基模教學對百分比問題之程序流暢程度的有效性研究

EFFECTIVENESS OF SCHEMA-BASED INSTRUCTION (SBI) ON PROCEDURAL FLUENCY WITH PERCENTAGES PROBLEMS

A Dissertation

Presented to

The Academic Faculty

by

Zhou Mingyan, Mani

In Partial Fulfillment of the Requirements for the Degree of

Master of Education

in the School of Education

University of Saint Joseph, Macao

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ENDORSEMENT

I certify that this report is solely my work, and that it has never been previously submitted to any other higher education institution for any academic award.

I, the supervisor, believe that this Dissertation is ready for assessment, and reaches the accepted standard for the Master of Education.

Zhou Mingyan

Student Name

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Supervisor Name

Abstract

Research suggested that students struggle because of lacking understanding of basic concepts, formulas, and procedures in algebra, leading to inefficiency in logical thinking and problem-solving skills. (Julius et al., 2018; Jupri et al., 2021). Schema-based instruction (SBI) aims to enhance learning and problem-solving by activating and building upon students' prior knowledge structures, known as schemas (Powell et al., 2008). The common schemas include the total, difference, change, equal groups, comparison, ratios/proportions (Hughes & Cuevas, 2020). SBI has been found to be effective, particularly for students who struggle with mathematics word problems (Marshall, 2012; Hughes & Cuevas, 2020). Research related to SBI has not yet been conducted in Macau region.

An early pre-test was administered by the researcher, thirty-one students were asked to solve 10 questions about percentages. The results showed that some students lacked the fundamental knowledge needed to investigate and explore the abstract ideas, patterns, and relationships in percentages problems. A daily schema-based instruction (SBI) as a part of an experimental intervention study was implemented, pre-test and post-tests were administered to investigate the effect of SBI on students' mathematical procedural fluency skills. Thirty-one students from the researcher’s class were invited to engaged in 40 minutes of daily SBI lessons for two weeks, 12 lessons in total. During each of the twelve 40-minute session, students practiced schemas to develop procedural fluency competencies, such as solid number sense and arithmetic operations, to solve percentages problems. Within-group descriptive and inferential statistics were adopted. The results indicated that after SBI, students can solve mathematical problems with greater procedural fluency. This research shares implications and provides suggestions regarding SBI and procedural fluency.

Keywords: percentages problems, procedural fluency, mathematics, secondary education, schema-based instruction, SBI.

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Chapter 1 Introduction

1.1 What is SBI?

Schema-construction theory is a psychological framework that suggests individuals ‘construct’ new information based on their existing knowledge structures, known as schemas. Schemas are units of knowledge that individual use to organize and store information, allowing them to interpret and make sense of new experiences or information, and that new information is organized and stored in relation to existing schemas (Mayer, 2002). In education, schema-construction theory has been used to develop instructional approach that activate and build upon students' prior knowledge structures (schemas), known as schema-based instruction (SBI) (Powell et al., 2008). In schema-based instruction (SBI) for mathematics education, teachers explicitly teach students problem-solving techniques and strategies, based on both the mathematical structure and its semantic structure. (Marshall, 2012; Jitendra, n.d.). SBI goes further than simple recognition to emphasizing the understanding of a situation represented in the problem and encourages students to identify patterns of similarities across new and familiar problems. Students can build a set of schemas that help them recognize and solve different types of mathematical problems.

1.2 SBI Strategy

For students using their existing knowledge to solve problems, the current problem needs to be identified, information needs to be translated and organized into an understandable schema. In the process, after determining the problem type and suitable schemas, students employ graphic diagrams to represent schemas about the mathematical structure and semantic structure (Powell, 2011). The schema helps the student access the relevant prior knowledge to solve the problem. The schema could reduce a learner’s cognitive processing load and allocate available mental resources for problem analysis and lead to solution (Jitendra, n.d.).

A four-step SBI strategy checklist called FOPS helps anchor the students’ learning was adopted for mathematics education (Hott et al., 2021).

F – find the problem type: Students recognize the type of problem and the problem schema (i.e., is this a change, group, or compare problem?).

O – organize the information by using the diagram: Students translate the information given in the current problem from words into a meaningful, systematic graphic representation (diagram).

P – plan to solve the problem: plan to solve the problem by recalling the action procedures taken when encountering the abovementioned problem type in the past (e.g., multiply, adding).

