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Linear programming problem applications in engineering curriculum

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ABSTRACT

The goal of this paper is to submitting linear programming methods and the applications in Engineering Education through Scientific approach in the Curriculum. In solving Linear Programming and Optimization Problems we utilized operation research techniques and according to gathered data, the decision making was recognized systematically and linear programming model was formed after model solving and execution it in academic semesters and comparing the results with the previous semester,

Keywords— *Scientific approach, Optimization problems, Decision making, Research techniques*

1. INTRODUCTION

Linear programming is one of the compulsory subjects for students of mathematics education in order that students can apply mathematics in solving real problems. Provision of this course is also based on several reasons. Firstly, all the problems in real life can be modelled into a math problem. Secondly, LP is included in applied mathematics which contains steps systematically to solve optimization problems in various sectors, including the education sector. Some applications of LP are to solve problems in the field of education, it can be seen as the allocation of student majoring Scheduling problems. Determines the location of the test material and mapping mathematical abilities of students In general, LP problems have three or more variables solved by the simplex method Solving LP with this method is done with some iteration to obtain optimal results.

The more variables and constraints will be, the more iterations are performed. Consequently, learning becomes problematic for students of mathematics, namely the lack of interest in solving LP. Therefore, innovation is needed in learning it, so that the goal of the lecture can be achieved well. The aim of this study is to solve LP with multimedia software so that students will get easier to develop others multimedia to solve the problem LP, increase students' interest and creativity, and the aim of lecturing can be achieved well. Linear programming (LP) is a general technique which allows modelling a great range of problems, in particular, problems arising in the field of Industrial Engineering.

That is why LP draws remarkable importance in mathematical methods for Industrial Engineering students in Universities. In this paper, it present a program which has been devised to improve the learning of methods involved in solving linear programming problems. The main novelty of the program consists of those modules which allow the user to follow in different degrees of detail the operations involved in achieving the optimal solution to the problem at hand. The user can examine in detail the effects of making right or wrong choices with regard to the rules involved in solving an LP problem. Both students at home and the professor in class can take advantage of the program.

1.1 Application oriented multimedia

At the beginning of the history of education, teachers are only one as a medium of learning. In the modern era, the teachers have realized that everything can be used as a medium of learning, including the school environment and at the end, namely computer. Learning media is something that can be used to deliver a message from the sender to the receiver so that the learning process will occur. Media are physical means which are used to send messages to the students and stimulate them to learn.

Learning Media is a combination of hardware and software. There are several types of media that is media graphics, audio and multimedia. Graphic media is a media using visual symbols, such as sketches, graphs, flow charts or other. Audio media is a medium that is associated with the sense of hearing. Multimedia can be defined as an interactive communication system and combination from the data operators, such as the internet and software. Multimedia is a media associated with the use of technology like computers and software. The advantageous of multimedia in teaching is to increase students' learning experiences make time efficiency, create a conducive learning environment actively participate in the learning process and improve students' enthusiasm and performance.

2. LINEAR PROGRAMMING

Linear Programming Basically, the problem of LP refers to a mathematical program that has the objective functions and constraints of linear to minimize or maximize a problem in the field of optimization. LP problem can be stated as Max Z = CT X Subject to AX b X 0 Designing Multimedia Learning for Solving Linear Programming where x is a decision variable, c and b are coefficients vector and A is a matrix. The simplex method is a method of splitting designed to solve LP problems that have three or more variables, and settlement is performed by iterations with the same steps until the optimum solution is achieved. LP settlement with the simplex method is based on the idea of the graphical method, where the optimum solution is always located at the corner point of the feasible region.

The summary of simplex algorithm is (1) smallest reduced cost, (2) test for optimality, (3) incoming variable, (4) test for unbounded, (5) outgoing variable, (6) pivot on a¯rs to determine a new basic feasible solution set jr = s and return on step 1. Up to this present, a lot of multimedia can be used in solving the LP, where algorithm simplex method has been applied in some software, such as LINDO and LINGO package. LINDO is a convenient, but powerful tool for solving linear, integer, and quadratic programming problems. LINGO is a comprehensive tool designed to make building and solving linear programming problems. Additional Software for solving LP like Excel program still needs to set the algorithm on a worksheet. Therefore, using the Excel program allows students to innovate, be creative and increase students' interest to solve further LP.

