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Application of Project-Based Learning Method for Acquisition of Student Expertise in Solving the Industrial World Problems

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ABSTRACT
To face the world of work, especially in the industrial sector, students majoring in mathematics at Andalas University need to have expertise in expressing real-world problems into mathematical equations. These skills aim to enable students to solve problems mathematically or by using computer software. The Linear Programming Lectures through the Project-Based Learning Method aim to help students build these two skills. With this method, 29 students in four groups completed several different projects theoretically and using Lingo software. The research results on the application process of this method showed that 96.55% of students were able to complete the project with Lingo, and 94.65% of students could work well together.

Keywords: *Project Based Learning, Linear Programming Course, Integration Skill, Lingo*

1. INTRODUCTION

After completing their studies, students of the Mathematics Department will enter the world of work full of obstacles or problems. In order to be able to solve problems in work related to their fields, students must have expertise in applying the knowledge or mathematical theory obtained in lectures. Therefore, to acquire these skills, students need to be given real-world cases or problems designed in a project.

One of the jobs for students of the Mathematics Department is working in industrial companies. To work in the industrial world, students also need to have expertise in mathematical modelling. The expertise needed by the company is the ability to express company problems into mathematical equations. The expertise can help the company in decision-making. The right decisions will, of course, provide maximum benefits and can prevent the company from losses. The theory of modelling problems related to the industrial world and various problem-solving methods for decision-making is in the Linear Programming course [1].

The Linear Programming is one of the compulsory subjects in the Mathematics Department, FMIPA Unand. Linear programming discusses optimal solutions to application problems. Based on the variable conditions, linear programming consists of several types of parts, namely integer linear programming [2] and ordinary linear programming (all variables are a real number). So far, in learning these courses, lecturers teach and directly explain all materials to students (Teacher-Centred Learning). Therefore, students seem less active, not enthusiastic in obtaining the knowledge they need, relying on lecturers, and not trying to develop or improve their abilities. In addition, for the level of the problem or questions discussed, the problem is still relatively simple (only has a maximum of three variables). However, real-world problems are large-scale problems in models or mathematical equations with more than three variables. Therefore, expertise in using computer software such as LINGO software used explicitly for solving Linear Programming problems in the industrial world is needed. Then, in analysing and interpreting the results obtained, there needs to be cooperation between teams. As a result, the course must include the software in lecture materials and divide the students into small groups. It aims to train students to work together to solve more extensive and more complex problems.

Project-Based Learning (PjBL) is a learning method that involves students in research activities summarized in a learning project [3]. This method has several characteristics, namely 1) having a process over a period (several days, weeks, or months), 2) integrating skills, 3) developing students'

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understanding of the topics discussed, 4) students collaborate with other students in their workgroups, 5) creates a sense of project ownership in students, 6) produces actual products [4]. In addition, PjBL is also a method designed to produce something realistic or as if it were happening in the real world [3] and is a dynamic approach that develops 21st-century skills while working in small collaborative groups [5]. This method gives students some advantages because students can obtain and develop essential skills such as critical thinking, creativity, problem-solving, decision making, and at the same time, are seen as effective in developing self-confidence [6]. Based on its implementation, PjBl takes possession of some projects, namely structured projects (lecturer determines the topics, materials, and methodologies), unstructured projects determined by students, and semi-structured projects arranged and determined by the lecturer and students [5].

Finally, because of the suitability between the demands of the world of work (skills in solving real-world problems through teamwork) with the characteristics of PjBL methods and to equip students to face the world of work, especially the industrial world, a convenient method for Linear Programming course is Project-Based Learning method.

2. PROJECT BASED LEARNING IN LINEAR PROGRAMMING COURSE

Implementing the PJBL method on this linear programming course starts from the beginning of the semester until before the midterm exam. Three days before the first lecture starts, the lecturer uploads all learning materials (4 chapters) and lesson plans. The lecturer then divides 29 students into four groups and chooses members of each group randomly. It aims in order the students with different abilities academically can share his knowledge each other. The students with their group must do a project outside the lecture hours. The students must submit the group project results in a written report (product) at the set time. Then the lecturer gives scores and questionnaires to measure the achievement of group work and each student [7]

According to [8], the project work process in PjBl consists of six steps, namely preparation, planning, research, conclusion, presentation, and evaluation. The steps in this course are:

1) Preparation

For each chapter, the lecturer assigns a different project for each group. Before the lecturer clarified the project, the lecturer explained the mathematics learning materials related to the project. Explaining learning materials through examples of the general case (theoretical) and simple (small scale with a maximum of 2 variables) aims to make students have basic knowledge in completing projects. In addition, the lecturer also described how the process of using Lingo software in obtaining solutions from the case examples provided. To provoke student activity, the lecturer prepares time for questions and answers. Lecturers provide opportunities for other students to express opinions or express solutions to questions. In the discussion, the lecturer acts as a moderator, motivator, and supervisor of students in finding answers to questions. At this stage, each student can conclude what needs in working on the project.

