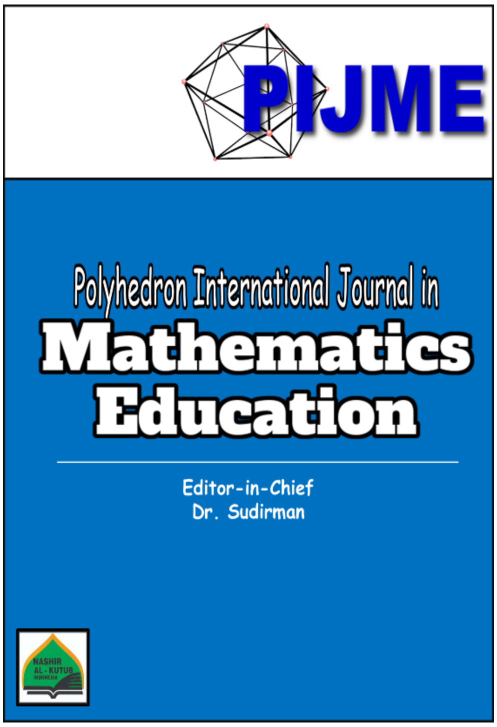
Polyhedron International Journal in Mathematics Education
Journal homepage: https://nakiscience.com/index.php/pijme



Fostering Prospective Teachers' Disposition: A Lesson Study in Linear Programming Topics Embedded by Technology

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To cite this article:
Krisnadi, E & Kandaga, T (2024). Fostering Prospective Teachers' Disposition: A Lesson Study in Linear Programming Topics Embedded by Technology. (2024). *Polyhedron International Journal in Mathematics Education*, *2*(1), 10-17.
To link to this article:
https://nakiscience.com/index.php/pijme
Published by:
Nashir Al-Kutub Indonesia

Polyhedron International Journal in Mathematics Education, 2(1), 10-17
Online ISSN: 2987-6540
https://nakiscience.com/index.php/pijme

Fostering prospective teachers' disposition: a lesson study in linear programming topics embedded by technology

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Submit: 5/8/2024, accepted: 6/8/2024, published: 6/8/2024

Abstract
In modern education, especially in higher degree programs, disposition is a factor that highly affects the learning process. The purpose of this research was to foster mathematical disposition among prospective teachers through a technology approach. POM-QM represented technology embedded into the learning process. Each cycle started with planning the embedding of technology into learning, realizing the plan by engaging a model teacher and an observer, and then ending with reflection to improve the next learning process to be applied to another class or the next topic. This lesson study began at the very beginning of linear programming. The conclusion was that the chapter design was able to foster mathematical dispositions. Some other affective and cognitive skills were known to have improved. The conclusion also covered some other unwritten but proper actions to take in the learning process based on lesson study reflection and evaluation. It was hoped that subsequent researchers would be able to implement lesson study activities during lecture activities.
Keywords: Disposition, linear programming, prospective teacher

1. Introduction

Disposition is formed inside learning and any educational approach that undermines disposition is miseducation (Katz, 1993; Hill-Jackson & Lewis, 2010). Furthermore, according to NCTM (2000) students' disposition in dealing with mathematics and their beliefs can affect their achievement in mathematics. Therefore, mathematics classroom learning must be specifically designed to improve students' mathematical dispositions (Yaniawati et al., 2019; Nababan & Tanjung, 2020). Students need dispositions that will make them persistent with more challenging problems, responsible for their learning, and develop good habits in mathematics (Gresalfi, 2009). That is needed to be able to improve their learning achievement (NCTM, 2000). To achieve this, educators must implement teaching strategies that not only convey mathematical content but also nurture a positive attitude toward learning mathematics.

