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Enhancing Pupils' Skills in Solving Decimal Addition Operations Using the 3D Decimal Board

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Abstract

This study aimed to enhance Year 3 pupils' proficiency in decimal addition operations, specifically those involving regrouping skills. The research was conducted at a school in the Kuala Kangsar district and utilized an action research design. Three participants, comprising one male and two female pupils, were selected based onpurposive sampling method via their diagnostic test performance. The data collection methods included pre-tests, post-tests, document analysis, observation, and interviews. Qualitative data was analyzeddescriptively according to the research participants. The findings revealed several identified issues, such as a lack of understanding of the regrouping concept, inadequate mastery of decimal place values, errors in placing decimal points in the final answer, and carelessness during calculations. However, the intervention using the 3D Decimal Board was successful in helping all participants comprehend the concept and develop proficiency in adding decimal numbers up to three decimal places through regrouping. The 3D Decimal Board's key strengths were its applicability to daily life, user-friendliness, and its ability to reinforce the concept of decimal addition.

Keywords: 3D Decimal Board, decimal numbers, regrouping addition

1. Introduction

This chapter will overview the research context, problem statement, aims and objectives, research questions, hypotheses, and variables under investigation. Contextually, pupils must master three core areas in Mathematics: whole numbers, fractions, and decimals. According to the Malaysian Ministry of Education's (MOE) KSSR curriculum, pupils progress from concrete to abstract mathematical concepts(MOE, 2013, 2017). Thus, educators have a responsibility to adopt high-quality teaching methods and provide appropriate resources to ensure pupils comprehend mathematical ideas.

Mathematics involves conceptual understanding, not merely rote memorization. For instance, a pupil who simply memorizes calculation steps and tips for adding decimal numbers may lack the conceptual mastery needed to solve other decimal problems correctly. Excelling on exams does not necessarily indicate a pupil has truly grasped the mathematics they have learned(Siegler & Lortie-Forgues, 2017).

Consequently, research is needed to help pupils strengthen fundamental skills in decimal addition with regrouping, utilizing resources like the 3D Decimal Board. Such teaching tools can support KSSR's goals of fostering pupils' understanding of basic mathematical concepts and their effective, responsible application of mathematical knowledge and abilities in daily life. This study aims to expand on current research by investigating the effectiveness of the 3D Decimal Board in enhancing Year 2 pupils' proficiency in decimal addition operations, particularly those involving regrouping. The research will explore the impact of this hands-on learning tool on pupils' conceptual understanding, problem-solving skills, and overall performance in decimal addition tasks.

2. Background of Study

This study delves into the challenges faced by Year 3 pupils in mastering decimal addition, particularly operations involving regrouping, using a 3D Decimal Board as an intervention tool. Decimals, a crucial aspect of the number system, represent parts of a whole and are essential for various real-world applications, including financial transactions, measurement, and scientific calculations. A strong foundation in decimal understanding is therefore paramount for pupils' future success in mathematics and related fields(Lortie-Forgues et al., 2015). However, despite their importance, decimals often present a significant hurdle for many learners(Attard et al., 2014).

Research consistently highlights the difficulties pupils encounter when transitioning from whole number arithmetic to decimal operations. This difficulty stems from the conceptual shift required to understand place value in the decimal system, where digits to the right of the decimal point represent progressively smaller fractional parts of a whole(Lortie-Forgues et al., 2015). Theintroduction of regrouping, or "carrying over," in decimal addition further complicates matters, requiring pupils to apply their understanding of place value while simultaneously performing addition operations across different decimal places. This cognitive load can overwhelm some learners, leading to errors and misconceptions(Siegler & Lortie-Forgues, 2017). Common errors include misaligning decimal points, neglecting to regroup correctly, and a general lack of understanding of the underlying principles governing decimal addition(Attard et al., 2014).

The Malaysian Ministry of Education's Standard Primary School Curriculum emphasizes the importance of progressing from concrete to abstract learning in mathematics(MOE,2013). This approach recognizes that pupils often benefit from tangible representations of abstract concepts, allowing them to manipulate and visualize mathematical ideas before transitioning to more symbolic forms of representation. Manipulatives, such as the 3D Decimal Board used in this study, provide a concrete embodiment of decimal place value, offering pupils a hands-on experience that can solidify their understanding of decimal addition(Anne Roche, 2010).

3. Problem Statement

The researcher identified that Year 3 pupils had not fully mastered the skill of adding decimal numbers up to three decimal places with regrouping using the decimal addition algorithm. To investigate this issue, the researcher employed multiple research instruments, including observation, document analysis, interviews, and a diagnostic test. The results of this quantitatively analysed research have shown that the 5th grade pupils' number sense on decimal numbers is low. There was no significant difference in

number sense between the genders. These findings are consistent with the previous studies (Sengul &Gulbagci, 2023).