2) Planning

Based on the description at the preparation stage, each student collects additional material and designs the steps for working on the project. The design is helpful to see the obstacles that may arise during the completion of the project. This design will be the subject of discussion in the group. The group then specifies the final design of steps in solving the project.

3) Research

Based on the final design, the students and their groups sit together working on projects. Through discussion, students then construct a mathematical model for the industrial problem or project. From the theory they have learned, each group member tries to solve the problem manually or by using Lingo. Next, the group discusses the results obtained individually. From the discussion, the group summarizes the process of working on the project until the final solution obtained becomes the group's results.

4) Conclusions

Students conclude the work process and from the project solutions obtained. Students also summarize the interpretation of the solutions shown in the Lingo solution report.

5) Presentation

In front of the lecturers and other groups, the students and their teams present solving problems theoretically or using Lingo.

6) Evaluation

In part, the lecturer provides input, criticism, and suggestions to each group on the process and results of project work. Furthermore, the lecturer also conducted an assessment of 4 types of projects carried out by each group. Lecturers assess students' academic abilities through manual project completion and assess student skills through project completion with Lingo.

In addition, the lecturer gave each student a questionnaire to determine teamwork, self-ability, and

the relationship between learning materials, Lingo, and the integration of the two skills.

3. RESULTS AND DISCUSSION

In the Linear Programming lecture, four groups of students worked on four different projects. Lecturers give scores for each project to measure students' skills in the problem-solving process and account for the results of their group work. The types of projects and the achievements of each group are:

- Project 1, students solve theoretically cases about matrices and systems of linear equations using the Gauss Jordan method.

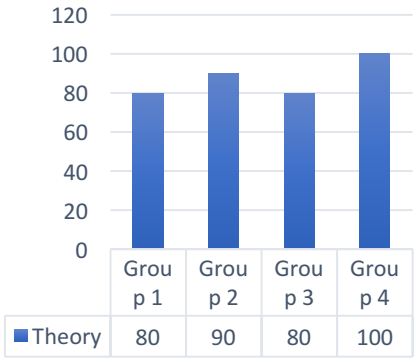

Figure 1 Group achievement of the matrix problem-solving project.

From the achievement of the scores obtained (80 and above), it is illustrated that each group has a very satisfactory ability in solving matrix problems which are the basis for solving linear programming problems.

- Project 2, students manually solve a simple Linear Program case by converting the problem into a mathematical model. Here, the mathematical solution obtained graphically is also the solution for the case.

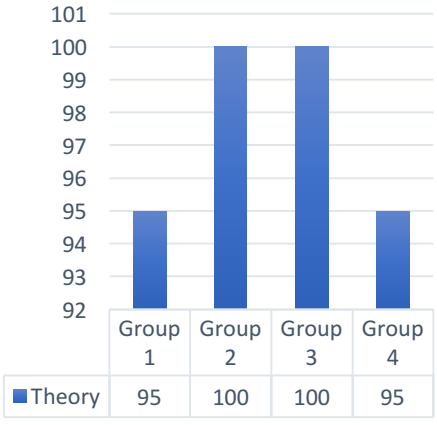

Figure 2 Group achievements for graphical linear programming modelling project.

Figure 2 shows that each group has outstanding skill in describing each constraint and constraint sign to get the feasible and optimal solution of the linear programming problem manually.

-Project 3, a project that has a more complex level of difficulty, also aims to train and at the same time improve students' abilities in constructing mathematical models. The solution for this case obtained manually and with Lingo is the same.

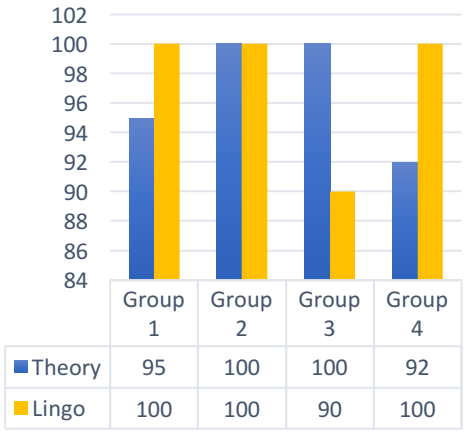

Figure 3 Group achievements to formulate the real-world problem into the mathematical model.

In Figure 3, the achievement of these scores states that each group has both excellent skills (theoretically and using Lingo) in solving real-world problems even though one group has more theoretical expertise than its expertise in using Lingo.

-Project 4 is a particular case of mathematics in the real-world Linear Programming problem. There are problems with many solutions, infinite solutions, and problems with no solutions.

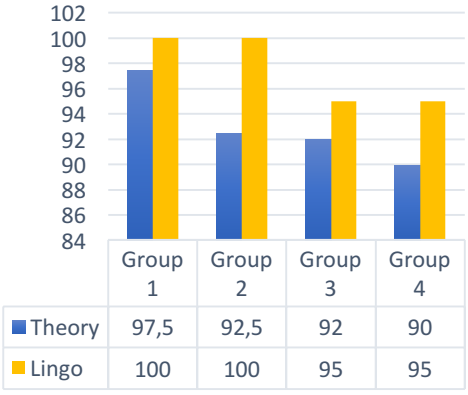

Figure 4 Achievement of the matrix problem-solving project.

