DEVELOPMENT AND THE EFFECTIVENESS OF USING FRACTION SLIDER IN SOLVING HIGHER ORDER THINKING SKILLS WORD PROBLEMS

LAVINA NAIR A/P MADAWAN NAIR

SULTAN IDRIS EDUCATION UNIVERSITY

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"I had sailed in the ship of ambition and anchored at the port of success"

ABSTRACT

This study aims to develop and determine the effectiveness of the Fraction Slider in improving the performance of Year 5 students in solving Higher Order Thinking Skills (HOTS) addition and subtraction of fraction word problems. This study also aims to determine the effective problem solving strategy using the Fraction Slider. This study employed the design and development research (DDR) with a combination of quantitative and qualitative approach. In this study, DDR is limited to two phases; (1) Design and Development and (2) Evaluation. The first phase involved design and development of Fraction Slider using ADDIE Model. Three panel of experts were involved to validate the Fraction Slider using the expert opinion questionnaire. The percentage of experts' agreement obtained was 87.9%. For the aspect of reliability, the Fraction Slider was used in teaching and learning for 27 students. Analysis of Cronbach alpha coefficient was calculated and obtained 0.82. The second phase employed a quasi-experimental design. It consists of 23 students for the control group and 25 students for the treatment group. The quantitative data was collected through pre-test and post-test. The study used Mann-Whitney test to show the significant difference between groups. The result showed that there is no differences between the control and treatment group in pre-test scores. There is a significant difference in the post- test between the two groups. Wilcoxon Signed Rank Test was used to compare the two related samples. This study revealed that there is no significant differences between the pre and post-test scores in solving the addition and subtraction of fractions in the control group. Next, there is a significant difference before and after being taught using the Fraction Slider for the treatment group. Qualitative descriptive research method was used to identify the problem solving strategy used by the students in solving word problems using the Fraction Slider. Qualitative data was collected via script analysis and task based interview. This study identified the Fraction Slider strategy to solve word problems effectively which was built upon existing idea of Polya's Model. In conclusion, the use of Fraction Slider strategy in teaching and learning HOTS Fraction word problem solving can significantly improve students' performance. Accordingly, the Fraction Slider strategy is expected to assist teachers in enhancing the effectiveness of teaching and learning of word problems and help the students to acquire word problem solving skills.

PEMBANGUNAN DAN KEBERKESANAN PENGGUNAAAN *FRACTION SLIDER* DALAM PENYELESAIAN MASALAH KEMAHIRAN BERFIKIR ARAS TINGGI

ABSTRAK

Kajian ini bertujuan untuk membangun dan menguji keberkesanan Fraction Slider dalam meningkatkan prestasi murid Tahun 5 dalam menyelesaikan masalah penambahan dan penolakan pecahan Kemahiran Berfikir Aras Tinggi (KBAT). Kajian ini juga bertujuan untuk menentukan strategi penyelesaian masalah yang berkesan menggunakan Fraction Slider. Kajian ini menggunakan penyelidikan Reka Bentuk dan Pembangunan (DDR) dengan gabungan pendekatan kuantitatif dan kualitatif. Dalam kajian ini, DDR terbatas kepada dua fasa; (1) Reka Bentuk dan Pembangunan dan (2) Penilaian. Fasa pertama melibatkan reka bentuk dan pembangunan Fraction Slider menggunakan Model ADDIE. Tiga panel pakar terlibat untuk menilai kesahan Fraction Slider dengan menggunakan soal selidik pendapat pakar. Peratusan persetujuan pakar yang diperoleh adalah 87.9%. Untuk aspek kebolehpercayaan, Fraction Slider digunakan dalam pengajaran dan pembelajaran melibatkan 27 pelajar. Analisis pekali alpha Cronbach yang diperoleh ialah 0.82. Fasa kedua melibatkan reka bentuk kuasi eksperimen. Ia terdiri daripada 23 pelajar untuk kumpulan kawalan dan 25 pelajar untuk kumpulan rawatan. Data kuantitatif dikumpulkan melalui ujian pra dan ujian pasca. Kajian ini menggunakan ujian Mann-Whitney untuk menunjukkan perbezaan signifikan antara kumpulan. Hasil kajian menunjukkan bahawa tidak terdapat perbezaan antara kumpulan kawalan dan rawatan dalam skor ujian pra. Terdapat perbezaan yang signifikan dalam ujian pasca antara kedua-dua kumpulan. Ujian Peringkat Bertanda Wilcoxon digunakan untuk membandingkan dua sampel yang berkaitan. Kajian ini menunjukkan bahawa tidak terdapat perbezaan yang signifikan antara skor ujian pra dan pasca dalam menyelesaikan soalan penambahan dan penolakan pecahan dalam kumpulan kawalan. Seterusnya, terdapat perbezaan yang signifikan sebelum dan selepas menggunakan Fraction Slider. Kaedah penyelidikan deskriptif kualitatif digunakan untuk mengenalpasti strategi penyelesaian masalah yang digunakan oleh pelajar dalam menyelesaikan masalah menggunakan Fraction Slider. Data kualitatif dikumpulkan melalui analisis skrip jawapan dan temu bual berasaskan tugasan. Kajian ini telah mengenal pasti strategi Fraction Slider untuk menyelesaikan masalah dengan berkesan yang dibina berdasarkan Model Polya. Kesimpulannya, penggunaan strategi Fraction Slider dalam pengajaran dan pembelajaran penyelesaian masalah KBAT dapat meningkatkan prestasi pelajar. Maka, strategi Fraction Slider diharapkan dapat membantu para guru dalam meningkatkan keberkesanan pengajaran dan pembelajaran penyelesaian masalah dan membantu para pelajar memperoleh kemahiran menyelesaikan masalah.

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LIST OF ABBREVIATIONS

DDR	Design and development research
DLP	Dual Language Programme
EPRD	Educational Planning and Research Department
HOTS	Higher Order Thinking Skills
IEA	International Association for Evaluation of Educational Achievement
JNJK	Jemaah Nazir dan Jaminan Kualiti
KSSR	Kurikulum Standard Sekolah Rendah
LOTS	Lower order thinking skills
MEB	Malaysia Education Blueprint
PISA	Program for International Student Assessment
RBT	Revised Bloom Taxonomy
SISC +	School Improvement Specialist Coach
TIMSS	Trends in International Mathematics and Science Study
UPSR	Ujian Penilaian Sekolah Rendah

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Education provides essential skills and knowledge for younger generations. Today, learning mathematics and gaining mathematical skills has become more certain than ever with the pace of technological and scientific progress. Mathematics today requires not only computational skills but also higher order thinking skills.

