



Understanding Learning Barriers in Fractional Multiplication: An Investigation Using Hermeneutics Phenomenology

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ABSTRACT

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The multiplication of fractions was considered an easy operation, but it posed a challenge for students. The lack of previous research on this topic, especially at the tertiary level, made it an intriguing subject for investigation. This study aimed to explore the factors contributing to these difficulties and the types of learning barriers students faced. Hermeneutics phenomenology was used as the research design. Fifteen participants, aged between 18 and 25, consisting of 7 boys and 8 girls, were selected for this study. Nine students had a background in natural sciences during high school, while six were from social studies majors. The researcher served as the main instrument, employing a fraction multiplication test with two questions developed by NCTM. Additionally, a semi-structured interview guide was used as an additional instrument. The data obtained were analyzed using NVivo-12-assisted thematic analysis for a simplified coding process. The study findings indicated that students encountered more learning difficulties when dealing with non-routine fraction multiplication problems. For routine problems, the learning obstacles were primarily ontogenic and psychological in nature (carelessness). However, when dealing with non-routine problems, students faced epistemological barriers due to their limited experience with word problems. Moreover, they encountered conceptual obstacles (inability to equivalence and convert fractions to decimal form) and psychological hurdles (doubt) during the learning process.

KEYWORDS:

multiplication of fractions, hermeneutics phenomenology, ontogenic and epistemological obstacle.

1. INTRODUCTION

Fraction multiplication is considered a relatively straightforward procedure in learning fractions (Purwanti, 2015; Shanty et al., 2011). However, previous studies have highlighted that non-routine problems involving fraction multiplication pose challenges for students in various educational settings, including lectures (Chen et al., 2013; Julie, 2017; Rifandi, 2017). Fraction multiplication is frequently utilized in educational lessons, both in advanced mathematics and agricultural-related subjects (Isnawan et al., 2022; Zhang et al., 2014; Fehr, 1968; Iulia & Gugoiu, 2006; Singh et al., 2021). Given the significance of fraction expansion for students and the presence of existing problems,

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research on fraction multiplication studies is crucial, and immediate attention is necessary when problems arise during fraction multiplication. While some previous studies have examined fraction multiplication, only a limited number have focused on universities as research subjects, with only a few researchers employing the hermeneutics phenomenology design (Chen et al., 2013; Rifandi, 2017; Shanty et al., 2011).

In the study conducted by Son and Lee (2016), although students were involved as participants, the research design could have been more precise. The study findings revealed that some participants encountered difficulties in converting real-life problems involving fractions into appropriate mathematical statements and suitable visual representations. In the research conducted by Ekawati et al. (2022), which involved students from schools as participants and employed a case study design, the findings indicated that some participants needed to transform non-routine problems involving fraction multiplication into suitable mathematical models. Similarly, the study by Bharaj et al. (2021), which

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utilized grade 5 elementary school students as participants and employed research designs requiring further clarification, concluded that some participants used strategies or concepts related to integers when multiplying fractions and resorted to addition and subtraction operations when solving non-routine problems that should involve fraction multiplication.

The preference for the hermeneutics phenomenology design stems from its relevance in studying a specific group of individuals (students) concerning a particular phenomenon (fraction) (Isnawan et al., 2022; Ramezanzadeh et al., 2016). The study's results are expected to provide insights into external factors that contribute to students experiencing difficulties in fraction multiplication. By understanding these factors, lecturers can develop alternative solutions or modify their teaching approaches to minimize the learning barriers faced by students during classroom instruction. Thus, this study aims to describe the types of learning barriers encountered by students in fraction multiplication using the hermeneutics phenomenology design.

II. METHOD

The approach used in this study was qualitative, with hermeneutics phenomenology selected as the research method. The aim of this study was to investigate students' experiences in solving problems related to fraction multiplication (Isnawan et al., 2022; Keshavarz, 2020; Ramezanzadeh et al., 2016; Stephenson et al., 2018; Tan et al., 2009). The research was conducted from September 2022 to February 2023 at a private university in West Nusa Tenggara Province, Indonesia. Fifteen students from three study programs participated in this study, with five students from the Mathematics Education Study Program, seven from the Agrotechnology Study Program, and three from the Food Technology Study Program. These programs were chosen because they included mathematics as a compulsory course during lectures. Participants' biodata were as follows: their ages ranged from 18 to 25 years, with seven males and the remaining females. Nine students had science majors during high school, while the others had social studies majors. The participants were selected using purposive sampling, which was appropriate for the study's purpose of identifying the types of learning barriers experienced by students who faced difficulties in multiplying fractions.

