

The Implementation of Project Based Learning Model To Improve Problem-Solving Ability And Mathematics Coding System In Number Theory Course

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Abstract

The Mathematics Studies Program of the Faculty of Science and Technology of the University of Jambi has a Vision as a center for the development of the field of Mathematics and its flows that supports the preservation of the potential of local natural resources and environment based on science and technopreneur-ship and one of the missions that can be applied to achieve this vision is to increase human resources (HR) in the field of Mathematics. Number Theory is one of the subjects in the Mathematics Study Program that played a role in achieving this vision and mission. The GLA of Number Theory is able to use advanced mathematics to develop and understand mathematical principles, analyze data, and solve real-world problems, be able to reconstruct, modify, and analyze structured mathematical models of a system/problem, examine model accuracy and model utilization, and interpret them and draw contextual conclusions relating to numbers and their properties as well as the concepts of divisibility and congruence. One of the learning models that facilitates students to meet the GLA Lectures in Number Theory is the PJBL (Project Learning) model. This study aims to determine the effectiveness of PJBL in improving problem-solving ability and mathematics coding systems in the number theory course. The method of this study is action research. Qualitative data was used in the activity process, and quantitative data was used in the student response after using PJBL-based modules. Positive things were obtained based on observations during this project-based learning research activity.

Keywords: PJBL, Problem Solving, Coding Systems, Number Theory

1. Introduction

Based on the Permenristekdikti No. 44 in 2015, learning involves interaction between students with lecturers and learning resources in a learning environment. Furthermore, in the Permenristekdikti dictionary No. 44 in 2015 it was communicated that the learning process standard is a minimum criterion of learning activities in the study program to cultivate graduate learning achievement that includes characteristics, planning and implementation and learning burden. In the learning plan, the GLA (Graduate Learning Achievement) is laid out. The GLA curriculum is designed for student-centered learning. The lecturer acts as a facilitator in both individual and group learning.

The University of Jambi is an educational institution that has the Vision of making UNJA as A World Entrepreneurship University. To support this vision, one of its missions is to provide quality education and develop entrepreneurial creativity in accordance with students' talents and interests. In line with the vision and mission of the University of Jambi, the Mathematical Studies Program of the Faculty of Science and Technology of the University of Jambi has a vision to be a center for the development of the field of Mathematics and its applications that supports the preservation of the potential of local natural resources and environment based on science and technopreneurship. One of the missions that supports this vision by enhancing human resources (HR) through the Education process is learning that involves the interaction of Lecturers or Students either directly or indirectly. The subject in the Mathematics study program plays a role in the fulfillment of that vision and mission is Number Theory Course.

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The field of number theory is a branch of pure mathematics that studies the properties of numbers and their proofs, applying algorithms related to integers, such as the division algorithm, the algorithm for finding LCF (Largest Common Factor) and the Largest Common Multiple (LCM), the concept of prime numbers, divisibility, and congruence. The development of such a discussion is a coding system. This course has been implemented during the Mathematics Studies Program established at the University of Jambi. In the learning process all this time because of its conventional nature it still feels not optimal based on the expected GLA and takes a lot of time. In discussing the nature of numbers, the concepts of divisibility and congruence are many mathematical problems to be solved and proven. To find the solution requires the ability to solve mathematical problems. In addition to the discussion of coding systems which are applications of this course, it contains a wide range of real-life problems and students can explore themselves and find solutions through project assignments.

In planning strategies, methods and learning models by lecturers it is not easy to adapt to the GLA that has been compiled. The GLA of Number Theory is able to use advanced mathematics to develop and understand mathematical principles, analyze data, and solve real-world problems, be able to reconstruct, modify, analyze structured mathematical models of a system/problem, examine model accuracy and model utilization and interpret them and draw contextual conclusions relating to numbers and their properties as well as the concepts of divisibility and congruence. One of the learning models that facilitates students to meet the GLA Lectures in Number Theory is the PJBL (Project Based Learning) model.

PJBL (Project Based Learning) according to Ngalimun (2012) is a learning model that involves students in problem-solving activities as well as students have the opportunity to construct their own learning thus producing valuable and realistic products. The advantages of learning with this model according to the Buck Institute for Education (1999) are that students create frameworks, students discover problems, design processes by managing the information collected and perform continuous evaluation. This learning is done either in groups or individually and thus contributes to an atmosphere of tolerance for error and change.

Through the implementation of the PJBL Model, it is expected to fulfill the GLA of Lectures, improve problem solving skills and mathematical coding systems resulting in the formation of mathematics students who are creative and systematic in solving problems and have the capabilities needed by the working world (industry, services and government). Based on these problems, research was conducted on the

implementation of Project Based Learning to improve problem solving skills and mathematical coding systems in number theory course.