The key issue for today's mathematics education is to teach in a way that enables students to acquire mathematics concepts while simultaneously acquiring higher level thinking skills. Many teaching strategies have been encouraged in 21st

century learning classroom especially the shift from the teacher-centered approach to the student-centered approach. According to Nasarudin (2014), transformation in teaching and learning is vital in order to achieve high aspirations in a competitive global environment. There is a need for new methods and strategies so that the students can master the skills aligned with science and technology development to meet the challenges of 21st century.

There have been many initiatives taken to reform the education system in Malaysia. The education reform is vital to improve teaching and learning. Malaysia education system now focuses on Malaysia Education Blueprint (MEB) 2013-2025. Ministry has obtained inputs from various sources such as research reports run by educational experts from UNESCO, World Bank, OECD and six Public Higher Education Institutions in order to develop MEB (Ministry of Education, 2013). The study evaluated the current performance of the country's education system by taking into account past achievement and comparing it with international benchmarks (Ministry of Education, 2013). Malaysian mathematics curriculum has undergone several significant changes within the past few decades. The current curriculum for primary schools, *Kurikulum Standard Sekolah Rendah* (KSSR) places great emphasis on the development of mathematical thinking through problem solving, communications, mathematical reasoning, mathematical connections, making representations and application of technology in mathematics.

Transition in mathematics education from understanding concepts and basic skills to Higher Order Thinking Skills (HOTS) has affected the implementation of the teaching and learning of mathematics. Thinking skills is one of the six main

characteristics required by each student to be globally competitive (Ministry of Education, 2013). In today's education, the students must be able to think critically outside the routine academic context. They should be able to connect pieces of knowledge and solve a problem. Thus, learning with understanding is more effective than simply memorizing the facts (Karami, Pakmehr, & Aghili, 2012). Students should be given opportunities to engage in the learning process. Through this, students will be able to explain "how" to do the mathematics and state "why" the mathematics works the way it does.

Mathematics curriculum at the upper primary level encompasses four main areas, which are Numbers and Operations, Measurement and Geometry, Relationship and Algebra, and Statistics and Probability. The curriculum has a great emphasis on problem solving (Kementerian Pendidikan Malaysia, 2016). Problem solving is an activity which encourages students to use HOTS (Apino & Retnawati, 2017). Therefore, mathematics is no longer the task of mastering basic mathematical skills like addition, subtraction, multiplication or division. Students these days are assessed not only on basic mathematical operations but also on how well they understand the concepts, transform the mathematical operations correctly, apply the mathematical procedures and solve the problem (Abdul Halim, Nur Liyana, & Marlina, 2015).

According to Najihah (2017), mathematics curriculum in Malaysia is only focused on thinking and reasoning in general. Therefore, a study is required to ensure the learning of mathematics is more comprehensive and effective. To encourage students to practice such thinking which involves problem solving, proper teaching

and learning should be designed, and one potential strategy is through Singapore bar model method.

1.2 Background of study

Fraction is one of the earliest topics introduced in mathematics primary education. Fraction is found as one of the hardest topics for primary school students and teachers because the students face difficulty in understanding the mathematical concepts (Deringol, 2019). In Malaysia, the primary students are exposed to the fraction after learning the basic arithmetic operations (Kementerian Pendidikan Malaysia, 2016). Consequently, the students assume that the characteristics of fraction are the same as whole number; they try to apply the same rule (Siegler, Fazio, Bailey & Zhou, 2013). Yusri, Rosnaini, Habibah and Shaffee (2016) revealed that students tend to use the concept of whole number operations in performing fractional addition and subtraction operations. Likewise, Mohd Afifi (2019) discovered that the students add the numerators as well as the denominators while performing the fractional addition as shown in Figure 1.1. Thus, this leads to the development of misconception which is influenced by the students' prior knowledge on the concept of whole number operations.

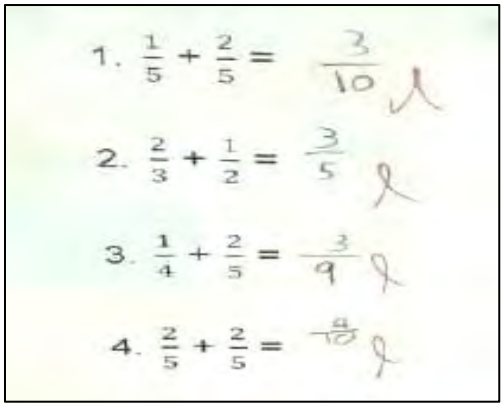

Figure 1.1. Fraction addition errors by Year 4 students. Adapted from Mohd. Afifi, 2019.

Since, the students existing knowledge on mathematics only involves whole numbers and operation (Noorbaizura and Leong, 2013), it is important for the teachers to wisely guide the students to comprehend the concept of fractions. According to Wijaya (2017) fraction is the most complex topic in primary education. If students encounter difficulties with fraction, they will face problems with other domains in mathematics such as algebra, measurement, ratio and proportion concepts (Braithwaite, Pyke & Siegler, 2017).

Teaching fractions in mathematics lessons calls for care and attention due to their complexity and conceptual richness. Learning fractions and related concepts well in primary school and having the skills to conduct fractional operations easily by learning them will not only lead to their success in using fractions in other classes, but will also set a strong preliminary learning basic for advance mathematics subjects. Therefore, an effective teaching approach is crucial.

Mohd. Afifi (2019) stated that teacher's correct teaching method is an important aspect for students' disposition to critical thinking. He added that this matter can be started by building appropriate teaching and learning material whereby innovation teaching method better serves the students. This is aligned with The Education Curriculum Transformation in the Malaysia Education Blueprint (MEB) 2013-2015, which emphasizes on the concept of HOTS (Ministry of Education, 2013). Previous studies were carried out focusing on the skills of teachers in teaching HOTS. Innovativeness and creativity of the teachers (Hargreaves, 2003), the application of effective methods of evaluation (Chai, Koh, Tsai and Lee, 2011) and the implementation of correct techniques (Fullan, 2014) are important qualities for developing HOTS.