The researcher first observed the classroom teaching and learning process. The observations revealed that some pupils struggled to answer worksheet questions, leaving them blank, while others simply copied answers from peers without showing the proper calculation steps. Additionally, when asked to demonstrate the decimal addition algorithm on the whiteboard, pupils exhibited difficulties in adding decimal numbers up to three decimal places with regrouping.

Furthermore, the researcher reviewed pupil documents, such as workbooks and worksheets, to identify the types of errors made by pupils. This review found that pupils often could not correctly display the step-by-step process of adding decimal numbers in standard form, leading to incorrect answers. Some pupils even left the answer space blank, indicating a lack of understanding of the necessary calculation steps.

To further investigate the issue, the researcher conducted interviews with the mathematics teacher and Year 3 pupils. The interviews confirmed that pupils faced challenges in mastering the skill of adding decimal numbers up to three decimal places with regrouping using the correct decimal addition algorithm. Additionally, the researcher administered a diagnostic test to 30 Year 3 pupils to identify specific errors made when adding decimal numbers up to three decimal places with regrouping.

The research participants were then selected based on their low performance on this diagnostic test. The results of the diagnostic test provided valuable insights into the areas where pupils struggled the most, such as understanding place value, properly aligning decimal points, and correctly executing the regrouping process when adding decimal numbers. To address these challenges, the researcher designed an intervention using the 3D Decimal Board, a specialized teaching aid that visually represents decimal place values and supports hands-on learning of decimal operations.

4. Literature Review

This chapter critically analyzes the theoretical foundations underlying this study. As Gibb & Engen, (1957) stated, a comprehensive literature review plays a pivotal role in generating ideas and guiding the research direction. Therefore, to gain a deeper understanding of the intended research area, the researcher must carefully examine previous studies. Consequently, the effectiveness of the 3D Decimal Board in the topic of decimals and the improvement of skills in solving addition operations of any two decimal numbers, which clarifies the variables being studied, will be thoroughly examined.

I. Challenges in Decimal Understanding: The difficulties students commonly encounter when working with decimals. It should begin by discussing the conceptual leap required to transition from whole numbers to decimals, emphasizing the change in understanding place value. The section should then explore common misconceptions and errors, such as difficulties in aligning decimal points during operations, problems with regrouping, and a general lack of number sense related to decimals. Relevant research that supports these points, like the work of Lortie-Forgues et al., (2015), which discusses the inherent challenges in learning fraction and decimal arithmetic, should be cited.

Additionally, studies of Pierce et al., (2008) highlighted the importance of a foundational understanding of decimal numbers for correct calculations can be drawn upon.

II. Concrete to Abstract Learning and Manipulatives: This section discusses the pedagogical benefits of moving from concrete representations to abstract concepts in mathematics education. It highlights the Malaysian Ministry of Education's emphasis on this approach (MOE, 2013). The role of manipulatives in mathematics, particularly those used for teaching number concepts and operations is crucial for conceptual understanding for pupils (Bakar et al., 2019). Furthermore, Zainudin & Zainudin, (2023) discusses the use of representations in supporting early mathematics learning, which can be connected to the use of the 3D Decimal Board. Additionally, Lee et al., (2020) explore the effectiveness of different learning supports for math problem representation, which can inform the discussion of the 3D Decimal Board's role.

III. Regrouping in Decimal Addition: The challenges of regrouping in decimal addition stem from learners' limited understanding of place value and the carry-over process inherent in whole number addition (Lortie-Forgues et al., 2015). Existing research has explored effective strategies for teaching regrouping, including the use of manipulatives or visual aids to support students' conceptual grasp of this operation. Lortie-Forgues et al., (2015) have further emphasized the inherent difficulties associated with decimal arithmetic, underscoring the need for targeted instructional approaches to address this skill.

5. Methodology

This study employs a mixed-methods approach, combining quantitative and qualitative data collection methods to investigate the effectiveness of the 3D Decimal Board in enhancing Year 3 pupils' skills in decimal addition.

Quantitative Methods: A diagnostic test was administered to 30 Year 3 students to assess their initial proficiency in decimal addition and identify specific areas of difficulty. Pre-tests and post-tests were also utilized to measure students' performance before and after the intervention with the 3D Decimal Board, allowing for a quantitative analysis of the impact of the tool on their decimal addition skills.

Qualitative Methods: Observations of classroom activities provided insights into students' learning processes and engagement with the 3D Decimal Board. Document analysis, including review of student workbooks and worksheets, helped identify common errors and misconceptions related to decimal addition. Interviews with the mathematics teacher and selected students provided further context and understanding of the challenges and successes experienced by students in learning decimal addition with regrouping.