2.1 The result for LPP model

The solving of LP, the simplex method and multimedia with the Excel program, LINDO and LINGO package will be shown the stages and the results are based on a model LP stated as follows. Max Z = 3X1 + 6X2 + 4X3

Subject to:

$$3X1 + 4X2 + X3 \leq 60$$
$$2X1 + 3X2 + X3 \leq 50$$
$$X1 + 2X2 + 2X3 \leq 44$$

Where X1, X2, X3 ≥ 0

In Simplex Method the summary stages of LP solving with the simplex method is described as follows.

Standard form Max

$$Z = 3X1 + 6X2 + 4X3 + 0S1 + 0S2 + 0S3$$

Subject to:

$$3X1 + 4X2 + X3 + S1 = 60$$
$$2X1 + 3X2 + X3 + S2 = 50$$
$$X1 + 2X2 + 2X3 + S3 = 44$$

Where X1, X2, X3 ≥ 0

In in its second stage will determining the initial table simplex proceed to the next stage, iterating with steps of testing and calculations respectively as the following: smallest reduced cost Hardi Tambunan test for optimality, incoming variable, test for unbounded, * outgoing variable, pivot on a¯rs to determine a new basic feasible solution set jr = s and return on first step. The iteration process is done to obtain the maximum value of the objective function. Results of the solving can be summarized in the tables.

Table 1: Results

	Cj	3	6	4	0	0	0		
CB	VB	X1	X2	X3	S1	S2	S3	LHS	RHS
0	S1	3	4	1	1	0	0	60	15
0	S2	2	3	1	0	1	0	50	(16,67)
0	S3	1	2	2	0	0	1	44	22
Zj		0	0	0	0	0	0		
Zj - Cj		-3	-6	-4	0	0	0		

Table 2: Results

	Cj	3	6	4	0	0	0		
CB	VB	X1	X2	X3	S1	S2	S3	LHS	RHS
6	X2	3/4	1	1/4	1/4	0	0	15	60
0	S2	-1/4	0	1/4	-3/4	1	0	5	20
0	S3	-2/4	0	6/4	-2/4	0	1	14	9.33
Zj		(4,5)	6	(1,5)	(1,5)	0	0		
Zj - Cj		(1,5)	0	-2,5	-1,5	0	0		

Table 3: Results

	Cj	3	6	4	0	0	0		
CB	VB	X1	X2	X3	S1	S2	S3	LHS	RHS
6	X2	2/3	1	0	5/6	0	-4/24	12,67	-
0	S2	-1/6	0	0	- 2/3	1	-1-6	2,67	-
4	X3	-8/24	0	1	-8/24	0	4/6	9,33	-
Zj		5,33	6	4	0,33	0	1,67	113,33	
Zj - Cj		2,33	0	0	0,33	0	1,67		

The results of solving LP with simplex method, the value of the maximum, Z = 113.33 at X1 = 0, X2 = 12.67 and X3 = 9.33.

3. EXCEL PROGRAM

The solving of LPP can also represent in the form of Excel program carried out as (1) creating a spreadsheet with models the Designing Multimedia Learning for Solving Linear Programming problem, (2) specifying the cell which contains the objective function, and (3) specifying the decision variable. Example

Variable	X1	X2	X3	Control	LHS	RHS
Coefficient	3	6	4			
Solution	0	12.66	9.33			
Max Z=	113.33					
Constraint 1	3	4	1		60	60
Constraint 2	2	3	1		47.3333	50
Constraint 3	1	2	2		44	44

Microsoft Excel 12.0
Answer Report
Worksheet: [SOLV LP by EXCEL.xlsx] Sheet]
Report Created:26.03.2019 21:15:26 PM

