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Research Article

Ksystematic literature review: How students learn linear programming with realistic mathematics education?

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ABSTRACT

This study aims to investigate more deeply the material of linear programming with a realistic mathematics education (RME) approach. This research is a literature study with a descriptive qualitative research type with library research using various written sources such as articles from Springer, ScienceDirect, and Google Scholar. This study focuses on the characteristics of RME, the principles of RME, the steps of learning RME on linear programming material, and examples of implementing RME learning on linear programming material. From the results of previous research, it was found that using the RME approach can help students understand linear programming material. This is because real-life problems in linear programming are in line with realistic principles that exist in the RME principle, namely being able to apply mathematics in solving real-life problems and mathematics must start from problem situations that are meaningful for students.

Keywords: linear programming; realistic mathematics education; systematic literature review

1. INTRODUCTION

The Ministry of Education and Culture (2016) states that the goals of high school mathematics education are (1) understanding mathematical concepts and using mathematical procedures in a flexible, accurate, efficient, and precise manner in solving problems, (2) using patterns as conjectures in solving problems, (3) using reasoning , (4) being able to communicate ideas, reasoning, and being able to compile mathematical proofs by using complete sentences, symbols, tables, diagrams, or other representations to clarify situations or problems, (5) have an attitude of appreciating the usefulness of mathematics in life, and (6) have attitudes and behaviors in accordance with the values in mathematics and learning. This is line with NCTM (2000) which defines five standards of mathematical ability that students must have, namely problem solving skills, reasoning skills, communication skills, connection skills, and representational skills.

In Indonesia, learning mathematics has been taught from the elementary school level to tertiary institutions. However, in fact the learning outcomes of students' mathematics are still low. Based on the results of the 2018 Program for International Student Assessment (PISA) survey presented by The Organization for Economic Co-operation and Development (OECD) on December 3 2019, it shows that the mathematics scores of Indonesian students are at a score of 379 lower than the OECD average 489 and decreased compared to the previous year (OECD, PISA 2018 Results Combined Executive Summaries Volume I, II & III, 2019). Based on the analysis of the 2018 PISA results, it was found that Indonesian students were only able to solve problems up to level 2, while other countries involved reached levels 3, 4, 5 and 6.

In PISA questions, students are asked to analyze the problems given in the form of word problems that can be found in everyday life and then solve them mathematically (Utaminingsih & Subanji, 2021). The low achievement level of mathematical literacy ability is due to the fact that math literacy questions have never been done by students (Fadholi, Waluya, & Mulyono, 2015). OECD (2019) a recommends educators to accustom students to solving problems in everyday life according to three domains of mathematical processing ability, namely: (1) formulating situations mathematically, (2) using mathematical concepts, facts, procedures, and reasoning; and (3) interpret, apply, and evaluate mathematical results. One of the problems in everyday life is the problem of optimization (Wijayanti, 2014). Optimization problems are the subject of linear programming material (Monariska & Komala, 2021). Linear programming is a branch of mathematics that is often applied in everyday life. Linear programming refers to a mathematical concept consisting of a set of variables and constraints expressed in linear constraints and an objective function that aims to maximize profits and minimize costs (Patrick, 2020). The basic competence to be achieved in linear programming material is that students can solve contextual problems related to linear programming (Handajani, Pratiwi, & Mardiyana, 2018). Linear programming is used to find the

best solution for the problem of a particular project in various sectors, namely in the business of manufacturing, health, construction, personnel planning and investment management.

In a linear program, students are trained to make several strategies to determine maximum income by minimizing expenses (Sutiaharni & Permana, 2021). To achieve the desired optimal value, many steps must be taken, so that learning linear programming requires prerequisite material related to mathematical topics, namely linear algebra, systems of linear equations and inequalities. In reality, there are many problems faced by students in learning linear programming. Students have difficulty expressing problems in verbal language and linear programming language (Hidayat & Iksan, 2015); (Octaria, 2016), students do not understand the questions, are not yet skilled in writing problems in linear programming mathematical models, have difficulty in constructing the mathematical meaning of symbols (Charles-Ogan & George, 2015) and errors in doing calculations (Baidawi, Pertiwi, & Esti, 2020).

One solution that can be used to overcome the above problems is by using the Realistic Mathematics Education (RME) approach. This is because real-life problems in linear programming are in line with realistic principles that exist in the RME principle, namely being able to apply mathematics in solving real-life problems and mathematics must start from problem situations that are meaningful for students (Heuvel-Panhuizen & Drijvers, 2014). According to Freudenthal, mathematics must be connected to reality, remain close to students and relevant to society so that it has human value, so that mathematics is not a subject matter but a human activity (Heuvel-Panhuizen M. V., 1996). This systematic review is intended to investigate more deeply the learning of linear programming with a realistic mathematics education (RME) approach. It is projected that the findings reported in this systematic review will help find answers to questions. It is hoped that this systematic review will reveal trends, limitations, and rules, thereby creating opportunities for further research.