S – solve it: apply appropriate mathematical procedures and operations that they have learned, such as writing then solving the mathematics equation; they shall check the solution at the end.

Teachers must teach students to identify the unique features of each type of problem and how to represent the relevant information in the problem situation using suitable and consistent diagrams. SBI strategies are crucial and helpful to relate current problem with familiar and similar problems.

1.3 Why is SBI important for mathematics education?

Schema-Based Instruction (SBI) uses a conceptual teaching approach that integrates mathematical problem solving and reading comprehension strategies (Kalyuga, 2006). The core feature of SBI involves teaching students to build a rich schema for problem solving, students are taught to identify similarities and differences and classify problems into type, where the surface-level information related to the problem may vary but does not change the problem structure, enabling them to understand the fundamental mathematical properties embedded (Quilici & Mayer, 1996).

Employing SBI in lessons, particularly using the four-step SBI strategy checklist known as FOPS (Find, Organize, Plan, Solve) in every question, has several benefits for students' learning and understanding (Mayer, 1999).

Firstly, SBI helps students activate their prior knowledge or schemas related to the current problem. By encouraging students to draw upon their existing knowledge, they can make connections between what they already know, and the new information or concept being presented. This process of making connections allows students to build a more comprehensive understanding of the topic.

Secondly, SBI guides students in identifying key features or underlying structures of the problem. By considering these key features, students can effectively organize and categorize the information, which aids in problem-solving. Additionally, after identifying the problem type, students are encouraged to create diagrams to visualize the problem, which further enhances their understanding.

Thirdly, SBI teaches students how to chunk complex information into smaller, more manageable pieces. This systematic approach helps students process new information more effectively and reduces cognitive load. By breaking down the information into chunks, students can better organize and retain the material. Another benefit of SBI is the development of metacognitive skills. Through the FOPS strategy checklist, students "think about what they are doing and why they are doing it, evaluate the steps they are taking to solve the problem, and connect new concepts to what they already know" (Woodward et al., 2012, p. 17), they become aware of their own understanding and evaluate their progress. This metacognitive monitoring allows students to identify similarities and differences across different problems, further enhancing their problem-solving abilities. Furthermore, SBI enables students to transfer and apply their acquired knowledge and skills to new situations or problems. By recognizing similarities between the current problem and previously solved problems, students can effectively apply their schemas and adapt their problem-solving strategies.

Lastly, SBI promotes reflection and review of learned material. Students are encouraged to reflect on what they have learned, reinforcing their schemas, and promoting long-term retention. According to Star & Rittle-Johnson (2009), when students use, share, compare, and contrast multiple solution methods for a given class of problems, procedural knowledge and procedural flexibility are improved. This reflective practice helps solidify their understanding and facilitates the transfer of knowledge to future scenarios.

By consciously activating and utilising schemas, SBI help students make more meaningful connections, recognise underlying structures, and apply their knowledge in diverse contexts, thus promote a deeper understanding of the subject matter and support the development of flexible and adaptive thinking skills.

1.4 Current Situations in Mathematics Education

National Academies of Sciences, Engineering, and Medicine (NASEM) defined mathematical proficiency to have five strands: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (Kilpatrick et al., 2001). These strands are interdependent as they represent different aspects of a complex whole. As students advance from pre-kindergarten to junior secondary, proficiency in mathematics increases gradually, such proficiency should enable them to cope with the mathematical challenges in daily lives and enable them to continue their study of mathematics in senior secondary school and beyond.

Problem-solving refers to the process of finding solutions to mathematical or real-life problems (Dossey, 2017). It involves applying mathematical concepts, reasoning, and critical thinking skills to analyse, strategize, and make decisions to reach a solution (answer). Nowadays teaching of mathematics is where problem solving comes to the forefront, and the mathematical processes students use in learning mathematics are essential (Rittle-Johnson & Alibali, 1999).

From observations made by the researcher, students in Form One sometimes have difficulty in problem-solving because they have the following issues: (i) do not know how to make connections between familiar problems and the current problem, (ii) do not understand the context of the current problem, (iii) do not know how to present their ideas systematically, (iii) do not carry out algebraic steps in sequential order. As a result, they students could fail to find the solution to the current problem, even experience frustration with mathematics.