In the Mathematical Studies Program the load of the Number Theory Course is the understanding of the study of the concept of numbers and their properties, the operations that apply in numbers, the concept of divisibility and its properties, the concept of number primality, the concept of congruence, the Chinese remainder algorithm and its application to the mathematical coding system. In the implementation of the curriculum of Number Theory according to Rukmana, K (2006) is to equip students with basic but general analysis concepts so that they are able to generalize and abstract wider mathematical concepts. So the emotional development that students form after taking these courses is to be logical, critical and systematic. In addition, in discussing the nature of numbers, the concepts of divisibility and congruence are many mathematical problems to be solved and proven. To find the solution requires the ability to solve mathematical problems. To solve a mathematical problem according to Kramers et al. (1988) students must understand the problem, create a solution plan, execute the solution plan and check the solution. In addition to the discussion of coding systems which are applications of this course, it contains a wide range of real-life problems and students can explore themselves and find solutions through project assignments.

Based on these learning achievements, an effective learning model is needed, one of which is the PJBL (Project Based Learning) model. Ngalimun (2012) says that Project Based Learning is a model of learning that involves students in problem-solving activities as well as students have the opportunity to construct their own learning thus producing valuable and realistic products. Grant (2002) defines project-based learning as a learning model that expects learners to conduct in-depth investigations into a topic. So PJBL makes students dynamic because they work through their own thinking. According to Hosnan (2014), the learning steps of PJBL include defining projects, organizing projects and schedules, monitoring processes, compiling results and evaluation. The advantages of implementing PJBL according to Moursund (1997) are that it can increase learning motivation, improve problem-solving skills, improve students' ability to search for information, provide collaborative learning effects, and train students to organize projects and make allocations of time and other resources such as supplies that support task completion.

The course of Number Theory is a basic subject that contains analysis of numbers and their properties, the concept of divisibility and congruence. This course contains basic concepts and theorems that require

students to think analytically, creatively and systematically. In discussing the nature of numbers, the concepts of divisibility and congruence are many mathematical problems to be solved. To find the solution requires the ability to solve mathematical problems. In addition to the discussion of coding systems which are applications of this course, it contains a wide range of real-life problems and students can explore themselves and find solutions through project assignments. In order for the Number Theory course to run optimally and meet the expected GLA, the application of the PJBL Model is required. In its implementation, the lecture will be started by providing an understanding of the core material, concepts and methods and how to apply these methods to solve a problem. So, hopefully other subjects will also be able to apply project-based learning in the future.

Other contributions to the number theory course by applying this PJBL model are:

- a) Theoretical contributions: formulating and organizing learning instruments.
- b) Practical Contribution: Improving the Lecturer's skills in managing learning so that they are able to meet the expected GLA and Increasing Key Employment Indicators (KEI).
- c) Contribution to learning: The application of PJBL is able to form Students as Learning Centers (SCL) and Lecturers as Facilitators.

2. Method

The research approach is qualitative on the activity process and quantitative on the student response after using PJBL-based modules. The research method used is action research which is a scientific activity to solve problems and facilitate learning processes both offline and online.

Research activities include:

1. Preparation Phase

- a) The team prepares the instruments that support learning before the lectures are carried out: the formulation of the Graduate Learning Achievement (GLA), the syllabus documents and lectures contracts, the Semester Learning Plan (SLP), the Student Task Plan (STP), the Student Worksheet (SW), the Learning Outcomes Assessment Sheet (LOAS), and the exam questions and assessment rubrics.
- b) The team applies the PJBL Model to number theory course
- c) The team determines the instrument validator.

2. Implementation Phase

This stage is the implementation of number theory lectures during 16 meetings conducted on the basis of

the Semester Learning Plan (SLP) that has been compiled.

3. Final Phase

The final stage of this study is the implementation of evaluation and assessment assessments documented in the final report (video/document).

Qualitative data, are:

- 1) The actions of the lecturer to apply the PJBL model.
- 2) Student actions to participate in lectures that apply the PJBL model.
- 3) Description of the learning atmosphere during the implementation of the PJBL model.

The qualitative data assessment instruments in this study are:

- 1) Observation sheet
- 2) Minutes of lecture
- 3) Interview Rubric

As for the technique for data collection:

- 1) Observation
- 2) Interview/discussion

Quantitative data on the study were: Graduate learning outcomes obtained from GLA achievement tests including proficiency in mathematical problem solving and coding system projects.

The evaluation process is continuous. The form of the evaluation rubric is outlined as follows.

Table 1. Validation of Learning Instruments

Variable	Indicator	Description	Item number
The formulation of GLA, Syllabus, Lesson plan	Learning instrument content	Clarity of Course Descriptions	1
		Clarity of Reference Module	2
		Clarity of Module Material	3
		Clarity of Learning Outcomes	4
		Clarity of Learning Methods	5
		Suitability of GLA formatting, syllabus, lesson plan, SW, LOAS.	6
Formulation and Composition of Learning Evaluation Materials (SW and LOAS)	Learning Evaluation Content	Instructions for the project are clear.	7
		The questions are presented systematically	8
		Difficulty level of questions/projects	9
		Compatibility of training with GLA	10
		Compatibility of	11

Variable	Indicator	Description	Item number
		assessments with GLA	
		Reflection accuracy of student self-training	12