4. AN INQUIRY-BASED ACTIVITY FOR FORMULATING LP MODELS

The teaching challenge that prompted the development of the inquiry-based activity will be discussed first. Then the hook will be presented. Finally, a teaching strategy for using the hook will be described. Analyzing the Teaching Challenge The author regularly teaches an undergraduate core course in operations management, which all business students must take in their junior or senior year. Since no management science course is offered, linear programming and several other management science topics are taught in the operations

management course. Typically, two 75-minute class periods are allocated to linear programming. The objective of linear programming coverage is to teach students to formulate LP problems in standard form, solve them in Excel and Excel Solver, and interpret the results. Since time is so limited, manual methods of solving LP problems are no longer taught. The process for solving an LP problem is shown in Figure 1. The word problem must be translated into a standard algebraic formulation. Some information from the model formulation is used to set up a spreadsheet, while other information is entered directly into Solver. If all those steps have been done correctly, the problem can be solved quickly. The last step is to interpret the results. The remainder of this paper will focus on the first step: translating the word problem into a standard algebraic formulation In General LPP model simplification process Big 5 principles were used to analyze the way that LP model formulation had been taught in the past. Several uses of LP were discussed near the beginning of the first class in LP, but students seldom remembered this information when they were tested on it. This was a case of the teacher's "why", not the students' "why". Simple to complex, familiar to unfamiliar, and concrete to abstract: After the uses of LP were discussed, decision variables, objective function, and constraints were introduced. These abstract, unfamiliar concepts were presented before a concrete example was introduced. Interpret Results Word Problem Excel Spreadsheet Excel Solver Model Formulation Solve Problem Multiple languages: Words were translated into algebra.

The Hook The inquiry-based learning activity for LP was based on the principle of going from a concrete situation to abstract concepts. The underlying hypothesis was that many students understand calculations better than they understand algebraic functions and constraints. Students who had trouble setting up objective functions and constraints might be able to compute profit and resource usage for a specific combination of bowls and mugs. After they had practised with those calculations, the model formulation could be taught more easily.

4.1 The translation process for the hook

Word problem	Compute profit and resource usage	Develop formulas for profit and resource usage	Model formulation

The plan was to have students attempt to solve a two-variable product mix problem by trial and error. Students would be instructed to try various combinations of the two products, checking each time to see whether the constraints were met. They would be asked to make the profit as large as possible, without violating any constraints. No formulas would be given for profit or resource usage; students would have to figure out how to compute those quantities. To assist weak students, students would do the exercise in pairs. It was expected that working in pairs would also help students develop better strategies for finding the optimal solution.

5. EVALUATING THE INQUIRY-BASED APPROACH

First, inquiry-based activity will be evaluated from a theoretical point of view. Then assessment data will be presented. Finally, plans for further assessment and improvement will be discussed. Theoretical Evaluation The instructor's observation was that the exercise created a sense of excitement in the classroom and seemed to motivate students to learn linear programming, as predicted by Bright man Oliver and Prince and Felder For most students, the activity appeared to be challenging but not too difficult; this is consistent with the recommendations made by Colburn [In terms of the revised Bloom taxonomy, checking to see that the LP constraints are being met is an evaluation task. Some student pairs have mentioned well-developed strategies for finding the optimal solution; those students are using creation skills. Even those students who are using only evaluation skills are doing critical thinking. Business students understand the importance of profit and are motivated to increase profit. Simple to complex: The exercise begins with calculations that students already understand. A fair number of students can make the translation from arithmetic to algebra by themselves. Familiar to unfamiliar: The exercise proceeds from arithmetic to algebra, and then to the concepts of decision variables, objective function, and constraints. Concrete to the abstract: The exercise begins with a specific word problem. The class discussion of the exercise is used to introduce the model formulation and new concepts. Multiple languages: Students translate from a word problem to calculations, and then to algebra. Student reactions to the exercise suggest that the "hook" and the "Big 5" principles worked well in this case.