From solving real-world problems with various types of solutions, students also gain experience making decisions and interpreting the solutions obtained. Furthermore, theoretical values of 90 and above and the achievement of scores with Lingo of 95 and above in Figure 4 show that students with Lingo's ability are more dominant than

their theoretical ability. The ability is beneficial as capital for students in the field or the world of work in the 21st century, full of computerized technology.

In addition to evaluating projects that students and their groups have completed, a questionnaire is another indicator used to measure the implementation of the Project-Based Learning method in this Linear Programming lecture. This questionnaire contains ten questions in three groups that each student must answer. The questionnaire in group 1 consists of 4 questions, namely:

1. Is Lingo software easy to use

2.Did we get a solution to the linear programming problem or project with Lingo?

3.If we use Lingo, is Lingo can control the result or solution obtained manually

4.Are the solutions obtained with Lingo understandable and interpretable?

The observation results about students' opinions and ability in using Lingo while completing all projects in their groups are as follows:

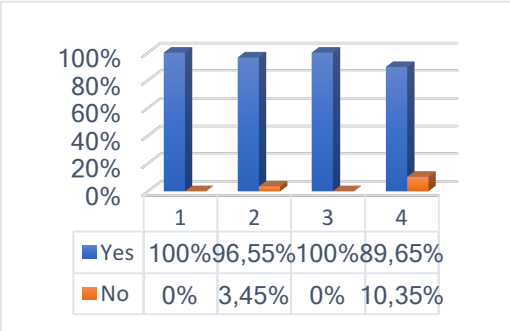

Figure 5 Self ability to use Lingo in project work

All students stated that using Lingo was easy because;

a. Because the menu choices used are not many

b. Because the user only enters the linear program model and clicks one button to get the result

Therefore, the solutions for each project were also easy to obtain. Then, the students state that the solution from Lingo can be a guide for students to validate the results obtained manually because the Lingo solution is the accurate solution. Furthermore, most of the students also stated that Lingo's solution is easy to understand because Lingo displays solution reports explained and interpreted in detail.

The questionnaire in group 2 also consists of 4 questions, namely:

1.What percentage of team members recorded what the lecturer or friend explained during the learning process?

2.What percentage of team members cooperate in solving problems or projects given by the lecturer?

3.What percentage of the team members are involved in the discussion in getting the project solution?

4.What percentage of team members participated in concluding the project?

The observation results on the activity and cooperation of individuals with their groups are illustrated in Figure 6 below,

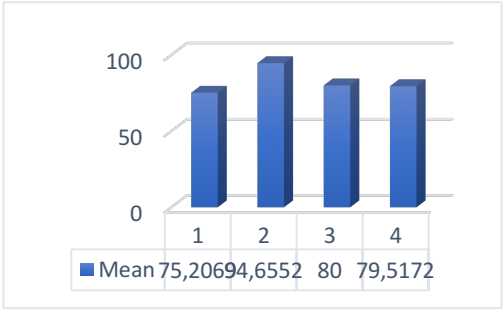

Figure 6 Activity and cooperation in project work

The percentage (75 and above) shown in Figure 6 states that the activeness and involvement of each student in project collaboration and drawing joint conclusions on project solutions are very good.

The questionnaire in group 3 consists of 2 questions, namely:

1. Is Lingo relevant to the learning material?

2. can we solve the industry problems by combining the two skills (solving linear programming problems manually and using Lingo)?

Figure 7 below declares that students need to combine manual problem-solving skills and problem solving with computer software in solving industrial problems, especially for more complex problems.

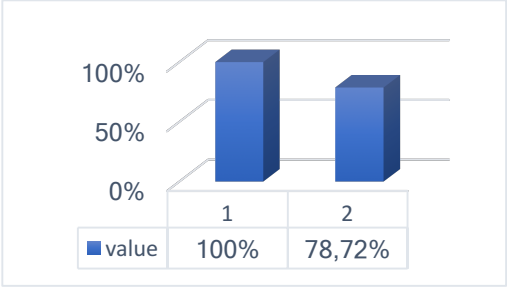

Figure 7 Relationship of learning materials, Lingo and Integration of skills

4. CONCLUSIONS

In this classroom action research, we can conclude that applying the Project-Based learning method application in Linear Programming lectures is beneficial to acquisition students' abilities and expertise in solving real-world problems, especially in the industrial world.

AUTHORS' CONTRIBUTIONS

Concept and design of the research: Susila Bahri, Radhiatul Husna; data collection: Radhiatul Husna; processing, analyse, and interpretation of the data: Susila Bahri, Radhiatul Husna; write drafting article: Susila Bahri; revision the article: Susila Bahri; final approval of the version to be published: Susila Bahri.

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