But in fact, many students are not comfortable with mathematics; complain about challenges in mathematics; and even question the benefits of learning mathematical topics. In several studies in Indonesia, this does not only occur in elementary or high schools, ironically at the college level majoring in mathematics, the students' disposition to their chosen field is still lacking. Sometimes, it gets worse when educators tend to ignore this negative disposition for the alibi that mathematics is a difficult topic. Consequently, this negative attitude can hinder students' overall learning experience and achievement in mathematics. Therefore, there is a crucial need to address these issues to improve students' mathematical understanding and appreciation.

Brahier (2011) suggested that the aspect of mathematical disposition motivates students and makes students absorbed in continuing to study mathematics. However, like other affective aspects, raising the mathematical aspects of disposition in students is not an easy thing to be achieved by practicing (As' ari et al., 2017). Conversely, too much practice and structured exams will not have much good impact on students' mathematical dispositions. Reflecting on ourselves, we often avoid something good because of ignorance of the benefits and have no pleasure in it. On the other hand, in many conditions, technology can turn complexity into a lot easier and more enjoyable.

The use of technology in education is not a recent development (Lai & Bower, 2019). There have been many studies on technology-based learning, but many of them are only confirmation and tend like to introduce technology to the topic (Mishra & Koehler, 2006; Yaniawati et al., 2023; Sudirman). Such technology-based learning is not enough, less effective, and feels troublesome. Even Boyce (Gulley, 2003) says that the use of computers in learning is taking over the student's thinking process. This was like the use of calculators for simple calculations that have absolutely no learning and thinking processes in them (Martinovic, 2018; Chamoso & Cáceres, 2018). But that does not mean that the calculator cannot help mathematics learning at all. In various calculations and more complex problems, e.g. in numerical methods topics, the use of calculators greatly helps the learning process. Therefore, the use of technology in learning must be done appropriately. Otherwise, the misuse of technology in learning instead makes a negative impact on the learning process, specifically on students' dispositions as Boyce said (Gulley, 2003). It requires precision in embedding technology into certain parts of the topic in designing good technology-based learning. The measure of good technology-based learning in this study refers to the mathematical disposition indicator (NCTM, 2000; Zlatkin-Troitschanskaia, 2019) whereas lesson study is applied to design and improve the technological learning quality. Based on the previous description, the purpose of this study is to foster mathematical disposition among prospective teachers through a technology approach.

2. Method

This study was conducted at a university in Indonesia. The subjects were students of the Mathematics Education Study Program who took a linear programming class. The linear programming topics were chosen due to the researchers' capability and the strong relation between technology and the topics; for example, the simplex method requires a lot of iteration, which can be simplified by using a computer. The class already had two parallel classes, which made the lesson study activity easier.

The steps of the lesson study started with planning, followed by doing (implementing the teaching plan), seeing (evaluating and revising the chapter design), and repeating for the parallel class. The lesson design and chapter design were planned by the lecturer team for linear programming topics and reviewed by both topic and lesson study experts. The teaching sessions were observed, written down, and recorded to evaluate students' disposition in detail. In the reflecting session, every observer gave feedback to revise the chapter design regarding the mathematical disposition indicators to be achieved, and then the lesson study was repeated with the other parallel class. The final lesson plan and chapter design were expected to be ideal outcomes besides the students' mathematical disposition.

In this study, data collection was carried out using mathematical disposition questionnaires and problem-solving tests. The mathematical disposition questionnaire was used to measure students' attitudes, beliefs, and tendencies towards mathematics, while the problem-solving test assessed students' ability to tackle and solve various mathematical problems. The data obtained were analyzed qualitatively and descriptively, focusing on gaining an in-depth understanding of how students' mathematical disposition and problem-solving abilities interact and contribute to the mathematics learning process. This analysis aims to identify patterns, tendencies, and phenomena that emerge in the learning context, as well as to provide a comprehensive overview of the influence of mathematical disposition on problem-solving abilities.