In Malaysia, a student is considered to have HOTS if he manages to solve four of the top level of Bloom's taxonomy questions. HOTS refer to skills of applying, analysing, evaluating and creating as the following Table 1.1. While, Lower Order Thinking Skills (LOTS) involve remembering and understanding (Kementerian Pendidikan Malaysia, 2016). Based on Table 1.1, the students would use information in a concrete situation in applying stage. For an example, the students will draw a diagram which shows the fraction. On the other hand, when a word problem is given, the students need to determine the strategies that would be necessary to solve it. This stage is called analysing. The next stage is evaluation. At this stage, the students will be able to develop a proof or justify their answer. The last stage is creation which enquires the most complex cognitive effort. The students will apply and integrate several different strategies to solve a mathematical problem. They could design a model to inform and solve a problem.

Table 1.1

Higher Order Thinking Skills (HOTS)

HOTS	Description
Application	Using knowledge, skills and values in different situations to complete a piece of work.
Analysis	Ability to break down information into smaller parts in order to understand and make connections between these parts.
Evaluation	Ability to consider, make decisions using knowledge, experience, skills, and values and justify decisions made.
Creation	Produce an idea or a product using creative and innovative methods.

Adapted from Kementerian Pendidikan Malaysia, 2016.

The percentage of HOTS questions included in the Primary School Achievement Test, also known as Ujian Penilaian Sekolah Rendah (UPSR) 2016 is 20% (Ministry of Education Malaysia, 2017). However, Year 6 students seem not to be ready to answer the HOTS questions in UPSR leading to a decrease in average grade of 0.02 point (Marzita, Nor'ain, Mazlini & Azrul Azwan, 2017). HOTS are valued because they are believed to better prepare the students for the challenges of daily life and produce skilled workers. Nowadays, most of the jobs require employees with HOTS which involve creativity, problem solving and critical analysis compared to other skills (Hartini, Mohd Norawi & Mohd Ali, 2017).

Thinking is always associated with problem solving in mathematics (Mazlini, Muhammad Faizal Nizam Lee, Che Nidzam Ahmad, Najah, & Suhaini, 2017).

Therefore, problem solving is a grounding area for the students to acquire HOTS. Malaysia is now considered as advance nation in 2020. Without skilled workers, Malaysia will remain as consumer of technology and not as a producer of technology as a result of lack of researchers, scientists, engineers and innovators (Chang, Morshidi & Dzulkifli, 2018). Hence, engaging the students in the accurate problem solving strategy is essential to enhance the learning of mathematics. There are various problem solving strategies to solve the word problems. Posamentier and Krulik (1998) stated 10 problems solving strategies ; (1) Working backwards, (2) Finding a pattern, (3) Adopting a different point of view, (4) Solving a simpler or analogous problem, (5) Considering extreme cases, (6) Making a drawing (visual representation), (7) Intelligent guessing and testing (approximation), (8) Accounting for all possibilities, (9) Organizing data, and 10) Logical reasoning. According to Mahaletchumy (2019), the practice of memorizing procedures and keywords can help the students to solve routine problems without understanding the given mathematical problems. Therefore, an alternative method should be introduced to the students to solve mathematical word problems.

Singapore mathematics has one of the most successful techniques proven with the success of their students in the Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA). Moreover, Singapore is a country that has the highest achievement in both assessments (TIMSS & PISA, 2015). The bar model method is the main model for solving word problems in Singapore (Azrul Azwan, Marzita, Nor'ain, & Mazlini, 2017). It involves visual representation of problem solving strategy. In Singapore, 86% of primary schools use the bar model method where it helps to understand the word problems and thus solve

them easily (Clark, 2010). Bar model is a heuristic method of problem solving using a pictorial representation of rectangular bars in solving the mathematical word problems (Berinderjeet, 2015). According to Sibley (2015), the bar model method (1) help students to visualize the problems, (2) create concrete pictures from words and abstract situations, (3) demonstrate understanding of the problem and (4) lead the students to a possible solution plan.

Thus, the bar model method enables the students to translate the information from words into a diagram. The diagram can assist in problem solving because it helps the students to visualize the problem better and solve the problem.

1.3 Statement of problem

In the 21st century pedagogy, the teachers are expected to instill Higher Order thinking Skills (HOTS) elements among students. The School Inspectorate and Quality Assurance or *Jemaah Nazir dan Jaminan Kualiti* (JNJK) observed 847 teaching and learning sessions in 36 schools to ensure quality delivery of HOTS in the classroom (Ministry of Education, 2013). The observation revealed that the school-based assessments contained more than 40% of HOTS items for Mathematics papers. “Application” was the most dominant cognitive level observed in the students’ work, which is an encouraging trend. However, the “Creative”, “Critical” and “Innovative” skills which are the higher cognitive levels are less evident and thus, more needs to be done to incorporate these higher cognitive levels (Ministry of Education, 2013).

Studies from the implementation of thinking skills in the curriculum indicated that teachers had problems in inculcating higher order thinking for teaching word problem solving. Teachers seem to focus on surface level of understanding the subject matter and not on higher order thinking or problem solving (Ministry of Education, 2012). On the other hand, the employers seem to indicate that Malaysian graduates are lack of the problem solving skills required for the workplace (Ministry of Education, 2012). The employers give emphasis to graduates who have generic skills like problem solving and pay less concern with the highly specialized career skills which can be learnt on the job (Bassham, Irwin, Nardone & Wallace, 2012).

Additionally, low performances of Malaysian students in several international assessments have raised concern among the educators. The most popular surveys are TIMSS and PISA. TIMSS is a comparative study designed in 1995 by The International Association for Evaluation of Educational Achievement (IEA). It was designed to assess the quality of teaching and learning of mathematics and science among the fourth and eighth-graders across participating countries (TIMSS, 2011). On the other hand, PISA examines 15-year-old students' ability to use their reading, mathematics and science knowledge and skills to meet the real-life challenges (OECD, 2001). Malaysia has joined TIMSS since 1999.

