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Naif Mastoor Alsulami[a], Muhamad Galang Isnawan[b*]
[a]University of Jeddah, Saudi Arabia, nsulami@uj.edu.sa
[b]Universitas Nahdlatul Wathan Mataram, Indonesia, galangisna19@gmail.com

To cite this article: Alsulami, N.M & Isnawan, M.G. (2023). Significance and process of fraction concept comprehension: a study of learning constraints from the perspective of mathematics instructors. *Panicgogy International Journal, 1*(1), 1-7
To link to this article: nakiscience.com/index.php/pij

Orginal Article

Significance and process of fraction concept comprehension: a study of learning constraints from the perspective of mathematics instructors

Naif Mastoor Alsulami[a], Muhamad Galang Isnawan[b*]
[a]University of Jeddah, Saudi Arabia, nsulami@uj.edu.sa
[b]Universitas Nahdlatul Wathan Mataram, Indonesia, galangisna19@gmail.com

*Corresponding Author: galangisna19@gmail.com

Abstract
Conversion of mixed numbers into improper fractions was one of the challenging formulaic issues in fraction learning that posed problems in education. However, there were not many studies investigating this conversion. Furthermore, few studies have attempted to provide solutions regarding this conversion issue. Therefore, this study aimed to identify the learning constraints students experienced when converting mixed numbers into improper fractions and offer alternative solutions to minimize these learning obstacles. The research design used to achieve this goal was didactical design research (DDR). DDR was chosen as it employed the identified learning constraints to develop didactic designs in fraction learning. Participants in this study were mathematics teachers aged 26, with less than five years of teaching experience. The primary instrument in this research was the researcher, using several supplementary tools such as a fraction comprehension test, interview guidelines, and didactic designs. Data were subsequently analyzed using qualitative data analysis. The research findings revealed that students were indicated to encounter learning obstacles of an epistemological nature, as they seldom initiated learning with real-life problems. The proposed solution in the didactic design was using problems as initial situations in learning, which would then be responded to by students in the form of didactic conditions. The recommendation offered in this study is implementing the didactic design itself.
Keywords: *fractions, learning obstacles, didactic design, didactical design research*

Introduction

Converting mixed numbers into improper fractions presents challenges within fraction learning (G. Brown & Quinn, 2006; Fosnot & Dolk, 2002; Isnawan, 2022). Nevertheless, this conversion is frequently employed in the context of advanced mathematical education and other fields (E. S. Brown, 2016; Klothou et al., 2019; Wahyu, 2021). Thus, this research's primary objective is to explore the conversion of mixed numbers into improper fractions comprehensively. This endeavor is prompted by the relatively limited number of studies that delve into this specific type of conversion.

The research conducted by Yulianingsih et al. (2018) delved into the sequencing of fractions, concluding that only approximately 20% of students were proficient in sequencing fractions accurately. Meanwhile, the study by Joutsenlahti and Perkkila (2019) examined the selection of appropriate models for established fraction forms. Their findings indicated that around 61 out of 102 students struggled to identify suitable visual representations for particular fractions. Additionally, several other studies focused on fraction operations and sequences (Suwariyasa et al., 2016; Ubah & Bansilal, 2018; Walyanda & Yani, 2018). In essence, prior research did not emphasize the formulation of conversion as is highlighted in this current study.

The proposed solution within this research entails utilizing a qualitative approach through the didactical design research (DDR) methodology. DDR was chosen due to its capacity to provide alternate solutions to the learning impediments encountered by students (Suryadi, 2019b, 2019a, 2019c). Furthermore, DDR aims to scrutinize the types of learning obstacles experienced by students as a foundational step in constructing didactic designs (Suryadi, 2010). Identifying students' learning obstacles plays a pivotal role in education, aiding researchers in comprehending the principal origins or underlying causes of challenges in the learning process. By analogy, if learning hurdles stem from educators, the solutions would naturally pertain to teachers, such as enhancing their competencies. Consequently, the core aim of this research is to delve into the depiction of the learning obstacles students encounter when converting mixed numbers into improper fractions and to delineate a didactic design grounded in these identified learning obstacles. The research inquiries in this study are as follows:

a) What characterizes the learning obstacles experienced by students during the conversion of mixed numbers into improper fractions?
b) How do teachers employ the didactic design described when teaching the conversion of mixed numbers into improper fractions?

Metode

The methodology employed in this study adopted a qualitative approach. The chosen research framework was didactical design research (DDR). DDR was selected due to its utilization of an epistemological perspective for knowledge acquisition, which aligns with the phases of philosophical knowledge attainment (Suryadi, 2019b, 2019a). Moreover, the didactic design formulated within DDR was rooted in an analysis of the learning barriers encountered by students (Fauzi & Suryadi, 2020; Suryadi, 2019c; Umbara & Suryadi, 2019). Thus, incorporating didactic design into the teaching process mitigates previously encountered learning obstacles. The study participants comprised math educators with less than five years of teaching practice, and their average age was 26 years.