Assessment Data At the university, one of the learning goals for the Course program is: "Students will be able to demonstrate rational decision making using quantitative tools, strategies, and data". This goal is assessed in several courses, using both multiple choice tests and quantitative tasks in each course. The authors were asked to develop a task and a rubric for assessing this goal in the undergraduate operations management course. The assessment task is defined as follows: Assessment will be based on a test question that requires students to formulate a linear programming problem in standard form. The student should be prompted for the decision variables, the objective function, and the constraints. The problem must be a product mix problem with 2 variables, 2 resource constraints, and one additional constraint – such as a contract, booked orders, or a market size limitation. The problem must prompt the student for the decision variables, objective function, and constraints. Students must be required to set up the problem from scratch. Multiple choice questions cannot be used for this assessment. Faculty teaching an operations management course are required to include this task in one of the tests given in the course.

6. MAJOR LPP APPLICATIONS IN ENGINEERING

In nutrition, linear programming provides a powerful tool to aid in planning for dietary needs. In order to provide healthy, low – cost food baskets for needy families, nutritionists can use linear programming. Constraints may include dietary guidelines, nutrient guidance, cultural acceptability or some combination, Mathematical modelling provides assistance to calculate the foods need to provide nutrition at low cost in order to prevent non-communicable disease.

Linear programming also allows time variations for the frequency of making such food baskets.

Engineers also use linear programming to help solve design and manufacturing problems. For example, in air foil meshes, engineers seek aerodynamic shape optimization. This allows for the reduction of the drag coefficient of the airfoil. Constraints may include lift coefficient, relative maximum thickness, nose radius and trailing edge angle. Shape optimization seeks to make a shock-free airfoil with a feasible

shape. Linear programming, therefore, provides engineers with an essential tool in shape optimization.

Operation Research has contributed significantly to building engineering through mathematical modelling of ill-defined problems such a resource allocation and scheduling. While mathematical models are useful; their application is hindered by the non-availability of precise data and complexity in the formulation of objective functions and constraints that meaningfully reflect real-life situations. This may cause difficulties in representing these interacting variables for optimization. To overcome these difficulties, LPP methodology introduced the latest technique in operation research to represent the variations using a fuzzy logic approach.

This embedding approach will eventually acknowledge and postulate that objective function and constrains are for the same nature and that the distinction between them is gradual rather than abrupt. One application of this integrated approach to a case study demonstrates the qualitative factors in a more meaningful way than classical linear programming.

7. TRANSPORTATION OPTIMIZATION

Transportation systems rely upon linear programming for cost and time efficiency. Bus and train routes must factor in scheduling, travel time and passengers. Airlines use linear programming to optimize their profits according to different seat prices and customer demand Airlines also use linear programming for pilot scheduling and routes. Optimization via linear programming increases airlines efficiency and decreases expenses.

8. EFFICIENT MANUFACTURING

Manufacturing requires transforming raw materials into products that maximize company revenue. Each step of the manufacturing process must work efficiently to reach that goal. For example, raw materials must past through various machines for set amounts of time in an assembly line. To maximize profit, a company can use a linear expression of how much raw material to use. Constraints include the time spent on each machine. Any machines creating bottlenecks must be addressed. The number of products made may be affected, in order to maximize profit based on the raw materials and the time needed.

9. ENERGY INDUSTRY

Modern energy grid systems incorporate not only traditional electrical systems but also renewables such as wind and solar photovoltaic. In order to optimize the electric load requirements, generators, transmission and distribution lines, and storage must be taken into account. At the same time, costs must remain sustainable for profits. Linear programming provides a method to optimize the electric power system design. It allows for matching the electric load in the shortest total distance between the generation of the electricity and its demand over time. Linear programming can be used to optimize load-matching or to optimize cost, providing a valuable tool to the energy industry.

10. CONCLUSION

The use of multimedia learning is very necessary for mathematics learning, including learning linear programming (LP) in mathematics education. Many multimedia software can be used to facilitate solving LP, such as LINDO, LINGO and Excel. Excel program is better to be used among of them in order that students can innovate and be creative. Since both of these programs, the algorithm simplex method has already been set in the software, while the Excel program still needs to set the algorithm in the worksheet.

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