In the beginning of the secondary school life, developing a mathematical mindset is crucial. A mathematical mindset refers to an individual's beliefs, attitudes, and approaches towards mathematics (Boaler et al., 2021). It includes having a growth mindset, which emphasizes the belief that intelligence and abilities can be developed through effort and practice. According to Sun (2018), a person with mathematical mindset opens to challenges, embraces mistakes or failures as learning opportunities, is persevering in problem-solving. These qualities and characteristics are essential for developing a strong foundation in mathematics, fostering growth and improvement, and cultivating a positive attitude towards not only mathematics, but also in life.

1.5 Current Situations with Teaching Mathematics

The main challenge faced by many mathematics educators is how to include problem-solving techniques in both their daily lesson and the mathematics curricula they teach. From observations made by the researcher, gaps or disparity can occur between what a teacher intends to teach and how students receive and understand the instruction. It is the difference between the teaching process from the teacher's perspective and the learning process from the students' perspective. The observed gaps or disparities between what a teacher intends to teach and how students receive and understand the instruction can be influenced by five factors:

1. According to Yuan Anisa et al. (2023), effective communication is crucial in conveying mathematical concepts to students. Teachers may face challenges in finding the most appropriate teaching methods and using language that students can understand. Factors such as the use of technical terminology or ineffective explanations can hinder students' reception of new information.
2. Individual differences among students, including learning styles, abilities, and prior knowledge, contribute to the gap. Teachers need to be aware of these differences and employ instructional strategies that cater to various learning needs (Cagape et al., 2023). Adapting teaching methods to accommodate diverse learners can help bridge the gap between teacher intent and student understanding.
3. Student engagement and attention during lessons play a significant role in the learning process (Pedler et al., 2020), whereas, distractions, lack of interest, or disengagement can impede students' comprehension and retention of the information. Teachers should strive to create a stimulating and engaging learning environment to enhance students' receptiveness to instruction.
4. The cognitive load experienced by students is another factor that can contribute to the gap between teacher intent and student understanding. Hembree (1992) stated that

if the complexity and volume of information presented by the teacher exceed students' cognitive capacity, it can lead to difficulties in comprehension and retention. Teachers should consider the cognitive load of their students and present concepts in a manner that aligns with their cognitive abilities.

5. Students' prior knowledge and background also significantly impact their reception of new information. Especially after the COVID-19 pandemic, potential gaps in foundational knowledge or lack of necessary prerequisites may hinder students' understanding and application of the content being taught. Teachers should be aware of these gaps and provide appropriate support and scaffolding to bridge them (Alreshidi, 2023).

In conclusion, to address the gaps between teacher intent and student understanding, it is essential for teachers to focus on effective communication, cater to individual differences, foster student engagement, manage cognitive load, and consider students' prior knowledge and background. By addressing these factors, teachers can enhance the learning experience and promote better alignment between teacher intent and student reception of instruction.

1.6 How could SBI help closing the gap in mathematics education

SBI is a promising approach for addressing the learning gaps in mathematics, particularly for students with learning disabilities (LD) or mathematics difficulties, since SBI can help students connect with prior knowledge, represent the situation described in the problem using diagrams, breaking down complex problems into smaller, more manageable parts, these actions can reduce the burden on working memory and improve understanding of the problem, thus improve their problem-solving performance (Jitendra & Star, 2011; Peltier et al., 2020).

To narrow the gap between students' reception and teachers' teaching, it is crucial for educators to dedicate instructional time and apply the schema-based instruction (SBI) strategy with the Four-Step SBI Strategy Checklist (FOPS). By incorporating the following practices, teachers can enhance the learning experience and promote better alignment between teacher intent and student understanding, to:

1. Provide clear explanations and instructions by being consistent with the steps of FOPS,
2. Apply visual aids (diagrams) and demonstrations to enhance understanding,
3. Assess students' prior knowledge and addressing any gaps before introducing new material,
4. Actively engage students by interacting with them through each step of FOPS,
5. Check students' understanding with FOPS,
6. Provide students with timely feedback to address misconceptions.

By implementing these practices and narrowing the gap between students' reception and teachers' teaching using SBI with FOPS, educators can create more effective learning experiences. This approach ensures a concrete progression in learning and promotes a deeper understanding of mathematical concepts among students.