The research participants were purposively selected based on their performance on the diagnostic test, with a focus on students who initially struggled with decimal addition. This purposive sampling strategy allowed for a detailed analysis of the learning trajectories of students who benefited most from the intervention. The small sample size (one male and two female students) facilitated in-depth exploration of individual learning experiences and the specific ways in which the 3D Decimal Board supported their understanding of decimal addition.

6. Findings

This chapter presents the research findings through descriptive statistical analysis and narrative discourse. The data were analyzed based on three instruments: observations, document analysis, and interview protocols. The study participants consisted of three individuals. A descriptive analysis was conducted for each participant. This action research encompassed a total of five intervention sessions, all of which were attended by the participants.

In the initial intervention session, participants were introduced to the 3D Decimal Board and guided in its utilization for adding any two decimal numbers up to three decimal places with regrouping. The primary objective was to familiarize participants with the use of the 3D Decimal Board. However, participants encountered errors while adding two decimal numbers up to three decimal places with regrouping. Consequently, minor refinements were made to the method of using the 3D Decimal Board to ensure participants' accuracy in adding any two decimal numbers up to three decimal places with regrouping.

The purpose of the second and third intervention sessions was to guide participants in utilizing the 3D Decimal Board to add any two decimal numbers up to three decimal places with regrouping, involving different decimal places. In the fourth intervention session, participants applied the 3D Decimal Board method on paper by referring to the place values in the 3D Decimal Board to ensure the correct arrangement of numbers for calculations. In the fifth intervention session, participants no longer used the 3D Decimal Board but applied the conceptual knowledge they had gained from it. The research findings indicate that the 3D Decimal Board facilitated participants' understanding of the place value system in decimal addition, enabling them to accurately regroup decimal numbers.

Throughout these intervention sessions, participants were introduced to the concrete stage up to the semi-concrete stage for adding any two decimal numbers up to three decimal places with regrouping. Participants were provided with worksheets containing three items in each intervention session. The researcher utilized all the research instruments to address the research questions in detail, such as examining documents like pre-test and post-test answer transcripts, Worksheets 1 to 5, comparing pre-test and post-test scores, interview protocols, and observations using a checklist prepared by the researcher for each participant.

Table 1: Pre-Test and Post-Test Results

	Pre-Test (%)	**Post-Test (%)**
Participant 1	0	100
Participant 2	0	100
Participant 3	20	100

According to Table 1, Participant 1 and 2 obtained the lowest scores on the pre-test which was 0%. Neither participant could answer any of the items correctly. Participant 3 achieved the highest score of 20%, answering only the first two items correctly. These low scores indicate that all participants had a very weak grasp of adding two decimal numbers up to three decimal places with regrouping.

However, a significant change occurred after the participants took the post-test. All the participants achieved the highest possible score of 100%, demonstrating their ability to solve all items correctly. In conclusion, all participants demonstrated positive development in the teaching and learning process from pre-test to post-test.

7. Discussion

This study investigated the effectiveness of the 3D Decimal Board in enhancing Year 3 pupils' skills in decimal addition with regrouping. The findings reveal a significant improvement in pupils' performance from pre-test to post-test after the intervention. This aligns with the broader literature on the benefits of using manipulatives in mathematics education. Manipulatives provide concrete representations of abstract concepts, bridging the gap between conceptual understanding and procedural fluency. The 3D Decimal Board, in particular, seems to support the development of a robust understanding of place value, a crucial element for success in decimal operations. While further research is needed to explore the generalizability of these findings, the observed improvement suggests that the 3D Decimal Board can be a valuable tool for teaching decimal addition.

The initial difficulties faced by the participants highlight the common challenges students encounter with decimal addition, particularly with regrouping. These challenges often stem from a lack of understanding of the underlying place value system and the carry-over process from whole number addition. The 3D Decimal Board appears to address these challenges by providing a visual and tactile representation of decimal place value, allowing students to physically manipulate the units, tenths, and hundredths. This concrete experience can help solidify their understanding of how regrouping works in the context of decimal addition.

The progression from concrete manipulation of the 3D Decimal Board to the semi-concrete stage of applying the method on paper suggests that the tool effectively scaffolds students' learning. By initially providing a concrete representation, the 3D Decimal Board helps students build a strong foundation for understanding the concept. As they progress to working on paper, they can still draw on their experiences with the manipulative to visualize the process of regrouping. This gradual transition from concrete to abstract thinking is a key principle of effective mathematics instruction.

The small sample size of this study allowed for in-depth analysis of individual learning experiences and provided rich qualitative data. However, it also limits the generalizability of the findings. Future research with larger and more diverse samples is needed to confirm the effectiveness of the 3D Decimal Board across different student populations. Furthermore, exploring the long-term impact of the intervention on students' decimal understanding and their ability to apply this knowledge to other mathematical concepts would be valuable. Investigating how the 3D Decimal Board can be integrated into existing mathematics curricula and teacher training programs would also contribute to its practical application in the classroom.

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