Table 2. Evaluation Rubric of student learning activities

Indicator	Statement
Student learning activities	1. Implementaion of the PJBL model can increase student participation in number theory course
	2. Implementation of the PJBL model contains clear guidance on the given case
	3. Implementation of PJBL models contributes to improving problem solving ability
	4. Implementation of the PJBL model helps students to reflect on learning outcomes

3. Results and Discussion

Learning innovation research The Innovation Research in Lectures (MK) Number Theory has been implemented according to the plan that has been drawn up for this semester. Starting from the formulation of the Learning Achievement, Semester Learning Plan (SLP) and supporting documents by the supporting lecturer team, the implementation of the lectures was done offline in the classroom and online through the Learning Management System (LMS) platform www.e.learning.unja.ac.id. The implementation of this study was carried out in the odd semester 2022/2023.

The subject of Number Theory is a compulsory subject in the Mathematical Prodi which is in the odd semester and is taken by students of semester 1. This semester the number of students in the M.C. number theory is 30 students. To this end, the team works to optimally implement project-based learning as planned together.

In this number theory course, 30 students are divided into 5 (four) large groups of 5/6 people. Students will be given three projects, each large group tasked with discussing the theory and theorems they are studying. Then, discuss with the other group by offering suggestions and questions.

For project III, each group was assigned to create a scientific prototype of the application of their article or topic of discussion using cases or data available in their environment about the concept of encryption in Number Theory. This project III will be collected at the 16th meeting. The lecturer here acts as a facilitator and supervisor of the student's discussions and learning activities to complete his project I and project II.

As an effort to expedite this research activity, before the lecture takes place, the team has designed documents that are needed during this project-based learning process. These supporting documents are the output of this research.

Following are the results of one of the projects that have been completed by students.

After the number theory lesson is over and ends with the end-of-semester exam, the research team will announce the best group that has completed the project and ask the students to fill out a questionnaire regarding the students' perception of PjBL-based number theory learning activities. The questionnaires provided consist of the Student Learning Motivation indicator and the Student Learning Activity indicator. Each indicator consists of 7 statement items and 6 statement items.

Table 3. Questionnaire Indicator

Indicator	Statement(item)
Student learning motivation	1. The lesson plan of Number Theory Course provides a clear picture of the expected learning outcomes at each meeting.
	2. The Project Task Plan given makes it more exciting especially when faced with proofs of theorems and problems.
	3. The modules provided stimulate curiosity to complete the given project task.
	4. The modules provided stimulate both independent and group work.
	5. The modules provided stimulate students to seek out various sources to solve the given problem.
	6. The modules provided stimulate students to present arguments when faced with problems.
	7. Teaching tools (Lesson Plan, GLA, Project Task Plans and Modules) encourage students to increase their attention to learning
Student learning activities	1. The learning provided encourages the student to participate actively in performing the learning task.
	2. Applied learning encourages students to engage in problem solving.
	3. The lessons given encourage students to ask questions if something is not clear.
	4. The learning given encourages students' curiosity when faced with problem solving.
	5. Applied learning encourages students to evaluate their own abilities
	6. Teaching instruments (Lesson plan, GLA, Project Task Plans and Modules) make you think creatively while learning

The questionnaire was completed by students with a choice of answers Very agree (SS) = 4, agree (S)

= 3, fairly agree (CS) = 2 and less agree (KS) = 1. Students' answers are accumulated in percentages. Here are the results of the questionnaire based on the indicators used.

For the student's learning motivation indicator, it was obtained that in items 1 and 2, students answered "Sufficiently agree" by 50% and 57%, and in items 3,4,5,6, students answered "Absolutely agree" and obtained percentages above 50%. For item 7, many students answered Agree 46% and quite agree 38%, and the rest answered Strongly agree and disagree. As for the indicators of student learning activities, students' answers were obtained in items 1, 2, 3, 5, and 6; many chose to agree on answers, as seen from the percentage above 50%. In item 3, many students answered, agreeing 40% and quite agreeing 37%. The rest strongly agree and disagree.

Furthermore, the research team conducted statistical tests, namely validation and reliability tests. It was found that the correlation was strong as seen from the significance value which was smaller than 0.05. To be sure, it needs to be followed by a reliability test. The result is a Cronbach's alpha value of 0.949 which states that the reliability is very high.

Table 4. Reliability results

Cronbach's Alpha	N of Items
.949	13

The results of this research are also supported by research results from (Fariasih & Fathoni, 2022) and (Susanti et al., 2022) which state that PJBL can increase student learning motivation. Apart from that, research results from (Novitasari et al., 2018) show that PJBL can increase student responsibility and increase student creativity (Hastuti et al., 2023) and increase problem solving skills (Jalinus & Nabawi, 2017).

4. Conclusion

Based on observations during this project-based learning research activity, positive things were obtained, including: The students showed high attention and enthusiasm for the topics discussed., Students broaden their knowledge regarding the application of mathematics and its application in everyday life, The students know hot issues in mathematics, The students have been able to present both live and video presentations. Increased managerial skills and cooperation of each student with his/her group even if they have to collaborate online to complete the project

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