Previous research of SBI has established that students' problem-solving accuracy could be improved after SBI (Hughes & Cuevas, 2020). According to National Council of Teachers of Mathematics (2000), students' problem-solving accuracy could be measured by procedural fluency. Procedural fluency is the ability to carry out mathematical procedures accurately, efficiently, and flexibly. It involves mastery of computational algorithms, formulas, and problem-solving strategies. Procedural fluency enables students to perform calculations proficiently and effectively solve mathematical problems. In relation to each other, SBI can be used as an instructional approach to develop problem-solving skills, including procedural fluency, when solving various types of problems, such as percentages problems. SBI provides students with a cognitive schema to approach and solve problems effectively. When students have more problem-solving practice, their procedural knowledge and fluency, as well as problem- solving skills are likely to be improved, positively affecting their overall arithmetic growth and success (Corral et al.,2019).

Percentages problems involve calculations and comparisons with percentages, such as finding percentages, calculating percentage change, or solving problems that involve proportions and ratios. These problems require both procedural fluency and conceptual understanding to accurately interpret and solve the given tasks. Percentages is a topic in junior secondary mathematics curricula that students often found difficult, teacher applying SBI strategy with FOPS could help students develop conceptual understanding, improve procedural fluency and lead to problem solving. While most research on SBI has primarily been conducted in the context of primary education, its relevance for secondary students, particularly those in Form One, is equally important. Adolescents in Form One are at a critical developmental stage where they are transitioning from concrete to more abstract thinking. Therefore, exploring the application of SBI in secondary education, specifically with Form One students, can provide valuable insights into the effectiveness of SBI and contribute to the development of instructional strategies tailored to students' learning needs.

1.7 Research Questions

The study is specifically guided by the following research questions:

1. What are the impacts of schema-based instruction (SBI) on students' procedural fluency in solving percentage problems?

2. Does the effectiveness of SBI on procedural fluency with percentage problems vary across different students (i.e., low-achieving, average, and high-achieving students)?
3. What are the effects of SBI on students' transfer and retention of procedural fluency in percentage problem solving?

1.8 Purpose and Design

The purpose of this dissertation titled "Effectiveness of schema-based instruction (SBI) on Procedural Fluency with Percentage Problems" is to examine the impact of Schema-Based Instruction (SBI) on students' procedural fluency in solving percentage problems. Experimental intervention study is adopted to explore the effectiveness of schema-based instruction (SBI) strategies on procedural fluency. Details about the methodology will be presented in Chapter 3. The experimental intervention study was conducted during teaching the topic of percentages to a class of mixed- abilities (i.e., low-achieving, average, and high-achieving students) Form One students. Students in this study completed common practice problems involving different schemas, such as the total, difference, change, equal groups, comparison, ratios/proportions.

The investigation consisted of 40 minutes every day in the researcher's Form One mathematics class with 12 lessons in two weeks period. Students completed pre-/post-tests during this study. Students must justify or explain their answers to practice and test questions to show their procedural fluency, fostering their development in problem solving schemas, procedural fluency, and mathematical mindset. By using descriptive statistics of these pre- and post-tests data, this study evaluates the overall effectiveness of SBI on students' procedural fluency.

1.9 Conclusion

In conclusion, this chapter has provided an overview of the research topic of the study.

The current situations with students and with teaching were identified, emphasizing the need for instructional strategies that can enhance students' problem-solving abilities. The rationale for conducting this research has been established, emphasizing the potential benefits of SBI in improving students' performance in problem solving, particularly procedural fluency. By addressing the research gap and contributing to the existing body of knowledge, this study aims to provide valuable insights about the effectiveness of using SBI in mathematical problem solving, which is measured by procedural fluency.

A brief overview of the subsequent chapters as follows: Chapter 1 Introduction, Chapter 2 Literature Review, Chapter 3 Methodology, Chapter 4 Results, Chapter 5 Discussion, Chapter 6 Conclusion, providing a comprehensive analysis of the findings and their implications. Overall, this research endeavours to contribute to the field of mathematics education and provide practical recommendations for improving instructional practices related to procedural fluency.

Chapter 2 Literature Review

The literature review chapter aims to provide a comprehensive overview of the existing research on the schema-based instruction (SBI) and procedural fluency. This chapter begins by discussing the theoretical foundations of schema theory and its application in mathematics education. The review then delves into previous studies that have examined SBI and its impact on problem-solving, with a specific focus on procedural fluency in mathematics. The synthesis of these studies will shed light on the current state of knowledge in this area, identify any research gaps, and establish the rationale for conducting the present study. Furthermore, this chapter will explore the underlying cognitive processes involved in solving problems and highlight the potential benefits of SBI in enhancing students' procedural fluency. By critically examining the existing literature, this chapter will provide a solid foundation for the subsequent chapters of this dissertation, including the methodology, results, and discussion sections.

