

Error Analysis in the Use of Simplex Method in Determining the Optimal Solution in Linear Programming

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Abstract- Simplex Method of Linear Programming is a repetitive optimizing technique to determine the possible output in order to maximize a profit in a business plan. A good foundation in Mathematics is the main tool in getting the solution. Many papers aimed to find out the Mathematics performance and the factors affecting the learner's performance and yet this problem remained unsolved. The objective of this paper is to analyze the common errors committed by the Second Year Bachelor of Science in Accountancy students at the University of Northern Philippines. The scores of the written examination of the respondents were interpreted using error analysis. It was found out that the common errors are: basic application of the operations of numbers, determining the entering variable, miscopied values, incomplete variables in the final answer, and unfinished solution. These errors maybe due to ignorance to the rules in applying the simplex method. The study recommends giving higher percentage to basic operations in the total score of the written examination of students, Furthermore, the College should give seminars to the Accountancy students on how to manage their time in solving Mathematical problems.

Index Terms- Error Analysis, Simplex Method, Optimal Solution

I. INTRODUCTION

Situation Analysis
One of the challenges that Mathematics mentors is facing today is on how to give a quality education. There had been many studies in the factors affecting the Mathematics performance of the students and many recommendations had been made but still the problem in the Mathematics performance of the students remains a problem. These recommendations done by previous researchers may help minimize the problem but not actually solving the problem. One of the factors could be the fact that the idea of Mathematics is purely computations and thus affecting the students' performance. They forgot to realize that these computation skills they learn in Mathematics is actually a tool to solve life real situations,

Linear Programming is a method of dealing with decision problems that can be expressed as constraints linear models. The primary objectives of all linear programming models are certainly of the parameters and linearity objectives of the objective function and all constraints as mentioned by Sirug [1].

The simplex method of linear programming is a repetitive optimizing technique. It repeats the process of mathematically

moving from an extreme point to another extreme point until an optimal solution is obtained according to Victoriano [2].

One reason why students get the answers incorrectly is because of errors that they do in solving problems. Some of the many are operations on sign numbers, operations on fraction and giving the correct final answer. It is the aim of this study to analyze the common errors committed by the Bachelor of Science in Accountancy second year students in solving optimal solution using simplex method. The findings of this study may help minimize these common errors by reiterating to them the rules in performing operations. This may help them solve linear programming problems with mastery and accuracy.

II. FRAMEWORK OF THE STUDY

As mentioned by Li [3], student's errors are the symptoms of misunderstanding. Among many different types of errors, systematic errors occur to many students over a long time period and is relatively easy and thus possible to research with current knowledge and tools. The cause of systematic errors may relate to students' procedure knowledge, conceptual knowledge and tools. The case of systematic errors may relate to students' procedure knowledge, conceptual knowledge, or links between these two types of knowledge. An error can be a mistake, blunder, miscalculation, or misjudge and such category fails under systematic errors.

Cohen [4] said that the purposes of error analysis are to (1) identify the patterns of errors or mistakes that students make in their work, (2) understand why students make the errors, and (3) provide targeted instruction to correct the errors. When conducting an error analysis, the teacher checks the student's mathematics problems and categorizes the errors. The following is a list of errors that students commonly make in various mathematical areas.

The College of Business Administration and Accountancy is screening their students, in particular the Bachelor of Science in Accountancy every semester. It can be concluded that those who passed the screening successfully are knowledgeable enough to meet the academic requirements of the course. It is with this assumption that these students have good foundation in their Mathematics which is actually required in their course. Having this background, the mistakes they commit during exam is not actually of the reason that they do not know how to perform the operation but fails to analyze the error they had committed. Because of this reason that this study was made, that is to determine the common errors committed in solving for the

optimal solution of a linear programming problem. The errors.
result of this study may be minimize if not eliminate the common