39 countries involving eighth grade students participated in TIMSS 2015 including Malaysia. Malaysia was represented by 207 sample schools consisting of Ministry of Education schools and non-Ministry of Education schools. The sample selection was made by the IEA according to the random stratified sampling method. A total of 9726 form two students have sat for the TIMSS test (TIMSS, 2015).

Table 1.2 discussed the Mathematics TIMSS assessment between Singapore, Malaysia and two other neighbouring countries. Mathematics assessment framework for TIMSS 2011 and TIMSS 2015 are organized around two domains which are the content domains and cognitive domains. The content domains are number, algebra, geometry and data and chance; while the cognitive domains measured knowledge on facts and procedure, concept usage, routine problem solving and reasoning skill (TIMSS, 2011 & TIMSS, 2015). Both Malaysia and Singapore who are neighbouring countries participated in TIMSS 2011 assessment. However, Singapore has attained much better results compared to Malaysia. Although achievement of Malaysian students in the mathematics content and cognitive domains in TIMSS 2015 is higher than TIMSS 2011, it is still lower than the international average.

Table 1.2

Comparison of Malaysian 8th grade (Form 2) achievement at the TIMSS 2011 among neighbouring countries

Country	Content Domains				Cognitive Domains		
	Number	Algebra	Geometry	Data and Chance	Knowing	Applying	Reasoning
Singapore	77	72	71	72	82	73	62
International Average	43	37	39	45	49	39	30
Malaysia 2011	39	28	33	38	44	33	23
2015	41	31	32	41	48	34	25
Thailand	33	27	29	38	38	30	22
Indonesia	24	22	24	29	31	23	17

Adapted from TIMSS, 2011 & TIMSS, 2015.

The Number domain includes Whole Numbers, Fractions, Decimals, Integers, Ratio, Proportion and Percent (TIMSS, 2011). TIMSS assessment also focuses on problem solving. In this study, Fraction is one of the mathematical topic selected by the researcher as a field of study and Fraction is part of the number domain. Regarding the operations of fraction for Grade 4, TIMSS includes equivalence, order of fractions, addition and subtraction.

Based on Table 1.3, Malaysian students' performance are below the international standard in Mathematics. Malaysian students' performance took a sudden decline in year 2011. In 1999, Malaysia scored 519 followed by 508 in 2003. Consecutively, mathematics score dip from 474 in 2007 to 440 in 2011. However, there is an increase of 25 points in 2015 from the figure in TIMSS 2011. The result indicates that Malaysia students are still in the low international benchmark. There are four scales identified as international benchmarks; Advanced (625), High (550), Intermediate (475), and Low (400) (TIMSS, 2011). Singapore has the highest achieving students in primary and secondary in TIMSS from 39 countries (TIMSS, 2015). Based on PISA 2012 report (OECD, 2014), the average score obtained by Malaysian students for the Number is 409. Malaysia is ranked the lowest in Southeast Asia compared to countries such as Thailand (419) and Singapore (569). The questions tested in PISA involved the application of HOTS similar to TIMSS.

Table 1.3

Trend of the Average Mathematics Scores of Eighth Grade Students by Selected Countries from 1999 – 2015

Country	1999	2003	2007	2011	2015
Singapore	604	605	593	611	621
Malaysia	519	508	474	440	465
Korea	587	589	597	613	606
England	496	498	513	507	518
United States	502	504	508	509	518

Adapted from TIMSS, 2011 & TIMSS, 2015.

The finding is aligned with the report by Kestrel Education Consultant (UK) and 21 Century School (USA) which shows that the level of HOTS among Malaysia students is low (Ministry of Education, 2012). The declining mathematics performance of Malaysian students is a concern which needs collective efforts of the teachers and school administration. Therefore, evidence-based interventions on effective instructional practices should be taken into account.

Previous studies had identified various factors leading to the poor students' achievement in mathematics, such as mathematics anxiety and phobia (Paul and Hlanganipai, 2014), the demotivation of students (Abdul Halim et al., 2017), and lack of problem solving skills in mathematics (Galadima & Yusha'u, 2007).

Fraction is considered to be difficult by the students and teachers (Aksoy, & Yazlik, 2017; Hamza, 2018; Wijaya , 2017). Students find it difficult because they have to memorize the algorithm instead of understanding the concept and they perceive the numerator and denominator of fractions as two different integers (Hamza, 2017). In addition, Fraction has been described as a challenging area for the students as it requires a deeper understanding than natural numbers (Siegler et al., 2013). They revealed that natural numbers are discrete and countable for the students compared to fraction. It is difficult for students to visualise the concepts of fraction as it is an abstract concept. According to Wijaya (2017), students' prior knowledge of numbers do no longer hold for fraction which is called whole number bias.

A student's limited conceptual understanding of fraction will lead to serious implications especially to master higher level mathematics topics such as probabilities and algebra (Gabriel et al., 2013). Figure 1.2 shows an excerpt of TIMSS 2015 test item for Eight Grade/ Form 2; Item 19. 53.4 % of students were unable to compare the fractions and explain their answer (TIMSS, 2015). This shows that the students have not mastered the concept of equivalent fractions in primary school. The students who fail to learn fraction in primary school have little opportunity to acquire these skills in secondary school as it underpins many complex topics.

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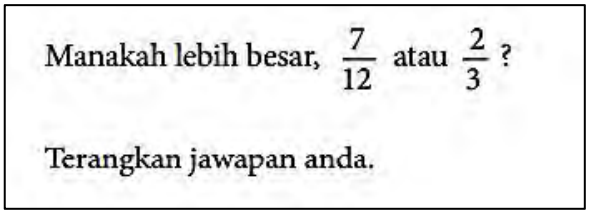
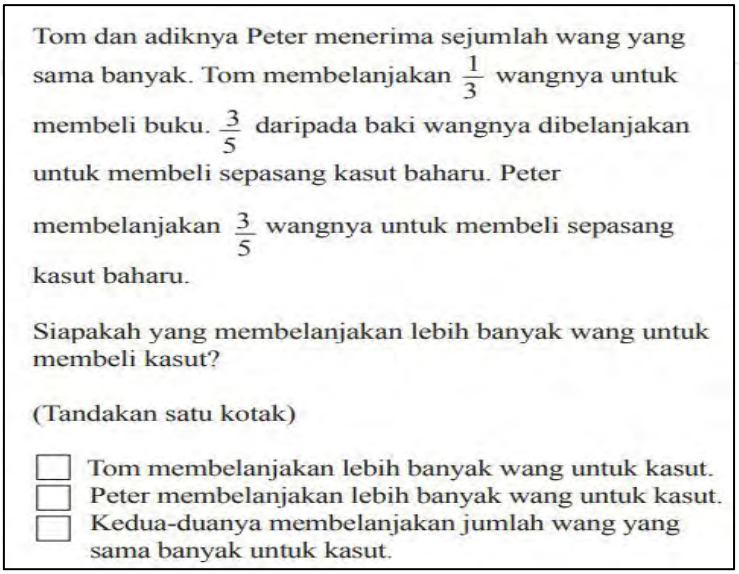


Figure 1.2. Excerpts of Item 19 TIMSS 2015. Adapted from TIMSS, 2015.