2.1 Conceptualization of SBI

Research has shed light on the importance of schemas in mathematics teaching and learning for long. Morales et al. (1985) found that older children demonstrated sorting patterns consistent with a refined schema theory when solving mathematics word problems. While not solely focused on schema acquisition, Hembree (1992) examined Piaget's theory of cognitive development and its implications for mathematics learning. It discussed the development of cognitive structures (schemas) and their role in problem-solving and conceptual understanding. Similarly, Chandler and Sweller (1991) found that instructional methods that reduce extraneous cognitive load and promote the efficient use of working memory led to better learning outcomes, they also established the relevance of schema acquisition in learning mathematics and techniques for detecting schemas in mathematics learners, which laid the foundation for SBI.

Mayer (2002) examined the distinction between rote learning and meaningful learning in mathematics. He discussed the role of schema construction in promoting meaningful learning and emphasized the importance of helping learners connect new mathematical concepts to existing schemas. Moreover, Powell et al. (2008) emphasized the cognitive importance of problem-solving schemas in mathematics learning, highlighting how challenging mathematical problems can stimulate creativity, encourage collaboration, and support the formation of problem-solving schemas.

2.2 Problem solving and Conceptual understanding

Problem solving in mathematics had long been recognized as a crucial goal of mathematics instruction, yet it remained a complex and challenging area to understand and teach (Kilpatrick, 1969). Teaching problem solving in mathematics required a broad knowledge base that went beyond general problem-solving ability (Chapman, 2015). This knowledge included an understanding of how problem solving was learned and how it could be effectively taught (Kilpatrick, 1969). Research on problem solving in mathematics has been ongoing for decades, with significant advances in understanding the affective, cognitive, and metacognitive aspects of problem solving (Lester & Cai, 2016). Dossey (2017) suggested that problem solving in mathematics was a multifaceted and dynamic process that required conceptual understanding, problem-solving strategies, and metacognitive skills.

NASEM defined conceptual understanding as comprehension of mathematical concepts, operations, and relations (Kilpatrick et al., 2001). Niemi (1996) emphasized the significance of representations, problem solutions, justifications, and explanations in assessing conceptual understanding in mathematics. Fraivillig et al. (1999) presented a pedagogical framework to support children's development of conceptual understanding in mathematics, emphasizing eliciting solution methods, supporting conceptual understanding, and extending mathematical thinking. For students with learning difficulties and intellectual disabilities, visual aids, repetition, and strategy flexibility were emphasized to promote conceptual understanding and led to successful problem solving. Moreover, secondary teachers might have varying levels of understanding and beliefs about mathematical problem solving, particularly in terms of problem-solving strategies and the meaning of problems themselves (Siswono et al., 2016). Therefore, current research continued to explore the best practices for teaching and learning problem solving in mathematics, problem solving remains a central focus in mathematics education (Koichu, 2014).

2.3 Effectiveness of SBI

Several studies had explored the effectiveness of SBI in enhancing mathematical problem-solving skills among students. Fuchs et al. (2004) conducted a study with third-grade students and found that SBI, when combined with practice in sorting word problems into schemas, that positively impacted mathematical problem-solving abilities of students. Xin et al. (2005) compared SBI to general strategy instruction (GSI) and discovered that the SBI group outperformed the GSI group on various assessments.

Jitendra et al. (2009), students with learning difficulties who received SBI instruction outperformed students in a control group on a problem-solving test, both at posttest and on a delayed posttest administered four months later. The study also found that SBI had a large impact on students' ratio and proportion problem-solving, with an average percent improvement from pretest to posttest of 24% for SBI students compared to only 2% improvement for the control students.