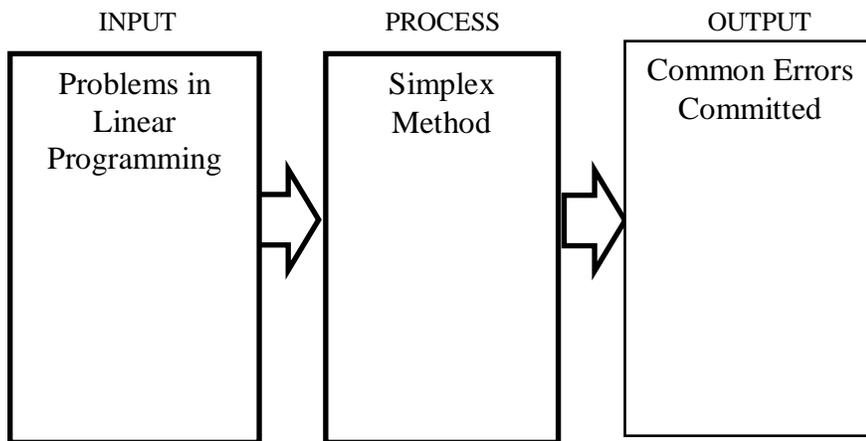


Figure 1: Common Errors Committed by the BSA Second Year Students

Linear Programming Problems were given to the respondents and they are to solve for the optimal solution using the simplex method. The common errors committed by the respondents were identified and analyzed.

Statement of the Problem

This study aimed to analyze the common errors in solving optimal solution using the Simplex Method of the second year accountancy students at the University of Northern Philippines during the second Semester of School Year 2015-2016.

Specifically, it sought to answer the following questions: What are the common errors committed by the respondents in solving the optimal solution using the simplex method? What is the weakness of the respondents in solving the optimal solution using the simplex method?

The Review of Literature

This part consists of the summary of studies of several researchers which were considered relevant to this study.

Errors in mathematics may arise for a variety of reasons. They may be due to the pace of work, the slip of a pen, slight lapse of attention, lack of knowledge or a misunderstanding. Some of these errors could be predicted prior to a lesson and tackled at the planning stage to diffuse or un-pick possible misconceptions. In order to do this, the teacher needs to have the knowledge of what the misconception might be, why these errors may have occurred and how to unravel the difficulties for the child to continue learning.

(<https://www.ncetm.org.uk>)[5]

Optimization, also called mathematical programming, helps find the answer that yields the best result--the one that attains the highest profit, output, or happiness, or the one that achieves the lowest cost, waste, or discomfort. Often these problems involve making the most efficient use of resources--including money, time, machinery, staff, inventory, and more. Optimization problems are often classified as linear or nonlinear, depending on whether the relationship in the problem is linear with respect to the variables.(<http://www.gurobi.com>)[6].

Research Design

This study made use of the descriptive method of investigation. This design aims to gather data from existing conditions. Further, the qualitative design was also used. This is appropriate for the study since it made use of quantitative techniques to show the errors of the students in solving linear programming.

Sources of Data

The population of this study were the second year Bachelor of Science in Accountancy (BSA) students. Section A with 39 students. The topic was taken from the course Quantitative Technique in Business. Specifically, the topic on Linear Programming in getting the optimal solution using the simplex method. Only the maximization problems were considered. This was taken during the second semester of school year 2015-2016.

Instrumentation and Data Collection

An examination was given to the students with three items that was taken from the course book on Basic Quantitative Methods for Business. The three problems were taken from Chapter Three of the said book whose topic is on linear programming on simplex methods particularly on standard linear programming model involving maximization problem. The first problem deals with two variables whose numerical coefficients are whole number, the second problem consists of three variables with whole numbers as numerical coefficient, and the third problem has three variables wherein the numerical coefficient of the optimal solution is decimal number.

Analysis of Data

The data gathered and collected were subjected for analysis and interpretation using the appropriate statistical tool. The raw data were gathered and tabulated for easier understanding. The frequency was used to present the common errors committed by the respondents and rank was used to present the weakness of the respondents in linear programming by simplex method.