Most students make mistakes in basic operations such as addition and subtraction of Fraction (Ndalichako, 2013; Khairul Anuar & Norazrena, 2011). However, Tong and Loc (2017) stated that the students performed poorly in solving mathematics word problems compared to computational problems involving Fractions. They added that manipulating fraction is particularly challenging when embedded in word problems as they are related to many concepts and a lot of mathematical relationships. Figure 1.3 shows an excerpt of Item 27, TIMSS 2015 whereby only 7.2 % of students are able to answer the question correctly. This shows that the students have not mastered the word problem solving skills and unable to make comparison (TIMSS, 2015).


Tom dan adiknya Peter menerima sejumlah wang yang sama banyak. Tom membelanjakan $\frac{1}{3}$ wangnya untuk membeli buku. $\frac{3}{5}$ daripada baki wangnya dibelanjakan untuk membeli sepasang kasut baharu. Peter membelanjakan $\frac{3}{5}$ wangnya untuk membeli sepasang kasut baharu.

Siapakah yang membelanjakan lebih banyak wang untuk membeli kasut?

(Tandakan satu kotak)

☐ Tom membelanjakan lebih banyak wang untuk kasut.
☐ Peter membelanjakan lebih banyak wang untuk kasut.
☐ Kedua-duanya membelanjakan jumlah wang yang sama banyak untuk kasut.

Figure 1.3. Excerpt of Item 27, TIMSS 2015. Adapted from TIMSS, 2015.

The students' ability in word problem solving can be analysed using Newman's Error Analysis. There are five stages of Newman's Error Analysis which are reading, comprehension, transformation, process skills and encoding (Newman,

1977). According to Abdul Halim et al. (2015) and Ismail (2010), the common errors made by the students in solving fraction word problems are comprehension, transformation, process skills and encoding. This shows that the students have problems to interpret the word problems, failed to devise a plan and eventually unable to select the correct operation and thus failed to answer the problems correctly. Therefore, the teachers need to take appropriate approaches to improvise their teaching to overcome the difficulties and errors encountered by the students.

On the other hand, the students also face difficulties in Fractions when the teaching and learning process does not promote understanding. Liew, Sian, Siti Syardina Erdina and Parmjit (2019) revealed that the teachers' conventional method in teaching mathematics affects the students' performance as they only focus on acquiring the knowledge to arrive at the right answer without paying attention towards the conceptual understanding. This shows that the problem arises from the teachers (Abdul Halim, et al., 2017). According to Noorbaizura and Leong (2013), typical teachers would just give simple tricks in learning fractions. For an example, providing steps in manipulating the values of the numerators and denominators. Hence, the students do not really understand what and why they are doing certain steps to get the answer.

In learning Mathematics, the students should actively construct their understanding of concepts. In order to help the students to develop mathematics understanding, Piaget emphasizes on teaching from concrete to the representational and lastly to the abstract (Piaget, 1964). Obviously, the use of manipulative can

facilitate the students' learning and knowledge construction as it is a potential way to introduce the abstract mathematical ideas (Rosli, Goldsby & Capraro, 2015).

Manipulatives are concrete learning materials designed to represent abstract mathematical ideas concretely (Laski, Jor'dan, Daoust, & Murray, 2015). The use of manipulatives allow the students to comprehend abstract concepts and enhance the students' learning. In learning of fraction, manipulatives allow students to construct mental images and enable them to understand concepts.

The use of manipulative is not to make the students forever dependent on it, but gradually move from concrete to abstract (Willingham, 2017). Students must be able to see the manipulative as representing a mathematical idea. However, Sarama and Clements (2016) stated that there is possibility that instruction does not sufficiently promote connection between the students' representations using the manipulatives and the paper and pencil activity. They further suggested on mapping instruction. It is designed to help the students to connect concrete knowledge shown by the use of manipulative to symbolic. In this study, Fraction Slider is designed to support the development of problem solving knowledge and understanding of fraction concepts. According to Sarama and Clements (2016), there are few roles of manipulative in supporting development of knowledge. The roles of manipulative to represent mathematical ideas and serve as symbols will be cater by the Fraction Slider.

The Fraction Slider is a manipulative adapted from Singapore bar model method. The bar model method is the main model for solving mathematical word problems in Singapore. However, there are some difficulties commonly faced by

primary school teachers and students in drawing models involving fractions 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 (Westenskow, Packenham, Pence, Shumway & Jordan, 2014).

The developed Fraction Slider is able to overcome those difficulties. It is focused in facilitating the students to solve fraction word problems. It comprises Concrete-Pictorial-Abstract (CPA) instructional approach. CPA instructional sequence has its root from Bruner's theory (Bruner, 1966). According to Bruner, learning should use the concrete material, followed by representation and manipulation of symbols. The Fraction Slider is used along with Polya's four-step approach to problem solving; Step 1: Understand the problem, Step 2: Devise a plan, Step 3: Carry out the plan and Step 4: Look back (Polya, 1957).

The researcher implemented the Polya's model in her lesson as the model was recommended by the Malaysia Ministry of Education for all the schools in Malaysia. Meanwhile, primary mathematics textbooks also use the bar model method in their problem-solving instruction (Kementerian Pelajaran Malaysia, 2016). The Fraction Slider is used as a visual representation to illustrate the problem in the second approach of Polya's Model (Devise a plan). From the diagram, the students will form a number sentence and solve the problem which caters the third approach (Carry out the plan). The usage of the Fraction Slider along with Polya's problem solving approach is expected to have a positive effect in improving students' problem solving abilities.