Jitendra et al. (2011) further emphasized the role of SBI in meeting the needs of students with learning disabilities in inclusive mathematics classrooms. They highlighted how SBI introduced students to multiple problem-solving strategies and encourages the selection of appropriate methods. Furthermore, according to Jitendra et al. (2014), SBI was particularly effective at improving students' performance on items related to percentage, and that students with mathematics difficulties significantly outperformed students with more severe difficulties on all measures of proportional problem-solving. In another study by Jitendra et al. (2015), a post-test that was administered immediately after SBI intervention to assess the students' mathematical problem-solving performance in proportional reasoning. The results showed that the SBI group had significantly higher marks on the post-test compared to the control group, indicating that the SBI intervention was effective in improving students' proportional reasoning skills. Further support was found in a study on the effects of a schema approach on the verbal mathematics problem-solving skills of individuals with autism spectrum disorders, highlighting the importance of schema-based interventions in improving problem-solving abilities (Kasap and Ergenekon, 2017). In addition, when students have more problem-solving practice, their procedural knowledge and fluency, as well as problem- solving skills are likely to be improved, positively affecting their overall arithmetic growth and success (Corral et al.,2019). Overall, previous research of SBI had established that students' problem-solving accuracy could be improved after SBI (Hughes & Cuevas, 2020).

2.4 Procedural Fluency

When students used a procedure which they do not understand, they were more likely to make errors and failed to notice when the answer does not make sense (Narode et al., 1993). Procedural fluency in mathematics is another crucial aspect of mathematical proficiency. National Council of Teachers of Mathematics (2000) defined procedural fluency as the skill in carrying out procedures flexibly, accurately, efficiently, and appropriately, it was suggested that once students have been taught problem-solving procedures, after practice using these procedures, students could solve unfamiliar problems (transfer). Therefore, it is essential for students to have procedural fluency in mathematical problem-solving, and procedural fluency could be used to measure students' conceptual understanding and problem-solving skills. Learning is supported when instruction on procedures and concepts is explicitly connected in ways that make sense to students and iterative (Osana & Pitsolantis, 2013; Rittle-Johnson et al., 2015). Learners who do not have enough information or skills to complete procedural stages, find it challenging to deeply understand mathematical topics or to apply those concepts to solve new problems. Whereas, when students do not have accurate conceptual understanding of a topic, they cannot perform the required procedural steps fluently, hindering their ability to connect ideas and remember and use a variety of problem-solving approaches. Students must have solid foundation in procedural fluency and conceptual understanding in order to progress to other grade levels. (Riccomini et al., 2017).

The findings in Fuchs et al. (2009) and Asmida et al. (2018) have significant implications for mathematics education. These studies emphasize the importance of developing procedural fluency alongside conceptual understanding in mathematics teaching. By focusing on procedural fluency, students can enhance their ability to apply mathematical procedures efficiently and accurately, leading to improved problem-solving skills and a deeper understanding of mathematical concepts. This balanced approach to mathematics education can help students navigate mathematical challenges effectively and ultimately improve their overall mathematical proficiency. Therefore, integrating procedural fluency with conceptual understanding is crucial in enhancing students' mathematical learning outcomes and fostering a more comprehensive grasp of mathematical concepts. According to Clinch (2018), students enhanced their procedural fluency by being able to provide justifications for each step in problem-solving. However, prioritizing conceptual understanding over procedural fluency was imperative, as students need to comprehend the reasoning behind selecting one method over another to solve specific problems.

Different educational systems prioritized procedural fluency in different ways, Son and Senk (2010) compared the development of multiplication and division of fractions in the everyday Mathematics curriculum in the USA and the Korean mathematics curriculum, noting that while in the USA, conceptual understanding was developed first followed by procedural fluency, in Korea, they are developed simultaneously.

Significant correlations were found between students' conceptual understanding, procedural fluency, and performance in mathematics among Nigerian senior secondary school students (Awofala, 2017). Efforts to improve procedural fluency in mathematics often involve targeted interventions such as remedial tutoring. Fuchs et al. (2009) conducted a randomized control trial to assess the efficacy of remedial tutoring for 3rd graders with mathematics difficulties and found that Math Flash enhanced fluency with number combinations with transfer to procedural computation. This highlights the importance of targeted interventions in addressing procedural fluency deficits among students. Targeted interventions and instructional approaches, such as SBI, aimed at improving procedural fluency could have a significant impact on students' mathematical abilities.

2.5 Procedural Fluency and SBI

In the research of Jitendra et al. (2015), the SBI intervention to improve the proportional problem-solving abilities of students at risk for mathematics difficulties , emphasised on developing both conceptual and procedural knowledge, the findings highlighted the importance of addressing both conceptual understanding and procedural fluency within mathematics instruction.