III. RESULTS AND DISCUSSION

The test given to the students consists of three items. The first item is a two variable problem wherein x_1 and x_2 were considered. This is a basic problem and a good way to determine the common error of the respondents.

Problem 1: Maximize $100x_1 + 80x_2$
 Subject to : $4x_1 + 2x_2 \leq 100$
 $2x_1 + 4x_2 \leq 140$
 $x_1, x_2 \geq 0$

The first error identified that is common in the first problem is determining the entering variable.

The students failed to write the correct entering variable. This is one of the steps in solving standard linear programming maximization model using simplex method. The entering variable is identified from the previous tableau constructed to determine the pivot row and column. This is the column wherein it intersects with the pivot row.

In the study of Egodowatte [6], the result indicated a number of error under variable, the main reason was lack of understanding of basic concept of the variable in different context.

The second error that was identified was the incomplete values for the all variables in the final answer. The student failed to realize that he has two variables and therefore must have values for each of these variables in the final answer. Students usually fail to write the value of a certain variable when it is equal to 0.

This is the same with the study of Nasser [7] which revealed that some of the errors and misconceptions were due to lack of conceptual understanding whereas others were due to lack of procedural fluency.

The third error was on multiplication of numbers. The student fails to give the correct product in multiplying a series of number to one number outside the parenthesis.

There are five test papers which were submitted that was not solved completely. One factor could be, the students do not have time to continue solve the problem or they do not know the next step to be done.

In the study of Siniguan [8] the data gathered were analyzed to explore difficulties faced by students when solving problems. The major results of the study showed that the student's difficulties are on the inability to translate problem into mathematical form and inability to use correct Mathematics.

Problem 2: Maximize: $P = 50x_1 + 100x_2 + 150x_3$
 Subject to: $2x_1 + 2x_2 \leq 200$
 $3x_3 \leq 150$
 $4x_1 + 4x_3 \leq 600$
 $x_1, x_2, x_3 \geq 0$

The second problem consists of three variables x_1, x_2 , and x_3 .

The first common error identified in solving this three variable problem is the same as the first problem which was the replacement of the entering variable.

Most people would say that a careless error is one that could have easily been prevented if only they had paid a bit more attention to what they were doing as mentioned by Marcinat [9]

The second common error in the solution of the second problem is the application of division. They forgot that multiplication and division by zero to any number gives the product or quotient of zero.

The third common error is writing the correct numerical coefficient of the variable in the tableau. This error is due to lack of presence of mind of the student. It could be because the student is not focused on the problem he is solving or he is overwhelmed with the steps that he has to perform in order to obtain the optimal solution. As mentioned by Elbrink [10] carelessness and lack of attention can result in calculation errors. Procedural errors occur when a student computes or applies a procedure incorrectly. These types of errors suggest that students do not understand the concept related to the procedure. As a result, students do not have an understanding of why or how a procedure works; therefore, students do not recognize the importance applying and computing the procedure correctly.

Another error is rule violation in performing the test ratio, identifying the intersectional element of the pivot column and pivot row that the student is working with.

Lastly, in this problem, the common mistake committed was conversion of fraction to decimal number.

Problem 3: Maximize: $P = 10.50x_1 + 11.75x_2 + 10.50x_3$
 Subject to: $5x_1 + 12x_2 + 8x_3 \leq 1400$
 $7x_1 + 9x_2 + 9x_3 \leq 1250$
 $4x_1 + 3x_2 + 6x_3 \leq 720$
 $x_1, x_2, x_3 \geq 0$

The first error that was identified in this problem is performing the operation on division.

Before children attempt formal division calculations, they need to understand the process of repeated subtraction, or the 'measurement model' (Owens, 1993). This model is vitally important as later written methods will be based upon it. (Stated in <https://www.ncetm.org>) [11].

The second common error is the miscopied entry. Again this may be because the student is not focused on his work or we may say that the students cannot work and think well under time pressure since this is the last item to be solved within the period. There were ten of the respondents who did not finish solving the problem. This means that the students need more time to think and comprehend the steps in solving optimal solution using simplex method.

