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Transpotition Didactic Design in Mathematics Learning: A Hermeneutic Phenomenology

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Abstrak

Meskipun banyak penelitian telah mengeksplorasi pentingnya pecahan dalam kurikulum sekolah dasar, penelitian mengenai topik ini di tingkat sekolah menengah pertama masih terbatas, terutama dalam mengidentifikasi faktor-faktor penyebab kesulitan belajar siswa dan merancang pendekatan alternatif untuk mengatasi tantangan tersebut. Oleh karena itu, penelitian ini bertujuan untuk menyelidiki kedua aspek tersebut. Metode yang digunakan dalam penelitian ini adalah fenomenologi hermeneutik. Partisipan dalam penelitian ini adalah siswa SMPN 1 Narmada Lombok Barat yang terdiri dari 29 siswa kelas VIII. Peneliti berperan sebagai instrumen utama yang didukung dengan beberapa alat seperti tes operasi pecahan, pedoman wawancara mendalam. Temuan penelitian mengungkapkan bahwa rendahnya kemampuan siswa dalam mengoperasikan bilangan bulat, khususnya perkalian dan pembagian, merupakan faktor utama kesulitan belajar. Rancangan didaktis terdiri dari 3 tahap. Tahap pertama meliputi beberapa kegiatan yaitu Ayo Tebak dan Ayo Baca. Tahap kedua meliputi kegiatan-kegiatan seperti Mari Mencari, Mari Berdiskusi, dan Mari Menyimpulkan. Tahap ketiga terdiri dari kegiatan Ayo Latihan dan Refleksi Diri. Tahapan ini dikembangkan untuk memperkuat pemahaman terhadap prasyarat tersebut melalui kegiatan yang melibatkan penentuan kelipatan persekutuan terkecil dan faktor persekutuan terbesar. Sebagai rekomendasi, penelitian ini menyarankan agar guru matematika mengadopsi berbagai situasi didaktik berbasis masalah dalam pembelajaran pecahan.
Kata Kunci: transposisi didaktis; kesulitan belajar siswa; fenomena heurmeneutik

Abstract

Although numerous studies have explored the role of fractions in the elementary school curriculum, research at the junior high school level remains limited, especially in identifying factors contributing to students' learning difficulties and developing alternative instructional approaches to address these challenges. This study aimed to examine both aspects. A hermeneutic phenomenology method was employed, with participants consisting of 29 eighth-grade students from SMPN 1 Narmada in West Lombok. The researcher acted as the primary instrument, supported by tools such as fraction operation tests and in-depth interview guidelines. The findings indicated that students' difficulties stemmed primarily from their weak understanding of integer operations, particularly multiplication and division. To address this, a three-stage didactic design was implemented. The first stage included activities like "Let's Guess" and "Let's Read." The second stage incorporated "Let's Search," "Let's Discuss," and "Let's Conclude." The final stage consisted of "Let's Practice" and "Self-Reflection." These stages were designed to strengthen prerequisite knowledge through exercises on determining the least common multiple and greatest common factor. The study recommends that mathematics teachers integrate problem-based didactic strategies into fraction instruction.
Keywords: transpotition didactic; learning obstacles; hermeneutic phenomenology

I. INTRODUCTION

Mathematics constitutes a vital component of everyday life (Maass et al., 2019; Man-Keung, 2022; Yolcu & Popkewitz, 2019) and serves as a foundational discipline across numerous domains (Chorlay et al., 2022; Hoffmann & Even, 2023; Sandefur et al., 2022). In an ideal educational setting, learners are expected to acquire a deep and coherent understanding of mathematical principles (Chorlay et al., 2022; Koskinen & Pitkäniemi, 2022). Nevertheless, a substantial body of research has documented persistent challenges faced by students in mastering mathematics (Elia et al., 2016; Lin et al., 2017), with fractional concepts being particularly problematic (Isnawan et al., 2022; Zhang et al., 2014). Although many investigations have examined fraction understanding at the elementary school level (Mohamed et al., 2021; Zuhri et al., 2023), studies targeting junior high school students are still relatively scarce, especially those employing a hermeneutic phenomenological lens within mathematics education.

Copur-Gencturk (2021) conducted a nationwide survey in the United States to assess teachers' comprehension of fraction operations. The study concluded that many educators possess limited knowledge in this area, although teaching experience appeared to enhance their conceptual understanding. A related study by Diputra et al. (2022) used a qualitative case study methodology in Bali to explore how elementary school teachers conceptualize fractions. Their findings indicated a prevalent misunderstanding of fractions as parts of a whole. Similarly, Purnomo et al. (2022) adopted a qualitative method involving assessments and interviews to explore how elementary students in Jakarta understand and struggle with fraction multiplication. Their analysis revealed that students often demonstrate inadequate comprehension, particularly when attempting to contextualize mathematical problems.