1.4 Objectives of study

The objectives of this study are to:

i. develop a valid and reliable Fraction Slider for Year 5 students to answer HOTS addition and subtraction of fraction word problems.
ii. determine the effectiveness of the Fraction Slider in improving the performance of Year 5 students in solving HOTS addition and subtraction of fraction word problems.
iii. determine the effective problem solving strategy using the Fraction Slider in solving HOTS addition and subtraction fraction word problems.

1.5 Research Questions

The study is conducted to investigate:

i. Is the Fraction Slider for Year 5 students to answer HOTS addition and subtraction of fraction word problems valid and reliable?
ii. Are there any significant differences between the control and treatment groups in pre-test scores in solving HOTS addition and subtraction of fraction word problems?
iii. Are there any significant differences between the control and treatment groups in post-test scores in solving the HOTS addition and subtraction of fraction word problems?

iv. Are there any significant differences between the pre-test and post-test scores in solving the HOTS addition and subtraction of fraction word problem in the control group?

v. Are there any significant differences between the pre-test and post-test scores in solving the HOTS addition and subtraction of fraction word problems in the treatment group?

vi. What is the effective problem solving strategy using Fraction Slider in solving HOTS addition and subtraction fraction word problems?

1.6 Research Hypotheses

The research hypotheses for this study are:

i. H_{01} There are no significant differences in the pre-test scores between the control and treatment groups in solving the HOTS addition and subtraction of fraction word problems.

ii. H_{02} There are no significant differences in the post-test scores between the control and treatment groups in solving the HOTS addition and subtraction of fraction word problems.

iii. H_{03} There are no significant differences between the pre-test and post-test scores in solving the HOTS addition and subtraction of fraction word problems in the control group.

H_{04} There are no significant differences between the pre-test and post-test scores in solving the HOTS addition and subtraction of fraction word problems in the treatment group.

1.7 Theoretical Framework

There are three main learning theories, specifically behaviourism, cognitivism and constructivism. Constructivism functions as a theory of education in which the students construct their own knowledge (Olusegun, 2015). Constructivism supports the cognitive development theory in this study. This study applies Bruner's theory of cognitive development and Piaget's theory of cognitive development.

Bruner introduced three modes of representation which are enactive, iconic and symbolic representation (Leong, & Ho, 2015). Enactive stage gives the students the experience of handling physical objects. Iconic stage encourages the students to visualise concrete experience and provide link to the abstract while using mathematical symbols to model problems is the symbolic stage (Gningue, Park, West, & Fuchs, 2014). Thus, Bruner's theory of learning related to the way the students' thinking is developed. According to Fong (2009), the students should not depend too much on concrete representation. They need to conceptualize the abstract situations using the pictorial representation which is the iconic stage.

In this research, the iconic stage is emphasized since the Fraction Slider fits into the iconic phase of development (Hofer, 2015). At iconic stage, the students are

encouraged to make a mental connection between the physical object and the abstract levels of understanding by drawing a bar model. The use of the bar model method is based on the fact that the students are unable to solve the abstract problems (Fong, 2009). The Fraction Slider will represent the objects in the problem and simplifies the problem solving situation. Through this, the students are able to visualise the problems and help them to solve the word problems specifically involving HOTS questions.

This research also underpins Piaget's cognitive development. Piaget identified four stages of cognitive development; the sensorimotor, pre-operational, concrete operations and formal operations (Piaget, 1964). This study focuses on concrete operation stage. Piaget stated that children aged 7 to 11 years old are within concrete operation stage. The Fraction Slider is a concrete references made available for the students to learn and explore Fraction concepts and solve Fraction word problems. At this stage, the students rely on the concrete material, since they are unable to think abstractly and solve HOTS problems. The students will be able to solve the word problems through analysing the relations represented by the bar model.

On the other hand, Polya's problem solving strategy is facilitated by the Fraction Slider. The current Malaysian Mathematics text book uses a version of Polya's plan in their problem solving instruction. Polya identified four basic principles in word problem solving; understand the problem, devise a plan, carry out the plan and look back (Karrison & Carroll, 1991). Polya's first step is, understanding the problem. In this step, the students have to state the problem in their own words. In the second stage, the students would use the bar model to draw what they know and

what they are attempting to solve. Then, the carry out the plan step relates to mathematics computation. The last step which is look back advises the students to recheck their answers by using work backward strategy.

Therefore, the Fraction Slider which incorporates the Bruner's and Piaget's theory of cognitive development is an effective tool when devising a plan in the Polya's problem solving strategy. This leads to the formulation of a problem solving strategy as illustrated in Figure 1.4.