The research procedure involved determining the research instruments, providing test instruments to the participants, analyzing the students' answer sheets, conducting student interviews, and analyzing the research data. The primary instruments used in this study were the researchers themselves, along with fractional multiplication test instruments, and additional interview guidelines. The test instrument comprised questions developed by NCTM (NCTM, 2014).

III. RESULTS

After analyzing the student answer sheets, information related to the description of the Initial Code (IC) for problem number 1 are IC1_1 (*no obstacles*), IC1_2 (*mistakes in carrying out multiplication procedures-using the distribution procedure*), IC1_3 (*mistakes in simplifying fractions*), IC1_4 (*mistakes in the multiplication of the denominator*), and IC1_5 (*absence of the term "per" during the working process*). IC1_1 is the dominant initial code for problem number 1, indicating that students do not encounter learning barriers when solving routine problems involving mathematical multiplication with fractions.

The description of the Initial Code for problem number 2 are IC2_1 (*errors in making mathematical modeling (reduction model)*), IC2_2 (*mistakes in making mathematical modelling-division model*), IC2_3 (*mistakes in converting fractions into decimal form*), IC2_4 (*mistakes in the procedure for reducing fractions-using multiplication procedures*), IC2_5 (*doubt*), IC2_6 (*confusion between the distribution and multiplication procedure*), IC2_7 (*inability to make mathematical modelling-only writing what is known*), IC2_8 (*mistakes in quoting fractions*), IC2_9 (*inability to make mathematical modelling-percentage method*), IC2_10 (*errors in making mathematical modelling-addition model*), and IC2_11 (*addition of the number "2" to the numerator and denominator of the first fraction, and addition of the number "4" to the numerator and denominator of the second fraction*).

After identifying the Initial Codes (ICs), the next step involves identifying the themes, reviewing them, and providing names or definitions for each theme. The description of the themes for problem number 1 are T1_1 (*no obstacles*), T1_2 (*mistakes in carrying out multiplication procedures for fractions*), T1_3 (*obstacles related to prerequisite material*), T1_4 (*lack of carefulness*).

Next, the description of themes for problem number 2 are T2_1 (*mistakes in mathematical modelling*), T2_2 (*inability to follow procedures in operating fractions*), T2_3 (*obstacles related to prerequisite material*), T2_4 (*inability to create mathematical models*), and T2_5 (*uncertainty*).

For T2_1 and T2_4, students indicated that they needed help understanding the questions as they were not accustomed to solving word problems in mathematics. Based on the interview analysis, students facing T2_1 and T2_4 themes were found to struggle with mathematical modeling due to limited experience with word problems. Additionally, students encountering T2_2 and T2_3 themes needed to recall prerequisite procedures and materials for operating fractions, which was confirmed during the interviews. Regarding the T2_5 theme, students expressed uncertainty, leading them to provide two alternative answers. These interviews highlighted several learning barriers faced by the students, such as limited exposure to word problems, difficulty understanding prerequisite concepts for operating fractions, and uncertainties in their answers (related to problem 2).

IV. DISCUSSION

Based on the findings of previous research, it is evident that students are facing learning obstacles due to carelessness when working on problem number 1. When considering theories related to types of learning barriers (Brousseau, 2002; Suryadi, 2019b, 2019a), it can be concluded that the learning barriers experienced by students for problem number 1 are psychological ontogenic obstacles. This conclusion is drawn from the fact that students tend to be more cautious when approaching problem number 1, leading to correct processes and results. Students can perform well on the task when they approach it calmly. These results align with theories indicating that psychological or emotional calmness is essential for success in a lesson, including being cautious while studying and working on problems (Baylor et al., 1999; Cohen & Sherman, 2014; Critcher & Dunning, 2015; Gulevska & Atanasoska, 2015; Ioannidou & Konstantikaki, 2008; Purnamayanthi et al., 2022; Reskina & Kartini, 2022; Yulika et al., 2019). The findings of this study further support previous research (Fauzi & Suryadi, 2020; Isnawan, 2022; S. K. Rohmah, 2019; Ulfa et al., 2021), which suggests that students tend to encounter learning barriers with psychological ontogenic obstacles.

Regarding problem number 2, when considering theories related to types of learning barriers, the results indicate that students in this study are experiencing various types of learning barriers:

Students are experiencing epistemological obstacles as learning barriers because they have limited methods of learning fractions at school. They are not accustomed to dealing with word problems when learning fractions or mathematics.