The key tools in this investigation were the researcher (Creswell, 2012, 2014), who utilized a fraction comprehension test, interview guidelines, and an instructional module based on the theory of didactical situation (TDS) (Arslan et al., 2011; Brousseau, 2002; Mackrell et al., 2013) as supplementary aids. Data gleaned from teaching implementation underwent qualitative data analysis involving various stages like data reduction, data presentation, and result interpretation. Data reduction encompassed the exclusion of irrelevant information. Data presentation involves conveying data through descriptions, diagrams, or tables as appropriate. Concluding was linked to the deductions drawn from the research. Typically, these deductions relate to addressing research questions or objectives. The research procedure followed two DDR phases (Suryadi, 2019b). Firstly, a prospective analysis was performed to identify types of learning obstacles and potential forms of didactic design (hypothetical didactic design). Secondly, metapedadidactic analysis focused on integrating didactic design into the teaching process.

Research Findings and Discussion

Based on the results of the prospective analysis, it was found that learners tended to face difficulties when they were converting mixed numbers into improper fractions. Students were indicating problems when transforming mixed numbers into regular fractions. After a more in-depth analysis through interviews, a conclusion was reached that one of the factors that seemed to be causing these problems was the limited context used by mathematics teachers during fraction lessons. Teachers usually employ conventional teaching methods.

When associated with theories concerning learning obstacles (Brousseau, 2002; Suryadi, 2013, 2019b), it could be inferred that the type of learning obstacle experienced by students was an epistemological obstacle. This arose due to teachers' constrained contextual approach to teaching fractions. In other words, mathematics educators directly provided formulas to students, leading to a lack of sustained retention among learners (Isnawan et al., 2022). These research findings aligned with previous studies that revealed epistemological obstacles as a common hurdle students face when learning fractions (Aebi & Linde, 2015; Daut Siagian et al., 2022; Job & Schneider, 2014; Moru, 2007).

Based on this type of learning obstacle, a didactic design was formulated, presenting problems as initial situations in fraction learning activities. The presence of these problems was expected to guide students toward discovering the conversion formula for mixed numbers into improper fractions on their own (Dahl, 2017; Jitendra, 2002). The didactic design also incorporated various prompting questions to facilitate students in solving the given problems (Prihantini et al., 2021; van de Pol et al., 2010).

The decision to employ problems as initial situations in teaching was driven by several reasons. Firstly, introducing problems at the beginning of the learning process stimulated students to respond through actions, particularly mental actions, when addressing the problems. These mental actions then led students towards forming ways of thinking (WoT) and eventually achieving ways of understanding (WoU) (Lockwood & Weber, 2015; Sari et al., 2019). WoU was fundamentally connected to the conversion formula for mixed numbers into improper fractions. Secondly, presenting challenges to learners encouraged them to reach the zone of proximal development (ZPD), approaching the potential development zone (Adam, 2017; Clabaugh, 2010; Topciu & Myftiu, 2015; Verenikina, 2003).

Moreover, the didactic design employed prompting questions as a form of scaffolding to assist learners in problem-solving. These research findings aligned with the theory that scaffolding significantly aided students in overcoming challenges during learning (Pöhler & Prediger, 2015; van de Pol et al., 2010). Furthermore, it was revealed that scaffolding effectively bridged the actual potential development zone and the potential development zone possessed by students (Berns & Erickson, 2001; Davtyan, 2014; Verenikina, 2003). In the context of instruction, the didactic design also incorporated the didactical situation (TDS), including the action, formulation, validation, and institutionalization phases (Suryadi, 2013, 2019b). The action phase commenced with problem presentation and student problem-solving. The formulation phase provided students with the opportunity to share their ideas with their peers. Validation was the stage when students concluded the conversion formula for mixed numbers into improper fractions. Lastly, institutionalization involves students applying the acquired formula to solve mathematical problems in different contexts and situations.

Conclusions

About the preceding description, several conclusions can be inferred. It was evident that students encountered obstacles of an epistemological nature. This was attributed to the limited utilization of problem-solving approaches when teachers conducted fraction lessons in the classroom. Consequently, the proposed solution within the didactic design encompassed introducing problem-solving tasks to students to enable them to independently uncover the formula for converting mixed numbers into regular fractions. Furthermore, the didactic design included a range of prompting questions, serving as scaffolding to assist students in resolving the presented challenges.

A structured learning framework was also implemented, facilitating progression through the action, formulation, validation, and institutionalization phases. This framework was devised to support students in accurately constructing the conversion formula. As a result, the research recommended implementing the developed didactic design by researchers, followed by a subsequent verification of whether these student learning obstacles persisted.

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