3. Result and Discussion

Polyhedron International Journal in Mathematics Education, 2(1), 10-17
Online ISSN: 2987-6540
https://nakiscience.com/index.php/pijme

3.1. Lesson Design and Chapter Design

This lesson study started at the very beginning of the linear programming topics. Our course began with solving a problem in linear programming, which was feasible because linear programming had already been taught in senior high school. The objective of this session was to connect and introduce POM-QM as the technology. After the participants got to their best condition on linear programming, they started to emphasize their understanding. This session was conducted using POM-QM as a technology to generate solutions. Participants were expected to input their data, see the results, and describe their findings. In the last session, participants were given a problem to solve both manually and using POM-QM. They explained and described their findings in front of the class, providing as much supporting data as possible. In addition, details about the lesson design can be seen in the following steps. Moreover, details about the lesson design.

Student Action (Prediction of Student Response)

Individually, students think about and write various variables, objects, and mathematical models of the problems raised.

For: x = model A amount
y = model B amount

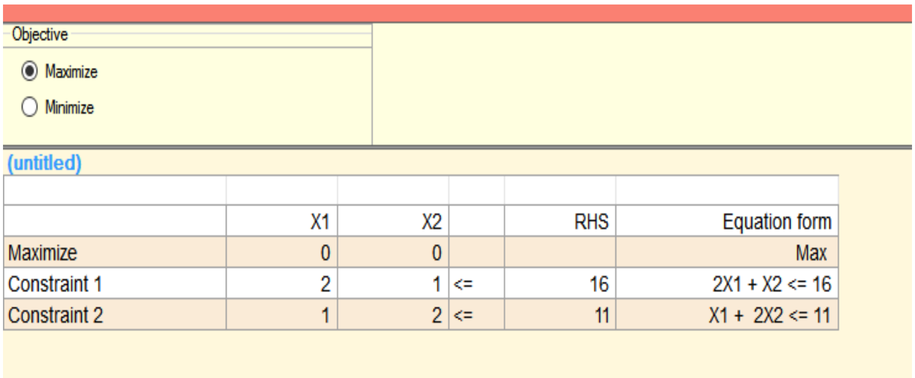
Fabric	Model A (x)	Model B (y)	Available
Silk	2	1	16
Wool	1	2	11
Cotton	1	3	15
Profit	30.000	50.000	

Expected students mathematical model :
Maximize z = 30000x + 50000y
constraits:

$2x + y \leq 16$
$x + y \leq 11$
$x + 3y \leq 15$
$x, y \geq 0$

- Exploring Program Linear menu in POM-QM
- Exploring Constraints in POM-QM
- Exploring objectives in POM-QM

Students experimenting with POM-QM:
Many variables / constraints
RHS, and the mathematical model try to input it in POM-QM
Experiment data:



	X1	X2		RHS	Equation form
Maximize	0	0			Max
Constraint 1	2	1	<=	16	2X1 + X2 <= 16
Constraint 2	1	2	<=	11	X1 + 2X2 <= 11

Idea sharing between students

The longer the variables, the more constraints, the objectives can be changed according to the *objective function*

- Students get the POM-QM output, read and determine the values of the variable in question.

- Students read that the various panels below are iterations and graphs that clarify the completion steps.
- Students try to answer using POM-QM then explain their findings.

In groups of students exchange ideas
- Beginning with making mathematical models
- Then input constraints and objectives
- Analyzing POM-QM output
- Students are asked to present their answers in front of the class

Anticipation/Assistance for Lecturers
In the previous meeting, students were asked to install the POM-QM application from the laptop.
Preliminary
A garment tailor has a supply of 16 m of silk cloth, 11 m of wool cloth, 15 m of cotton cloth that will be made of 2 clothing models with the following conditions:
- Model A requires 2 m silk, i m wool, and 1 m cotton per unit.
- Model B requires 1 m silk, 2 m wool, and 3 m cotton per unit.

Profit of model A clothes is Rp. 30,000 / unit and the profit of model B clothes are Rp. 50,000 / unit. Determine the number of each garment that must be made so that the maximum profit is obtained.