Students are facing conceptual ontogenic obstacles as learning difficulties. This is because they require a deeper understanding of the concepts or prerequisite material needed for learning fraction multiplication.

Students are encountering ontogenic obstacles of a psychological nature as learning barriers because they tend to have doubts when making decisions about the procedures or answers they choose and use while solving problems or learning.

The findings of this study also corroborate several previous studies, which have revealed that conceptual and psychological barriers are epistemological and ontogenic obstacles, experienced not only by students at the elementary and secondary school levels but also at the tertiary level (Aksoy & Yazlik, 2017; Maelasari & Jupri, 2017; Makonye & Khanyile, 2015; Malone & Fuchs, 2016; M. Rohmah & Sutiarmo, 2018; Safriani et al., 2019; Singh et al., 2020). If left

unaddressed, epistemological obstacles can lead to other learning barriers (Aebi & Linde, 2015; Daut Siagian et al., 2022; Moru, 2007). Therefore, educators, including teachers and lecturers, need to create learning environments that minimize these obstacles. For instance, lecturers can design didactic approaches or teaching materials with various contexts during lectures, encourage students to tackle real-life problems while learning, and establish an epistemic learning flow by utilizing the steps of didactic situations in learning. These steps include action-formulation situations (students solving problems in their way), validation (students discussing to determine solutions, concepts, or procedures from problems), and institutionalization (students using solutions, concepts, or procedures obtained in different situations or contexts from previous learning activities) (Brousseau, 2002; Suryadi, 2019b, 2019a).

To minimize learning barriers with psychological ontogenic obstacles, lecturers can incorporate ICT in lecture activities, such as using the quizizz platform to engage students in learning, provide challenging problems to enhance students' logical thinking, offer learning videos that illustrate the relevance of the material being studied, and encourage students to double-check their processes and work results during learning (Isnawan, 2022).

Lastly, when comparing the learning barriers experienced by students in problem number 1 and problem number 2, it becomes evident that students face more learning difficulties in problem 2. In other words, students tend to struggle more with solving non-routine problems (story or everyday life problems) rather than routine problems. This is because students need to comprehend the intent of the given problems (according to the results of the interviews). These findings align with theories suggesting that the ability to understand questions, including literacy skills, plays a crucial role in successful problem-solving in mathematics (Bolstad, 2019; Genc & Erbas, 2019; Umbara & Suryadi, 2019). The results of this study further reinforce previous research, which indicates that non-routine problems are more challenging for students than routine problems in learning mathematics (Johar & Lubis, 2018; Powell et al., 2020; Saygili, 2017; Shin & Bryant, 2017; Upu et al., 2022). Encouraging students to interact with non-routine problems during lectures could help them become more adept at solving such problems.

V. CONCLUSION

Based on the results of previous research and discussions, students experienced more learning difficulties when they solved non-routine fraction multiplication problems compared to routine fraction multiplication problems. It was indicated that students needed assistance in understanding the correct meaning of non-routine problems, which constrained their problem-solving process. In this study, students

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indicated that they encountered learning barriers of the ontogenic psychological obstacle type for problem number 1 (a routine problem in multiplying fractions). These obstacles were related to the need for students to be more careful. Additionally, the study revealed that students experienced epistemological, conceptual, and psychological ontogenic obstacles in multiplying fractions (a non-routine problem). The epistemological obstacle observed in this study was that students rarely encountered or worked on word problems while studying mathematics at school. Students faced conceptual ontogenic obstacles, such as needing corrections in equivalent fractions and converting fractions into decimal form. Moreover, learning barriers classified as ontogenic and psychological obstacles were observed in students who hesitated when using specific procedures to solve non-routine problems in multiplying fractions.

As a recommendation, this study suggests utilizing various forms of lecture design to minimize the previously described learning barriers. Some recommended characteristics for lecture design include integrating ICT (quizizz and learning videos), encouraging students to answer or solve non-routine problems during lectures, implementing epistemic learning steps, and providing practice questions that challenge students' mindsets during lectures. For future research, it is suggested that the results of this study serve as a basis for lecturers to develop didactic designs or teaching materials in mathematics lectures, particularly those related to rational numbers. This approach aims to align the learning design with the characteristics of different types of student learning barriers and provide potential solutions to minimize these learning barriers.

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VII. DISCLOSURE

The is no conflicts of interest in this work.

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