By Osana and Pitsolantis (2013), one of the most prominent findings in the research on classroom practices that support the development of conceptual understanding and procedural fluency is the value of making explicit connections. SBI incorporates with the process of making connections, involving comprehension and generalization and even metacognitive training, which can help students develop awareness and apply effective reading strategies when solving mathematical problems (Capraro et al., 2011). Implementing a reading-enhanced problem-solving approach can be a valuable strategy for teachers to support struggling students, without the need for extensive curriculum changes.

2.6 Solving Percentages Problems

Using schemas can facilitate mathematical reasoning in word-problem instruction (Powell & Fuchs, 2018), percentages is an elementary algebra topic across upper primary and junior secondary, which involves word-problems. Students may find it difficult to investigate and explore the abstract ideas, patterns, and relationships in percentages problems, thus fail to solve the problems. Research has shown that there have been difficulties surrounding the teaching of topic of percentages.

Students are often confused by the semantic meaning of the question. For example, 'out of' and 'of'. Hansen (2011) states that 'out of' represents the division operator, 20 out of 50 means 20 divided by 50, whereas 'of' represents the multiplication operator, 20% of 50 means 0.2 multiplied by 50. The teaching of the semantic meaning needs to be clear prior to teaching, so that children are confident with these terms. Another confusion is about finding a percentage or a quantity. For example, find 80% of £150 (a quantity representing money value). Students may be capable of calculating the answer of 120 but instead of writing down £120 (a quantity), they may even write down 120%. Teachers need to help students distinguish between a percentage and a percentage of a quantity.

The key in teaching percentages is the relating students' prior knowledge with fractions and decimals (Hansen, 2011). For example, students should be aware that 25% is equivalent to ¼ and 0.25, whereas 50% is equivalent to ½ and 0.5. Killen and Hindhaugh (2018) also noted that children need to continually link decimals, fractions, and percentages to their knowledge of the number system and operations that they are familiar with. However, Reys et al (2014) believed that percentages are more closely linked with ratios and proportions in mathematics. Mutually, these literatures suggest that understanding percentages requires no new concepts or skills, apart from those used in mastering fractions, decimals, ratios, and proportions. This provides foundation for using SBI in teaching the topic of percentages, where students could use their existing mental frameworks or schemas that help them recognize and solve different types of percentages problems.

2.7 Transfer and Retention

The retention of knowledge in mathematics is a crucial aspect of academic success, as demonstrated by various studies in the field. Conway et al. (1992) explored very long-term memory for knowledge acquired at school and university, highlighting the importance of retaining information over extended periods. Xiong and Beck (2014) investigated the impact of spacing and retrieval interval on mathematics skills, noting that students with weaker knowledge experienced more rapid forgetting. Lyle et al. (2019) highlighted the importance of retrieval practice and spacing in the short- and long-term retention of mathematics knowledge, advocating for increased spacing in real-world mathematics education.

Hughes and Cuevas (2020) investigated the effectiveness of SBI for solving mathematics word problems in special education, a transfer test was used to measure students' application of problem-solving to grade-level contexts. The transfer test was taken from the second-grade math textbook and had a different appearance than the pre-test and post-test materials used during instruction. While students demonstrated increased strategy use and problem-solving accuracy during SBI instruction, these skills did not carry over to posttest and transfer test results.

2.8 Mathematical Mindset

Mathematical mindset is a concept that has been explored in various studies to understand its impact on students' potential, motivation, and achievement in mathematics. Mathematics educators should encourage students to go beyond repetitive drills and memorization in order to uncover the fundamental concepts, as noted by Berger (2017). A growth mindset, as described by Sun (2018), emphasizes the belief that intelligence and abilities can be developed through effort, practice, and perseverance. Students with a growth mindset view challenges as opportunities for growth and are more likely to embrace and overcome obstacles in their mathematical learning. They are motivated to seek mastery and intellectual comprehension, which can positively influence both procedural fluency and conceptual understanding. In addition, Daly et al. (2019) provided evidence that mathematical mindset theory can increase student motivation in mathematics, even influencing brain activity during mathematical problem-solving. Furthermore, Boaler et al. (2021) highlighted the transformative impact of a mathematical mindset, showing that a mathematical mindset approach contributing to the development of both procedural fluency and conceptual understanding, significantly improves students' mathematical achievement, and ultimately changes their beliefs about learning.