In contrast to previous works, the present study focuses on identifying the root causes of students' difficulties in adding fractions with unlike denominators and on designing a didactic strategy to address these issues. This investigation applies a hermeneutic phenomenological framework, enabling a nuanced analysis of learning obstacles and informing the development of a blended didactic model tailored to mathematics education (Keshavarz, 2020; Suryadi, 2019a, 2019b). Accordingly, the research is guided by two central questions: (1) What underlying factors contribute to students' difficulties in learning to add dissimilar fractions? (2) What didactic design can effectively support students in mastering this mathematical concept?

II. METHOD

This study involved 29 female students from SMPN 1 Narmada in West Lombok, all of whom had prior exposure to learning fractions. In addition to the students, the research also engaged a 26-year-old mathematics teacher with approximately five years of teaching experience. The study was conducted at a junior high school located in West Lombok Regency, Indonesia. This particular school was

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selected due to its reputation as one of the leading institutions in the district, despite experiencing persistent challenges in delivering instruction on fractional concepts.

Adopting a qualitative methodology as proposed by Creswell and Creswell (2018), the researcher functioned as the principal instrument in the data collection process. To support the inquiry, several auxiliary tools were utilized, including diagnostic tests on the addition of unlike fractions, structured interview protocols, and a hybrid didactic teaching model. These instruments—particularly the fraction addition test and interview guide (Brown & Danaher, 2017; Husband, 2020)—were used to obtain detailed insights into the students' learning difficulties.

The research design aligned with qualitative inquiry principles (Creswell, 2012; Creswell & Creswell, 2018) and specifically employed hermeneutic phenomenology (Dangal & Joshi, 2020; Isnawan, Alsulami, et al., 2023; Isnawan, Azis, et al., 2023). The selection of this approach was grounded in two primary considerations. Firstly, it enabled an in-depth exploration of how didactic transposition—i.e., the conversion of expert knowledge into instructional content—shapes learners' cognitive processes. The study thus aimed to analyze the residual impact of prior teaching practices on students' conceptualizations of dissimilar fraction addition, while also identifying the root causes of their learning barriers. Secondly, the hermeneutic phenomenological framework facilitated the design of an instructional alternative. Specifically, the research sought to construct a didactic model to improve the teaching of dissimilar fraction addition and address students' conceptual challenges (Suryadi, 2019a, 2019b).

This investigation followed the structured phases of hermeneutic phenomenology (Dangal & Joshi, 2020; Isnawan et al., 2022; Laverty, 2003; Stolz, 2013). The initial stage involved a prospective or pre-instructional analysis, during which the researcher identified the factors contributing to students' misunderstandings in adding unlike fractions. This was followed by the design and development of an instructional approach tailored to support students' learning in this specific area of mathematics.

Ethical standards were rigorously observed throughout the study. Three main ethical principles were upheld. First, informed consent was obtained from all student participants prior to data collection activities, particularly the interviews. Second, participant anonymity was preserved by assigning coded identifiers to safeguard individual identities in research reports. Third, confidentiality was maintained, with all data exclusively used for scholarly purposes and for enhancing the quality of mathematics education.

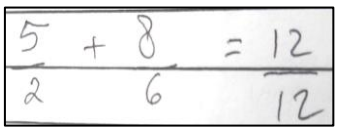
III. RESULT AND DISCUSSION

A. Result

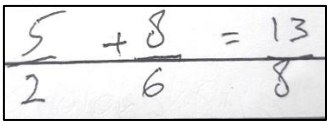
1) What are the underlying factors contributing to students' learning difficulties in adding dissimilar fractions?

Based on the analysis of data obtained from students' mathematics comprehension tests and in-depth interview sessions, several thematic categories were identified. These included T_a (students' procedural errors), T_b (insufficient mastery of prerequisite knowledge), and T_c (the extent to which students could demonstrate correct procedural understanding).

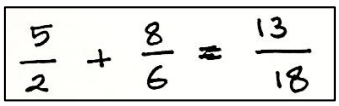
A common error observed during the process of adding dissimilar fractions was students' tendency to incorrectly combine numerators with numerators or denominators with denominators. Furthermore, Figure 1 illustrates instances of students' lack of carefulness in carrying out fraction addition. In Figure 1_a, for example, a student made an error in basic addition. In Figure 1_b, the student incorrectly added the denominators instead of finding a common denominator, as required. Similarly, Figure 1_c displays a mistake in which the student added the denominators and arrived at 18 instead of the correct result, which should have been 8 if their intention was indeed to add.