Create tables and mathematical models only.
(The solution is done with the help of POM-QM)
Focusing on students exploring the POM-QM application menus (Linear Program, Transportation, etc., 10 minutes). In groups of about 4 people, students are asked to experiment individually for different points in a variable using POM-QM to answer the problem.
Core activities
Observation of student activities by conducting experiments using the POM-QM application
Asking students to present the data input results of the MPL mathematical model in the POM-QM format. Sharing findings and interpreting experimental data in groups.
After the experimental data is displayed, all students are focused on paying attention and discussing experimental data (5 minutes). “What if more and more variables, more constraits, or objective changes? After a student argued, several students are asked to give some arguments.”
Students are asked to click solve and analyze the output results of POM-QM work
1. What are the various panels below? Students are asked to analyze the panel below
2. Look at the panel graph, where is the maximum value?
3. What does it mean?
4. (Try another point) is there more maximum? Why?
5. What about the points in the area outside the shading?
6. What happens when a sign less than or equal to (<=) is replaced?

Further Activities
The cooking demonstration committee provided 2 types of nutritious food in the form of powder for participants. Every 400 g, both types of food contain nutrients as follows:

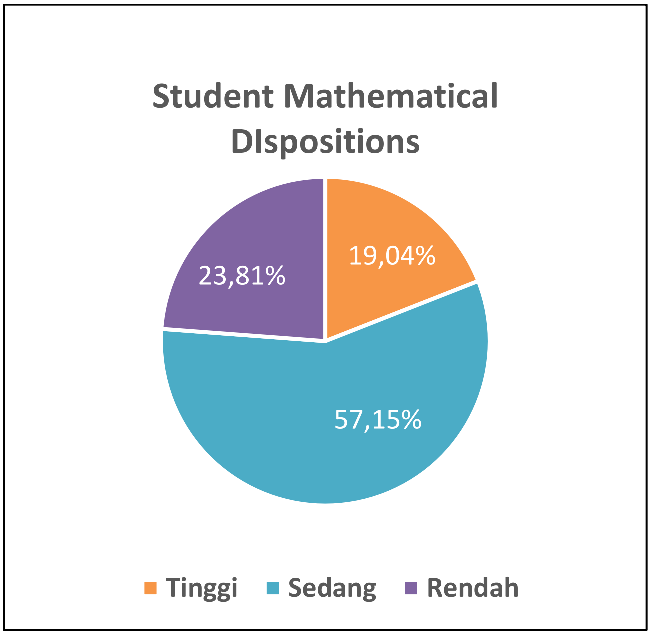
Nutrients	Food A	Food B
Protein	15 g	10 g
Fat	2 g	4 g
Carbs	25 g	30g

The participants need at least 15 g of protein every day, 4 g of fat, and 30 g of carbohydrate. If the price of food is IDR 15,000 every 40 g of food B IDR 20,000 every 400 g, determine the minimum price of food that the participants have spent each day.

3.2 Results Mathematical disposition scale questionnaire

Based on the results of the mathematical disposition scale questionnaire, three levels of disposition were identified: high, medium, and low. The high disposition category included 4 students (19%), the medium disposition category included 12 students (57.15%), and the low disposition category included 5 students (23.81%). The analysis of problem-solving ability tests on linear programming using Polya's steps, as well as the results of the interviews, indicated consistency between the two.

Figure 1
Results of the Mathematical Disposition Scale Questionnaire



The research subjects were further narrowed down by selecting three students from each disposition level to deeply analyze problem-solving abilities in linear programming at each level of mathematical disposition. The results of this analysis are presented in the following table, which provides an overview of the problem-solving abilities in linear programming about mathematical disposition.