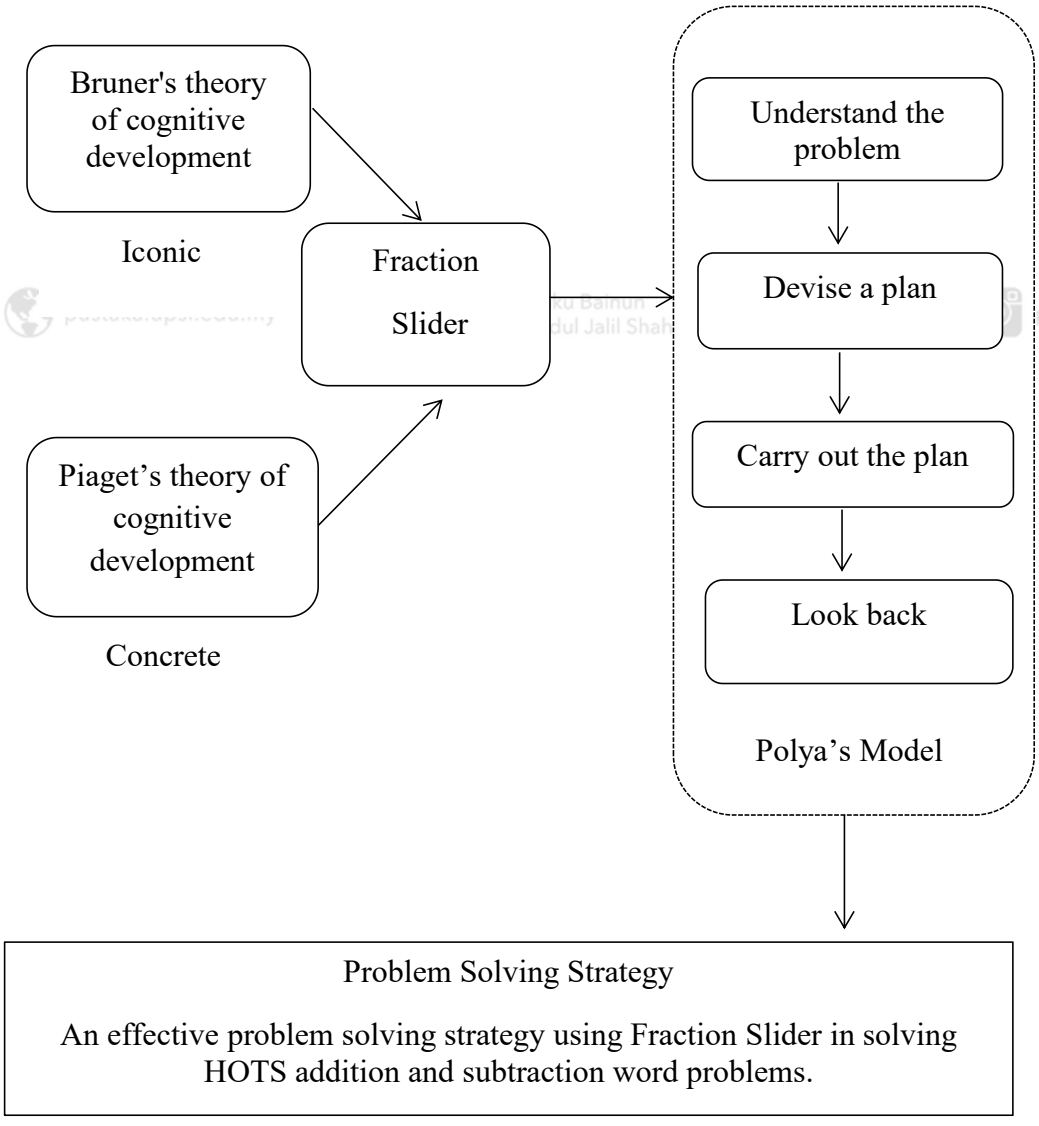


Figure 1.4. Theoretical Framework

1.8 Conceptual Framework

The conceptual framework was constructed to explain the overall process of the study. This study employed design and development research (DDR). Therefore, there are two phases as outlined in Figure 1.5; Phase I: Design and Development and Phase II: Evaluation.

The first phase involves design and development. There are two processes involved in this phase; (1) development of the Fraction Slider, (2) validity and reliability of the Fraction Slider. ADDIE model was used in the development process because it is a systematic instructional design model which consists of five phases: (1) Analysis, (2) Design, (3) Development, (4) Implementation and (5) Evaluation. The Fraction Slider is designed and developed based on literature reviews. Piaget's cognitive development theory and Bruner's stage of representation supports the development of the Fraction Slider. Moreover, the Fraction Slider is initiated from Singapore bar model method. It is a pedagogical strategy which able to help the students to solve word problems. The process of development of the Fraction Slider was followed by experts validation to evaluate the Fraction Slider. Then, pilot study was conducted in order to determine the reliability of the Fraction Slider. The DDR process will be further discussed in Chapter 4.

This study involves two variables which are the independent variable and the dependant variable. The independent variable refers to the Fraction Slider strategy and conventional instruction strategy in the teaching and learning of addition and

subtraction word problems. While, the dependent variable refers to the students' performance which is assessed through HOTS Fraction word problem test.

The second phase involves evaluation. In this phase, intervention was carried out with the treatment group involving Year 5 students using the Fraction Slider strategy. The students used the Polya's problem solving model along with the Fraction Slider. While, students in the control group used the conventional strategy; Polya problem solving strategy. The effectiveness of the both problem solving strategies were evaluated by HOTS Fraction word problem test administered in both groups. A problem solving strategy could be seen through the incorporation of the Fraction Slider with the Polya's problem solving method during the teaching and learning process. This leads to the formulation of an effective problem solving strategy to solve HOTS addition and subtraction of fraction word problems using the Fraction Slider.

