THE DEVELOPMENT OF BAR MODEL FRACTION KIT IN SOLVING HIGHER ORDER THINKING SKILLS MATHEMATICS WORD PROBLEMS

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ABSTRACT: The purpose of this study is to develop and validate the Bar Model Fraction Kit. To enhance the validity of this instrument, four experts had reviewed the instrument. The Cohen kappa value is 0.80. This indicates a "Good" extent of agreement. There were 15 students involved in the pilot test. The students used the Bar Model Fraction Kit to answer the test items. From the analysis, it was found that the Cronbach alpha coefficient value is 0.765. This shows that the Bar Model Fraction Kit has acceptable reliability.

Keywords: Bar Model Fraction Kit, Fraction, Word Problem, Higher Order Thinking Skills

1. INTRODUCTION

Over the past few decades, the Malaysian mathematics curriculum has undertaken several significant changes. The current Standard Based Curriculum for Primary Schools (KSSR) places great emphasis on the development of mathematical thinking through problem-solving. Problemsolving is an activity that encourages students to use HOTS [1]. Teacher's correct teaching method is an important aspect of students' disposition to critical thinking [2]. Similarly, the Education Curriculum Transformation as stated in the Malaysia Education Plan (PPPM) 2013-2015 emphasizes the concept of Higher Order Thinking Skills (HOTS) [3]. In Malaysia, a pupil is considered to have HOTS if managed to solve four of the top Bloom's taxonomy questions [4].

In the 21st century pedagogy, teachers are expected to instill Higher Order Thinking Skills (HOTS) elements among students. To ensure the quality delivery of HOTS in the classroom, School Inspectorate, and Quality Assurance has observed 36 schools and 847 teaching and learning sessions. The observation indicated that more than 40% of HOTS items are included in the school-based assessments for Mathematics papers. The most dominant cognitive level observed in students' work is Application. However, higher cognitive levels such as "Creative", "Critical" and "Innovative" skills are less evident [3]. This shows that teachers focus on the surface level of understanding and emphasizes in not given on higher-order thinking or problemsolving tasks [4].] Thus, steps need to be taken to incorporate higher cognitive levels as teachers have a problem in inculcating higher-order thinking skills in problem-solving.

In the Primary School Achievement Test 2016 or also known as UPSR, 20% of HOTS questions were included in the examination [5]. However, Year 6 pupils seem not to be ready to answer HOTS questions in the UPSR leading to a decrease in average grade of 0.02 points [6].

On the other hand, companies demonstrated that Malaysian alumni are lack of the critical thinking abilities required for the work environment [3]. Employers emphasize graduates who have generic skills like problem-solving and pay less concern with the exceptionally specific profession abilities which can be learned at work [7]. HOTS are valued as to prepare students to face the challenges of daily life and produce skilled workers. Nowadays, most of the jobs require employees with HOTS skills which involve creativity, problem-solving and critical analysis compared to other skills [8]. Additionally, low performances of Malaysian students in several international assessments have raised concern among educators. One of the most popular surveys is The Trends in International Mathematics and Science Study (TIMMS) and Program for International Student Assessment (PISA). Mathematics assessment framework for TIMSS 2015 has two domains which are content domains and cognitive domains. The content domains are number, algebra, measurement, geometry, and data; while the cognitive domains measured knowledge on facts and procedure, concept usage, routine problem solving and reasoning skill [9]. The Number domain includes Whole Numbers, Sequences and Patterns of Numbers, Fractions, Decimals, Percentages, and Integers [10]. TIMSS assessment also focuses on problem-solving. In this study, Fractions are one of the mathematical topics which have been selected by the researcher as a field of study and Fraction is part of the number domain.

A fraction is one of the earliest topics introduced in mathematics primary education. Primary students are exposed to the fraction after learning the basic arithmetic operations in Malaysia [11]. Fractions are considered to be difficult by students and teachers. Most students made mistakes in basic operations such as addition and subtraction of Fractions [12, 13]. However, students performed poorly in solving mathematics word problems compared to computational problems involving Fractions [14]. On the other hand, students face difficulties in Fractions when the teaching and learning process employed does not promote understanding. This shows that the problem arises from the teachers [15]. Typical teachers would just give simple tricks in learning fractions [16]. For example, providing steps in manipulating the values of the numerators and denominators. Hence, students do not understand what and why they are doing certain steps to get the answer.