(a)



(b)



(c)

Figure 1. Excerpts from students' responses illustrating errors in dissimilar fraction addition.

Regarding T_b (lack of mastery of prerequisite material), two key challenges emerged. First, students struggled with performing integer multiplication and division accurately. Second, they encountered difficulties in simplifying fractions to their lowest terms. Findings from in-depth interviews further supported these observations. Table 1 presents excerpts from the interview dialogue between the researcher and the students, highlighting these difficulties in their own words.

Table 1.
Excerpt of interview results

Researcher's question	Student's answer
If simplified, what does 18 per 12 become?	*S1: Maybe 0 per 12, sir.*
When simplified, what is 3 per 1?	*S2: That's the simplest form, sir.*
When 16 per 16 is simplified, what is it?	*S3: 16 per 16, I can't continue,*

Further analysis revealed that the primary cause of students' difficulties in adding dissimilar fractions was their lack of understanding of prerequisite concepts. Specifically, their struggles were rooted in an inadequate grasp of multiplication and division operations with integers, which are essential for correctly determining common denominators and simplifying fractions.

2) What is the structure of the didactic design for teaching dissimilar fraction addition in mathematics?

As discussed earlier, students' learning challenges in dissimilar fraction addition were primarily rooted in their limited understanding of foundational concepts, particularly the operations of multiplication

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and division with whole numbers. In response to these difficulties, this study introduced a targeted instructional approach aimed at addressing and overcoming these prerequisite gaps.

Recognizing that effective instruction must go beyond reinforcing prerequisite knowledge alone, this research formulated a didactic design for mathematics learning structured as a holistic lesson plan. The instructional framework was organized into three core phases: Activity 1 (preparation), Activity 2 (instruction), and Activity 3 (evaluation). These stages were grounded in existing educational theory, which suggests that mathematics instruction in schools can be effectively segmented into these three sequential phases (Aylward, 2012; The Learning Centres, 2013).

The design itself comprised a coherent sequence of activities intended to guide the teaching and learning process from the initial orientation to the final assessment. The preparation phase featured activities such as Let's Guess and Let's Read, which aimed to activate prior knowledge and introduce the learning context. The instructional phase included Let's Search, Let's Discuss, and Let's Conclude, fostering exploration, collaborative learning, and conceptual synthesis. The final phase, evaluation, involved Let's Practice and Self-Reflection, which encouraged students to apply their understanding and reflect on their learning progress.

To enhance comprehension of dissimilar fraction addition, the instructional design also incorporated a variety of visual and representational tools, such as number lines, area models, and object sets. These models were strategically used to support students' conceptual development and procedural fluency. The complete didactic design developed through this study for teaching the addition of unlike fractions is accessible via the following link: https://rb.gy/wxqrx.

B. Discussion

1) What is the overview of the didactic design for mathematics learning in dissimilar fraction addition?

When examined through the lens of learning obstacle theory (Brousseau, 2002; Prabowo et al., 2022; Suryadi, 2019b), the findings indicated that students encountered ontogenic obstacles, which are conceptual in nature. This result is consistent with earlier studies (Lestiana et al., 2016; Makhubele, 2021; Makonye & Khanyile, 2015) that found limited proficiency in basic integer operations can hinder students' ability to manage dissimilar fraction addition.

A frequently observed misconception was students' habit of adding numerators and denominators directly, a procedural error consistently reported in previous literature (Alkhateeb, 2019; Dhlamini & Kibirige, 2014; Namkung & Fuchs, 2019; Trivena et al., 2017), suggesting the widespread persistence of this misunderstanding.

As discussed earlier, the root of many of these difficulties stemmed from students' insufficient understanding of prerequisite operations—especially multiplication and division with whole numbers. To address this, the hybrid didactic model in this study integrated activities explicitly designed to

reinforce these basic skills, including exercises focused on determining the Least Common Multiple (LCM) and Greatest Common Divisor (GCD). Through LCM tasks, students were able to enhance their multiplication skills, while GCD exercises supported the development of division competence.

Recognizing that effective instruction requires more than simply revisiting foundational skills, the study developed a hybrid didactic design structured into three progressive stages:

- Activity 1: Preparation – Designed to activate prior knowledge and introduce central concepts;
- Activity 2: Instruction – Focused on engaging learners in exploration, problem-solving, and guided discovery;
- Activity 3: Evaluation – Provided opportunities for practice and encouraged metacognitive reflection.