2. RESEARCH METHOD

The method used in this research is Systematic Literature Review (SLR). SLR aims to describe, analyze, synthesize from existing literature to test hypotheses to develop a new theory (Xiao & Watson, 2019). According to Xiao & Watson, the SLR steps used in this study consist of eight steps which are divided into three main stages, namely the planning stage, the implementation stage and the reporting stage (Xiao & Watson, 2019). SLR steps can be seen in **Figure 1**.

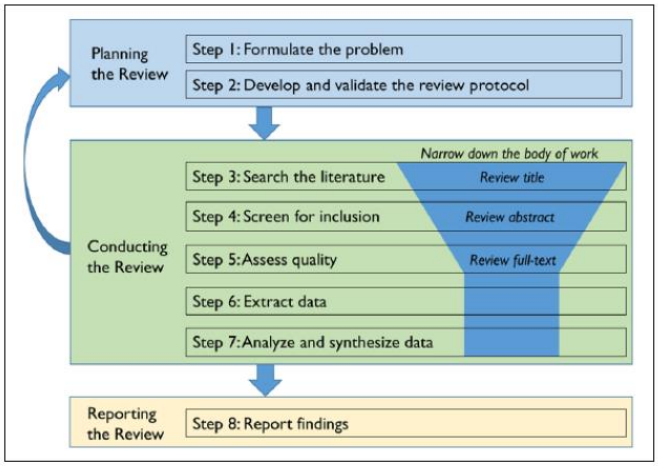

Figure 1. The Systematical Literature Review Stages

Planning Stage

At the planning stage there are twi steps that must be taken, namely formulating the problem and developing and validating the study protocol.

Implementation Stage

1) **At the implementation stage**, there are five steps that must be carried out, namely: Searching for literature, there are three sources for searching literature, namely electronic databases, backward searches and forward searches.
2) **Screening (Screen for inclusion)**, after compiling a list of references, the next step the researcher must take is to screen each article to decide whether the article should be included for data extraction and analysis. The method used is to filter based on an abstract review.
3) **Assessing quality**, quality assessment acts as a fine sieve to screen full text articles and is the final stage in preparing the study set for data extraction and synthesis.
4) **Extracting the data**, after assessing the quality of the next step is to extract the data.
5) **Data analysis and synthesis**, after the data extraction process is complete, the researcher will organize the data according to the selected review, often it will be some combination of charts, tables, and textual descriptions.

Reporting stage

After all the stages have been completed, the last step taken by the researcher is to make a report on the results of the article review that has been done.

3. RESULTS AND DISCUSSION

The research results are explained as follows:

Planning stage

At this stage the author formulates the problem presented in the form of a research question, namely how do students learn linear programming with realistic mathematics education (RME)?. After formulating the problem, the authors developed and validated the study protocol. This article contains a study that describes how students learn linear programming with realistic mathematics education (RME).

Implementation Stage

At the implementation stage begins with a literature search. The author starts with the keywords "realistic mathematics education", and "Linear Programming". The author searches for literature using databases such as Google Scholar, Researchgate, and Sciencedirect. The author limits publication in 2012 – 2022. The next step is the author makes a selection with acceptance and rejection criteria according to the keywords and year of publication. Then read the title and abstract to determine whether it is relevant to this research topic. So that the articles obtained meet the study quality criteria. The next step is to extract, analyze and synthesize data. Data synthesis was carried out with the aim of collecting evidence from selected studies to answer research questions.

Reporting Stage

The last step taken in this research is to make a report on the results of the review of the articles that have been carried out. This article indicates opportunities and directions for future research.

3.1 Linear Programming

The idea of linear programming originated with a Russian mathematician Leonid Vitalevich Kartovich in 1939 by publishing an essay entitled Mathematical Methods in the organization and planning of production. In 1947, an American mathematician, George Bernard Dantzig, in his book entitled Linear Programming and Extension, suggested how to describe and solve linear programming problems using the simplex method. Then John von Neumann, Leonid Khachiyan and Naranda Karmarkar developed linear programs for more complicated problems in the following years until the discovery of the graphical method (Siregar & Mansyur, 2021). Some characteristics of linear programming problems are (1) they can be turned into mathematical problems, (2) they contain a set of linear inequalities that must be met together, and (3) they have an objective function to be optimized, namely a minimum or maximum. In linear programming, there are five stages involved in modeling and optimizing a solution to a problem, namely (1) defining the problem, (2) formulating a model, (3) solving the model, (4) testing the validity of the model and (5) implementing the final results (Idris, 2015).

In introducing the subject of linear programming, it is preferable to present graphical methods for solving two-variable linear programming problems, because using graphical methods provides valuable insight into the general nature of multivariable linear programming. Completion of linear programming graphs provides learners with intuitive visual aids to facilitate understanding of concepts such as feasible region, feasible basic solution, infinite solution (Fernandes & Pereira, 2018). According to Sole (2016) the benefits of using open ended questions on linear programming problems, namely (1) students are able to model real world problems better, (2) challenge students with different abilities, and (3) strengthen skills student problem solving.