Singapore mathematics has one of the most successful techniques proven with the success of its students in the TIMSS and PISA. Moreover, Singapore is a country that has the highest achievement in both assessments. Bar model method is the main model for solving word problems in Singapore [17]. In Singapore, 86% of primary schools use Bar Model Method where it helps to understand the problems and thus solve the problem easily [18]. Bar Model Method enables students to translate the information from words into a diagram. The diagram can assist in problem-solving because it helps students to visualize and solve the problem. However, there are some difficulties commonly faced by

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primary school teachers and pupils in drawing models although it has been well accepted by most countries. Among the difficulties are (1) difficulty to draw an "accurate diagram", (2) dividing the block diagrams into an equal number of divisions, (3) inappropriate use of the model method [19].

Therefore, an appropriate manipulative is crucial to support the drawing models, hence to overcome the difficulties. The use of manipulative is an important aspect to enhance pupils' understanding of fractions and to make mathematics concepts concrete rather than abstract. Manipulatives are a valuable tool in the instruction of mathematics [20]. Teachers need to bridge the concrete manipulative to representational models such as diagram and then to the abstract level of understanding. Subsequently, pupils learn to make connections from the concrete to the abstract.

This paper presents the development of the bar model fraction kit to assist teachers to teach problem-solving involving the addition and subtraction of fractions.

THEORETICAL FRAMEWORK

There are three main learning theories, specifically behaviourism, cognitivism, and constructivism. Constructivism functions as a theory of education in which students construct their knowledge [21].

Constructivism supports the cognitive development and social constructivism theory in this study. This study applies Bruner's theory of cognitive development [22]. Bruner introduced three modes of representation which are enactive, iconic and symbolic representation [23].

The enactive stage gives the students the experience of handling physical objects. The iconic stage encourages the children to visualize the concrete experience and provide a link to the abstract while using mathematical symbols to model problems is the symbolic stage [24]. Thus, Bruner's theory of learning related to the way students' thinking is developed. Students should not depend too much on concrete representation. [25]. They need to conceptualize abstract situations using pictorial representation which is the iconic stage.



Figure 1.1: Theoretical Framework

In this research, the iconic stage is emphasized since the bar model fits into the iconic phase of development [26]. At the iconic stage, students are stimulated to make a mental connection between the physical object and abstract levels of understanding by drawing a bar model. The use of the bar model method is based on the circumstance that students are unable to solve abstract problems [25]. The bar model will represent the objects in the problem and simplifies the problem-solving situation. Through this, students can visualize the problem and help the students to solve word problems specifically involving HOTS questions.

On the other hand, Polya's problem-solving strategy is facilitated by a bar model. The current Malaysian Mathematics Text Book uses Polya's problem-solving strategy in their problem-solving instruction. Polya identified four basic principles in problem-solving; understand the problem, devise a plan, carry out the plan and look back [27]. Polya's first step is, understanding the problem. In this step, students have to state the problem in their own words. In the second stage, students should use the bar model to draw what they know and what they are attempting to solve. Then, carry out the plan which relates to mathematics computation. Finally, the last step which is look back advises the students to recheck the answer by using work backward strategy or use a different method.

Polya's model helps us to understand the potential of the bar model as an instructional strategy. Therefore, the integration of Bruner's theory of cognitive development and Polya's problem-solving strategy leads to the formulation of a developing a Bar Model Fraction Kit to solve the word problems.

2. EXPERIMENTAL DETAILS

The objective of this research is to (1) develop a Bar Model Fraction Kit for Year 5 students to solve addition and subtraction fraction word problems and (2) determine the validity and reliability of the Bar Model Fraction Kit. This research is development research. The product of this research is to develop a Bar Model Fraction Kit. The sample was chosen for this study consist of 15 Year 5 students from one of the schools in Batang Padang District, Perak.

BAR MODEL FRACTION KIT

Bar Model Fraction Kit is a manipulative used to assist pupils to devise a plan to solve word problems. Teachers must realize that students must be able to visualize mathematical concepts to solve a problem. Through Bar Model Fraction Kit, pupils can draw a pictorial rectangle using a concrete object to represent the problem. The bars will be precisely measured and proportional. Students then progress to abstract algorithms to solve a word problem.

DEVELOPMENT OF BAR MODEL FRACTION KIT

Bar Model Fraction Kit is developed by the ADDIE model. ADDIE stands for Analysis, Design, Development, Implementation and Evaluation [28]. This model is chosen because the researcher can make changes as there is an assessment factor for each level in this module [29].