Table 2
Students' ability to solve linear programming problems using POM-QM based on their Mathematical Disposition

Problem-solving indicator	Disposition Level		
	Low	Intermediate	High
1. Identifying data sufficiency	☑	☑	☑
2. constructing the mathematical model	✗	☑	☑
3. implementing strategies for problem-solving	✗	☑	☑
4. interpreting results/evaluating answers	✗	✗	☑

Based on Table 2 above, the findings indicate that students with low and medium dispositions experience difficulties in reading and interpreting the given word problems, converting general statements into mathematical models, and determining the objective function in linear programming. These challenges lead to an inability to proceed to the subsequent steps, such as determining the optimal value of the linear program, and ultimately, to an inability to solve the problem. This is due to a lack of understanding of the linear inequality system with two variables, which hinders students from solving issues related to linear programming.

3.3 Discussion

Some students with medium dispositions demonstrate problem-solving abilities in linear programming, including reading and interpreting word problems, creating mathematical models, determining the objective function, and finding the optimal value. However, there are still students within this group who struggle with constructing mathematical models. This study aligns with Kandaga et al. (2021) findings, which revealed that only 13.8% of students were able to create accurate mathematical models. These students also face difficulties in explaining or interpreting results in relation to the original problem and in verifying the correctness of their answers. Meanwhile, students with high dispositions nearly meet all the indicators of problem-solving ability, although some still make errors in interpreting results that align with the original problem.

This study on linear programming is consistent with research findings that highlight various perspectives on what is important in teaching linear programming in schools. Teachers also perceive linear programming as largely about the use and manipulation of symbols and the application of linear programming in everyday life.

Upon reflection, we concluded that it was necessary to review and confirm each group's ideas to ensure that students gained the confidence and persistence to continue developing their thoughts. This also helped to correct any misconceptions early on, preventing students from straying too far off course and having to start over from the beginning.

During the implementation of our lesson design, all students, including those typically less engaged, made efforts to understand and participate in solving the problem. Notably, students responded with enthusiasm, expressing satisfaction whenever their ideas were confirmed as correct, and they paid close attention when it was explained that their ideas were incorrect. These observations indicate that the applied learning approach successfully fostered perseverance, interest, and flexibility—all of which are indicators of mathematical disposition as outlined by the NCTM (2000).

Students were also asked to present their findings in front of the class. Although some students appeared hesitant and uneasy, even when their explanations and solutions were accurate, others demonstrated good confidence, effectively explaining their solutions even when faced with a series of challenging questions. Upon reflection, we concluded that these activities were essential for enhancing understanding, fostering critical and creative thinking, and building the confidence needed for public speaking—an important skill for future educators. Those unease gesture should not be done by a professional teacher, and those became our special concern as we preparing our prospective teacher to be ready on their future professional job. The concern has become a revision material of the chapter design. Before the core of learning activities, students need to be given understandings of how to be confident in speaking his minds. Another revision is to give students another more challenging problem, using three variables or more than is using simplex method. Those problems could connect their understanding of the use of the simplex method.

4. Conclusion

Build upon the result has been discussed, the chapter design can foster mathematical dispositions. Some other affective and cognitive skills have been known to be improved. Although student's confidence and representation still to think about to accommodate in the design, but those still be valid to foster some of the skills. The other unwrittten but proper things to do in the learning is; (1) In linear programming it best if you begin with a problem; (2)

Students grouping is making students easy to control and great to encourage discussion; (3) lecturers still need to check and confirm every groups' work; (4) series of question when students' explain their work in front of class is needed to improve understandings, critical and creative thinking, also their confidence; (5) connection between chapter also need to design correctly.

Acknowledgment
The researchers would like to thank all parties who have helped in carrying out this research.

Declarations
Author Contribution: Author 1: Conceptualization, Writing - Original Draft, Editing and Visualization, and Validation and Supervision; Author 2: Writing - Review & Editing, Formal Analysis, and Methodology.
Funding Statement:
There was no financial assistance during the implementation of this research.
Conflict of Interest:
The authors declare no conflict of interest.
Additional Information:
Additional information is available for this paper.

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