3.2 Realistic Mathematics Education (RME)

Realistic Mathematics Education is based on the thoughts of Hans Freudenthal who stated that mathematics is a human activity, not as a science that must be transferred from educators to students. Realistic Mathematics Education is a mathematical approach that involves students developing understanding by engaging in problems that are set in a context that involves students' interests. According to Treffers (Lerman, 2020) (Bray & Tangney, 2016) (Zubainur, Johar, Hayati, & Ikhsan, 2020), there are five characteristics of Realistic Mathematics Education, namely: (1) using real life problems to start lessons; (2) using models or symbols on the problem to bridge the concrete level to a more formal level; (3) encourage students to solve real life problems on their own; (4) facilitate students to interact, share, and construct problem solving with their peers during the learning process; (5) the interrelationships between mathematical concepts in order to strengthen all interrelated mathematics subjects.

Jazuli, et.al (2017); Yee & Bostic (2014); (Yuliana, Hartono, & Wijoyo, 2019) states that one of the learning strategies that can be used to increase students' understanding of concepts in the problem solving process is by using a contextual context. This is in line with Freudenthal's opinion (Trung, Thao, & Trung, 2018), educators need to find contexts, create contexts that support students to construct mathematical knowledge. Contexts that can be used for teaching mathematics are contexts in the history of mathematics, contexts in real life (students' lives and social problems), and integrated education. Meyer, et al (Clarke & Roche, 2017) states that a high-quality context consists of: (1) supports mathematics, does not make it a headache; (2) must be real, at least it can be imagined by students; (3) must be varied, not repeated; (4) must generate real problems to solve; (5) must be sensitive to norms, culture, gender, and race and not exclude groups of students; (6) must enable learners to create mathematical models.

There are six teaching principles from RME (Lerman, 2020), namely (1) Activity Principles, students are treated as active participants in the learning process; (2) The Realistic Principle, in RME is known in two ways, namely expressing the importance of the goals of mathematics education including the ability to apply mathematics in solving real life problems and mathematics education must start from a problem situation that is meaningful for students; (3) Level Principle, students go through various levels of understanding from 'model of' to 'model for'; (4) The Principle of Linkage, the domains of mathematical content such as lift, geometry, measurement, and data calculation are not considered as isolated curriculum chapters but are highly integrated; (5) The principle of interactivity, learning mathematics is not only an individual activity but also a social activity; (6) Guiding Principles, referring to 'guided retrieval' educators must have a proactive role in student learning and educational programs must contain scenarios that have the potential to be levers to achieve a shift in student understanding.

The RME approach focuses on how mathematics is taught and how students learn mathematics in class. To develop this focus, it is necessary to develop a learning trajectory that will facilitate students in achieving learning goals with the help of educators and learning resources (Putri & Zulkardi, 2018). The initial learning flow is in the form of a hypothesis about what will happen if students learn with a designed flow (Hypothetical Learning Trajectory (HLT)), after the HLT development process will become a theory about how to teach a mathematical topic (Local Instructional Theory (LIT)) (Fauzan, Plomp, & Gravemeijer, 2013).

3.3 Learning Linear Programming Material with RME

Learning designed on linear programming material with RME according to Metal, Hartono & Hapizah (2018) :

First Activity

Problems raised from context, then students are given the opportunity to explore problems to recognize sentences that contain decision variables, objective functions, constraint functions and non-negative functions. Students are given the opportunity to explore the problems presented on the student worksheets (LKPD).

Second Activity

Students are asked to model decision variables, objective functions, constraint functions and non-negative functions into mathematical language. In the first step, students exemplify the decision variables with the letters x and y, then students are asked to find the general formula for the mathematical model of the problems presented.

Third activity

Students are asked to solve problems in context with graphical methods.

Fourth Activity

Students are asked to test the value of the decision variable obtained whether it meets all the requirements or not.

Fifth Activity

Students are asked to determine the optimum value of the objective function in the problem.

Sixth Activity

Educators remind students about how students understand to solve linear programming problems.

The learning design with the RME approach shows how the characteristics of RME form the basis of each learning process. The results of research (Hidayat & Iksan, 2015) (Amrina & Rosnawati, 2019) (Patrick, 2020) (Sutiaharni & Permana, 2021) (Laelasari, Darhim, & Prabawanto, 2020) state that the RME approach to linear programming material gives good results, the RME approach to linear programming material can help educators overcome conceptual understanding through contextual questions so that it can encourage mathematical thinking, and can improve mathematical representation skills.

4. CONCLUSION

Based on some of the results of previous research, it was found that linear programming material can be taught using a realistic mathematics education (RME) approach. Real-life problems in linear programming are in line with realistic principles that exist in the RME principle, namely being able to apply mathematics in solving real-life problems and mathematics must start from problem situations that are meaningful for students.

AUTHOR'S CONTRIBUTIONS

The authors discussed the results and contributed to from the start to final manuscript.

CONFLICT OF INTEREST

There are no conflicts of interest declared by the authors.

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