Analysis Phase

In this phase, the researcher has defined the problem through need analysis, identify the cause of problems and determine solutions. The analysis is done by conducting a literature review related to students' problems in solving HOTS word problem questions. The TIMSS result shows that Malaysia students are lack of HOTS. This research shows the In this study, Fraction is one of the mathematical topics selected by the researcher as a field of study. TIMSS assessment contains two domains which are content and cognitive domain. Malaysians students performed very poorly in both domains. A fraction is included in the content domains while problem-solving is included in the cognitive domain [9]. Teacher's teaching method is an important aspect of students' disposition to critical thinking. Therefore, the researcher has determined a solution for students to answer HOTS fraction word problems.

Design Phase

Bar Model Fraction Kit is a tool or manipulative designed by the researcher using the Singapore Bar Model approach. Students picture a problem by drawing rectangle bars to solve a mathematics word problem. For fractions, pupils have to draw a wide rectangle and partition it equally with vertical lines to represent the fraction. Are students able to draw each unit equally?

Bar Model Kit is a ruler designed to aid the student to overcome the problem of drawing unequal units. It applies the concept of the equivalent fraction to solve a fraction word problem. The ruler consists of fraction scales to the denominator of 10 and it is adjustable. The ruler uses the concept of fraction strips by allowing them to manipulate parts of the same whole. The ruler keeps the whole consistent for students. Therefore, students divide the fraction of a whole equally. Through the bar model kit, students will be able to draw accurate models faster and easier. Hence, solve the higher level and non-routine problem effectively.

Development Phase

In this phase, the researcher has sent the design to a stationery company to custom-made the Bar Model Kit. The researcher did also seek the views of the experts for the development of the Bar Model Fraction Kit.

Implementation Phase

A pilot study using the Bar Model Fraction Kit has been carried out. The pilot test has been conducted with 15 Year, 5 students. In this study, a pilot test was conducted to identify the reliability of the Bar Model Fraction Kit to solve HOTS word problems. Extra classes were conducted for 12 lessons by the researcher before the pilot test was carried out. After the 12 sessions of teaching and learning, students were given a test.

3. RESULTS AND DISCUSSION Evaluation Phase

Validity and Reliability of Bar Model Fraction Kit

The validity of the Bar Model Kit was determined based on the views of experts [30]. At least three evaluators need to be appointed for the validity process [31]. The researcher has appointed four experts to validate the Bar Model Fraction Kit. The Cohen kappa value is 0.80. This indicates a "Good" extent of agreement. There were 15 students involved in the pilot test. The students used the Bar Model Fraction Kit to answer the test items. From the analysis, it was found that the Cronbach alpha coefficient value is 0.765. This shows that the Bar Model Fraction Kit has acceptable reliability where it exceeds 0.70 [32]. Thus, the Bar Model Fraction Kit is acceptable to be used in assisting pupils to solve fraction word problems.

Bar Model Fraction Kit Procedure

The following example shows how the bar diagrams can be drawn to demonstrate a solution plan for a word problem.

Zahra used $\frac{1}{4}\,kg$ of butter to make a cake. Afterward she had $\frac{5}{8}\,kg$ left. How

much butter did she have at first?

Step 1: Understand the problem

Zahra used $\frac{1}{4}$ kg butter.

She had $\frac{5}{6}$ kg left.

How much butter did she have at first?



4. CONCLUSION

Step 3: Carry out the plan

- a. Problem Solving Situation:
- Joining Problem Result is unknown
- b. Choose the operation and the number sentence

. Solve -Ensure both denominators are equal - Simplify the answer if needed

 $\frac{5}{8} + \frac{1 \times 2}{4 \times 2} = \frac{7}{8}$

 $\frac{5}{9} + \frac{1}{4}$

Step 4: Look back

1

Using backward strategy

 $\frac{7}{8} - \frac{1}{4} = \frac{5}{8}$

This study confirmed that Bar Model Fraction Kit is capable to facilitate students besides and subtraction of fractions

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involving word problems. The use of manipulative leads to the use of mental models, which builds pupils' understanding of fractions. Pupils had the opportunity to explore, experiment and experience to solve word problems. The Bar Model Fraction Kit indirectly gives pupils chances to grasp fraction concepts.

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