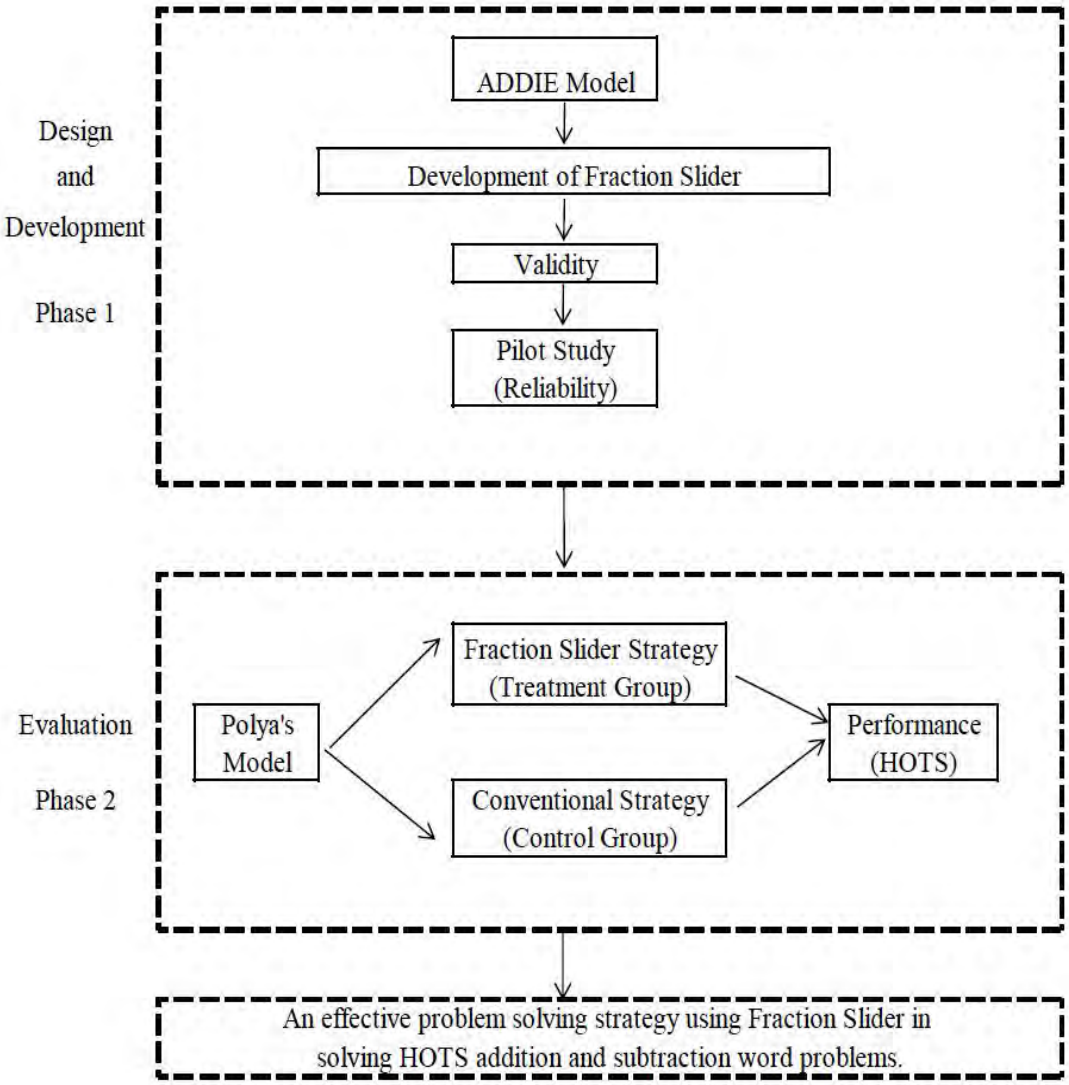


Figure 1.5. Conceptual Framework

1.9 Significance of the study

The dearth of studies about the usage of manipulative in teaching and learning of mathematics word problem solving in Malaysia has inspired the researcher to carry out this study. Thus, the empirical information of the study will support the use of the Fraction Slider in the classroom. The Fraction Slider is able to facilitate both teachers and students in teaching and learning of addition and subtraction fraction word problems.

According to Lopez (2008), the students who are lacking in the mathematical content fail at solving word problems because they are not equipped with the essential tools to learn how to solve word problems. However, the teachers can overcome the problem with the usage of the Fraction Slider. The manipulative does not only aid in the process of solving word problems but designed such that the students could understand the concept of fractions by manipulating it.

The bar model approach is an effective word problem solving strategy proven with the success of Singapore students (Clark, 2010). The students can simplify the complex word problems by breaking down into small units of known and unknown information. In this process, the students are taught to visualize the problem and make mathematical connection in order to comprehend a problem (Berinderjeet, 2015). The bar models do not give an answer. It gives the students an understanding of what to do in order to get to the answer.

Apart from helping the students to solve fraction word problems, the Fraction Slider strategy provides a useful procedure for guiding the mathematics teachers to deal with the word problems during the teaching and learning process. This method has the potential to improve the teaching and learning of problem solving involving HOTS questions. Moreover, the use of the procedures encourage students to improve their metacognitive awareness in word problem solving. They become aware of what they are doing and why they are doing it; they are unlikely to struggle when solving the problems.

Most teachers know that problem solving is a vitally important skill in mathematics, but there is a lack of well-defined techniques for teaching the students to analyse and interpret word problems. The findings of this study will demonstrate the effectiveness of the teaching and learning of fraction word problems from different approach. It is hoped that this study will help the teachers in Malaysia to better utilize the Fraction Slider as an instructional strategy to solve fraction word problems.

1.10 Limitation of Study

The usage of the Fraction Slider is not intended to be generalized to all the topics in mathematics. It is only applicable to examine fraction word problems involving addition and subtraction.

Another limitation is a small-scale of sample was used in this study. There were 25 students in the treatment group and 23 students in the control group. The

selection of classes for the research was limited by the school administration. Only one class of students was allowed to participate in the research.

Furthermore, for the task based interview only two scenario problems were used because too many problems might tire the students and thus affect their thought processes.

1.11 Operational Definitions

The following sections define the terminology used in this study.

1.11.1 Bar Model

Bar model refers to rectangular “bars” to represent the relationship between known and unknown numerical quantities and used to solve problems related to these quantities (Clark, 2007).

1.11.2 Fraction Slider

In the study, Fraction Slider refers to a manipulative which helps to draw the rectangular bars accurately. The tool is specifically designed to help the students to translate the information from words into a diagram. Through this, the students will

be able to visualize and solve fraction word problems involving addition and subtraction.

1.11.3 Fraction

Fraction is a number which can tell us about the relationship between two quantities (Hurrell, 2013). These two quantities provide information about the parts. In this research, researcher will focus on addition and subtraction of fraction.

1.11.4 Word Problem

Word problem is a verbal description of mathematical situation involving routine or non-routine problems (Sourav & Sudip Kumar, 2019). In this study, researcher focuses on HOTS mathematical word problems.

1.11.5 Performance

Performance is the extent to which a student has achieved in the pre and post-test. Comparison between pre and post-test will be made in order to measure the change in students' understanding.

1.11.6 Students

In this study, students refer to Year 5 students from two different schools in Batang Padang District.

1.11.7 Control Group

In this group, the teacher taught the students fraction word problem using conventional strategy; Polya's problem solving strategy which focused on identifying key words method.

1.11.8 Treatment Group

In this group, the teacher taught the students to solve fraction word problems using Polya's problem solving strategy along with Fraction Slider which is known as Fraction Slider Strategy.

1.12 Summary

Fraction is an important domain in mathematics. Learning Fraction is pivotal in order to proceed to the next level of mathematics. However, fraction is considered to be difficult. One of the reason is because of the teaching approach. Therefore, the

Fraction Slider has been developed for the intervention purpose. Constructivism learning theory underpins in this study. It consists of cognitive development theory, developed by Piaget (1964) and Brunner (1966). The Fraction Slider is a tool used in devising a plan stage based on Polya's problem solving method. This leads to the formulation of an effective problem solving strategy.

The purpose of this study is therefore to investigate the effectiveness of the Fraction Slider strategy in enhancing the problem solving abilities among the Year 5 students. The next chapter will present the literature review of the whole area of the study.