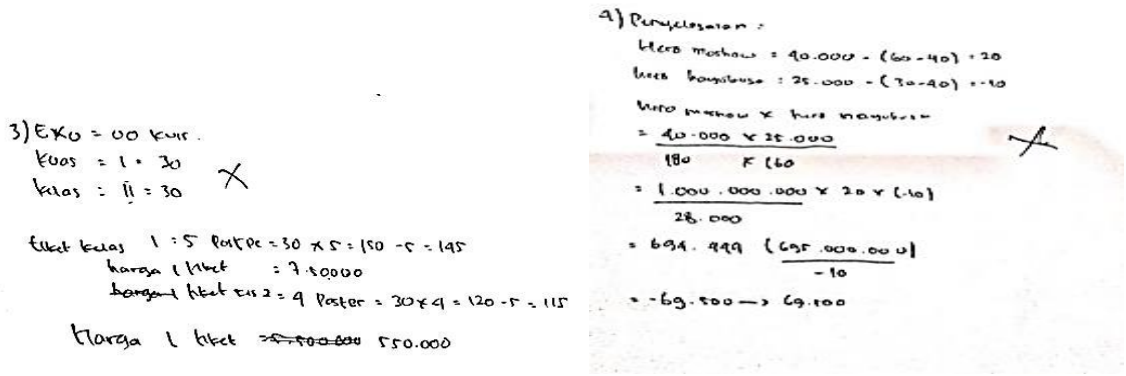


Figure 3. *Students' answers to questions number 3 and number 4*

Students can use the example of a linear programming issue in question 1 to create a mathematical model. a. The student can create the problem's objective function and constraint function, but there are no procedures to solve the problem, such as creating a problem table and assuming variables, as indicated by the researcher in the E-completion Module's step of creating a mathematical model.

Figure 2 shows an example of a student's incorrect answer to question number 2. When the processes for solving the issue are incomplete, such as needing to build a line equation with known the graph of the area of the solution and calculating the coordinates of the junction point of the two lines, students can accurately answer the greatest value.

This is in line with Afrianti and Qohar's (2019) research, which found that if the developed E-Module was declared valid and the trial results showed that the developed E-Module could improve students' learning motivation so that they could understand concepts and solve contextual problems, the use of E-modules in the learning process has a positive effect on student learning activities and learning outcomes (Gunawan, 2018). The E-Module Teaching Materials Based on Concept Understanding on the Linear Program developed product meets the criteria of being valid, practical, and having a potential effect on learning outcomes that refer to indicators of students' conceptual understanding after seeing the results of the research and being supported by previous relevant studies.

CONCLUSIONS

The E-Module product developed in this study is stated to be valid and very practical, based on the findings of the research and discussion. It is also stated to have a good potential effect based on the acquisition of test scores of participants' learning outcomes, which questions pertain to concept understanding indicators. The indicator of concept understanding has a percentage value of 100% for indicators providing examples and non-examples, 68.2 percent for indicators presenting the concept of various forms of mathematical representation, 60.6 percent for indicators using, utilizing, and selecting certain procedures or operations, and 51.5 percent for indicators applying problem-solving concepts and algorithms.

According to the findings of the research, it is preferable to construct the same E-Module but with various materials to get and be able to add an appropriate learning strategy, resulting in superior e-module teaching materials in terms of content and display quality.

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