Weakness of the respondents in solving the optimal solution using the simplex method

Table 1 presents the summary of the common errors committed by the respondents in solving the optimal solution using simplex method.

TABLE I: Summary of the Common Errors Committed by the Respondents

| Kinds of Error | Frequency | Rank |
|--|-----------|------|
| Wrong Value of the entering variable | 13 | 4.5 |
| Miscopied entry from previous solution | 18 | 1 |
| Wrong Quotient | 16 | 2 |
| Unwritten variable | 13 | 4.5 |
| Wrong entry of numerical coefficient | 14 | 3 |
| Wrong entry of entering Variable | 9 | 6 |

It is shown from the table that there are 6 common errors committed by the respondents. It could be noted that the top 3 common errors are miscopied entry from previous solution, wrong quotient, and wrong entry of numerical coefficient. It can be said that the common errors of the respondents are result of their being careless, not focused and not analyzing what they are solving.

IV. CONCLUSION

This research tried to analyze the common errors in solving optimal solution using simplex method.

Specifically, it identified the common errors committed by the respondents and their weakness in solving optimal solution using simplex method.

This study made used of descriptive method of investigation. The quantitative design was also used. The 39 Bachelor of Science in Accountancy was used as the respondents of the study. The questionnaire used to gather the data was constructed by the researcher. It consisted of three items taken from the course book of Math 114 (Quantitative Technique in Business).

The following are the findings of the study: The common error committed on the first question consisting of two variables were determining the entering variable, incomplete values in the final answer, multiplication of numbers, lack of time. The same error was done in the second question with three variables. There is also an error identified in the division of numbers and wrong entry of numerical coefficient. On the third question, all the errors in the first and second was also committed. The third

question consisted of three variables with the optimal solution of having decimal numerical coefficients.

The weakness of the respondents is Miscopied entries from the previous solution with a frequency of 18 and which ranked first as the common error.

Based from the results of the study, the common errors committed by the BSA second year students are determining the entering variables, wrong final answer, incorrect multiplication and division, and other errors which are categorized as violation to the rules of the simplex method.

As reflected from the findings, the weakness of the respondents is the result of their being careless in solving optimal solution using simplex method and inability to work with accuracy even under time pressure.

REFERENCES

- [1] Sirug, W. (2015). Basic Quantitative Methods for Business. Phils: Mindshopper Co. Inc.
- [2] Victoriano, P. (1990). Quantitative Technique for Business Management. zkhils: Rex Book Store
- [3] Li, X (2006). Cognitive Analysis of Students' Errors and Misconceptions in variables, Equations, and Functions. Journal for Research in Mathematics Education.
- [4] Cohen, L.(2010).Error in Analysis of Mathematics. Retrieved on March 15, 2016 from www.education.com.
- [5] Boys' Impulsiveness may result in better mental Ability(2012). Retrieved on March 10, 2016 from www.ncetm.com.
- [6] Egodawatte, G (2011). Secondary School Students' Misconception in Algebra (Doctoral Dissertation) <https://tsapce.library.utoronto.ca>.
- [7] Nasser, S. (2015). Proceedings from International Conferences of Teaching and Learning. Analyzing of Students' Errors and Misconception in Pre-University Mathematics Course. Retrieved on March 10, 2016 from www.academia.edu.
- [8] Siniquian, M. (2016). Students' Difficulty in Solving Mathematical Problem. Retrieved on March 10, 2016 from www.academia.edu.
- [9] Marcinat, D (2008). Top ten lists of common (Student) Math errors. Retrieved on March 16, 2016 from mathnotationblogspot.com.
- [10] Elbrink, M (2008). Analyzing and addressing common mathematics Errors in secondary Education. Retrieved on March 10, 2016 from <https://www.bsu.edu>
- [11] Misconception with the key objectives. Retrieved on March 10, 2016 from www.ncetm.com.
- [12] Scofield, T. (2003) Top Algebra Errors Made by Calculus Students. Retrieved on march 15, 2016 from www.calvin.edu.

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