This three-phase structure was informed by established instructional design frameworks (Aylward, 2012; The Learning Centres, 2013), ensuring the delivery of a systematic and well-rounded learning experience.

The design was further elaborated through the lens of didactic situation theory, which encompasses the stages of action formulation, validation, and institutionalization (Brousseau, 2002; Prabowo et al., 2022; Suryadi, 2019b). In this study, action formulation was implemented through the Let's Search activity, where students engaged directly with mathematical problems. The Let's Discuss and Let's Conclude activities reflected the validation phase, allowing students to test their reasoning and consolidate understanding. The institutionalization of knowledge was realized in the Let's Practice activity, where students applied concepts across various contexts. This sequence aligned with philosophical models of knowledge construction (Isnawan, Alsulami, et al., 2023; Suryadi, 2019a, 2019b).

The Let's Guess component was specifically developed to assess and reinforce students' prior understanding of multiplication and division—skills essential to mastering dissimilar fraction addition. These prerequisite competencies, identified as the root of many learning difficulties, served as the foundation for further instruction (Deeken et al., 2020; Makhubele, 2021). This activity aimed to cultivate fluency in basic operations and thereby reduce conceptual obstacles.

To foster engagement and contextual understanding, the Let's Read phase presented a narrative on the historical and practical importance of fractions. This storytelling approach aimed to increase student motivation and align learning with real-life applications, in accordance with theoretical perspectives that emphasize the relevance of mathematics in everyday contexts (Abramovich et al., 2019; Arthur et al., 2022).

In the Let's Search phase, learners were tasked with solving problems that required them to understand and apply the principles of adding dissimilar fractions. This approach draws upon the "world of math" framework, which utilizes contextual and relatable problems to build mathematical understanding (Hartmann et

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al., 2021; Tall, 2004, 2008; Tall & Vinner, 1981).

Let's Discuss encouraged collaborative learning by allowing students to share solutions and engage in peer feedback. This activity is supported by social constructivist theory, which posits that interaction and discussion can deepen mathematical understanding (Ahmad, 2021; Jaworski & Huang, 2014; Sjöblom et al., 2022).

The Let's Conclude phase guided students in deriving a general formula for adding fractions with unlike denominators. This step reflected problem-based learning principles that empower learners to construct procedural knowledge independently (Jaworski & Huang, 2014; X. Yang et al., 2020).

The Let's Practice segment provided opportunities for students to apply their knowledge in diverse situations, reinforcing and solidifying their understanding of fraction addition (Marfuah et al., 2022; Suryadi, 2019b). Finally, the Self-Reflection phase allowed students to evaluate their learning process and conceptual understanding. This practice aligns with educational theories emphasizing the value of self-assessment in improving learning outcomes (Ghorbanpour et al., 2021; L. P. Yang & Xin, 2022).

IV. CONCLUSION

The findings of this study indicate that one of the primary causes of students' learning obstacles in adding dissimilar fractions is ontogenic factors, particularly a low understanding of integer operations. To address this issue, a hybrid mathematics learning design was developed to help students master these prerequisite skills. This instructional design incorporated activities such as determining the Least Common Multiple (LCM) and Greatest Common Divisor (GCD) to strengthen students' understanding of multiplication and division operations, respectively.

The results of this study reveal that a major contributing factor to students' difficulties in adding dissimilar fractions is ontogenic in nature, particularly stemming from a limited grasp of integer operations. To address these foundational gaps, a hybrid mathematics instructional design was developed, aiming to support students in mastering essential prerequisite skills. This learning model integrated targeted activities such as identifying the Least Common Multiple (LCM) and Greatest Common Divisor (GCD), which were specifically designed to enhance students' understanding of multiplication and division, respectively.

The instructional framework was guided by didactic situation theory, which is organized into three essential phases:

- Action-formulation – engaging students in exploratory and problem-based activities to promote knowledge construction;
- Validation – facilitating opportunities for discussion and reinforcing conceptual understanding through interaction;
- Institutionalization – enabling students to apply, consolidate, and internalize newly acquired mathematical concepts.

This theoretical approach was selected for its capacity to support epistemic

learning, allowing students to build and internalize mathematical concepts through active engagement and discovery. In light of these findings, the study advocates for the use of this hybrid didactic model as an alternative instructional strategy for teaching dissimilar fraction addition.

Further research is encouraged to examine the broader impact of this instructional design on minimizing students' learning difficulties. Such investigations could yield valuable insights into the model's effectiveness and inform future refinements for enhanced pedagogical practice.

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