Mathematical knowledge of students is scaffolded, and students need to apply previous knowledge frequently, SBI is a promising instruction method to help students develop problem solving, conceptual understanding, procedural fluency, transfer, retention, and a mathematical mindset. However, there is a lack of research in Macau and in other places regarding the use of SBI to enhance mathematics knowledge, and more in particular, the procedural fluency.

2.9 Research Questions

The study is specifically guided by the following research questions:

1. What are the impacts of schema-based instruction (SBI) on students' procedural fluency in solving percentage problems?

2. Does the effectiveness of SBI on procedural fluency with percentage problems vary across different students (i.e., low-achieving, average, and high-achieving students)?
3. What are the effects of SBI on students' transfer and retention of procedural fluency in percentage problem solving?

2.10 Conclusion

When attempting to solve percentages problems, students in junior secondary school sometimes fail to understand the question conceptually and/or execute procedural problem-solving stages. This consequently affects children's proficiency in mathematics and their ability to advance to higher level of Mathematics classes. It is necessary to employ effective instructional strategies, such as SBI to assist these students in overcoming their areas of weakness and meet the diverse needs of learners. Overall, the literature suggests that incorporating SBI in mathematics can enhance students' conceptual understanding and problem-solving abilities, particularly for those with learning difficulties or disabilities. However, previous studies of SBI have not dealt with the effectiveness of SBI on procedural fluency. The purpose of this study is to explore the effectiveness of SBI on procedural fluency. This is experimental intervention study to be conducted during teaching the topic of percentages to a class of mixed- abilities (i.e., low-achieving, average, and high-achieving students) Form One students. As part of the SBI intervention, practice exercises (homework and classwork) that promote a mathematical mindset are given to each participant. Students must justify and explain their responses to demonstrate their conceptual understanding and procedural fluency, including SBI schema diagrams.

Chapter 3 Methodology

This study utilizes an experimental intervention study approach to examine the effectiveness of schema-based instruction (SBI) in promoting procedural fluency in solving percentage problems among students categorized into three groups: low-achieving, average, and high-achieving. Data collection methods focus on quantitative measures, including pre- and post-tests to measure students' procedural fluency. The focus on quantitative data collection allows for a systematic evaluation of the impact of SBI on students' procedural fluency with percentage problems, providing measurable evidence of any improvements. The chosen experimental intervention study methodology is appropriate for this study as it allows for the implementation and evaluation of SBI interventions in a real classroom context. The researcher drew students from his/her own class to ensure a strong connection between the research and the instructional context, enhancing the relevance and applicability of the findings.

3.1 Research Questions

The study is specifically guided by the following research questions:

1. What are the impacts of schema-based instruction (SBI) on students' procedural fluency in solving percentage problems?
2. Does the effectiveness of SBI on procedural fluency with percentage problems vary across different students (i.e., low-achieving, average, and high-achieving students)?
3. What are the effects of SBI on students' transfer and retention of procedural fluency in percentage problem solving?

3.2 Research Design

In this research, an instructional intervention was implemented to examine the effectiveness of SBI on procedural fluency with percentages problems, namely, an SBI intervention. The study was conducted at an English-medium, girls-only, inclusive-education secondary school in Macau, China. The thirty-one students that participated in the study were the students from the researcher's class. The researcher invited students from his/her own class to be the participants who were about to learn the topic of percentages. Purpose sampling and convenience sampling may introduce selection bias, as participants were not systematically selected from the larger population. To consider the appropriateness and representation of the sample, the researcher applied subgroup analysis, allowing for a more nuanced understanding of the effects of the SBI intervention across different achievement levels.

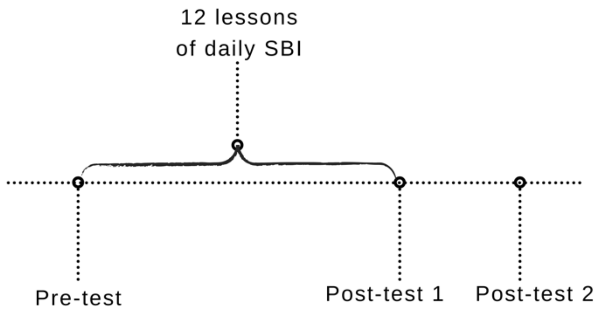
A single group participant setting was the most practical option due to limited resources, time constraints, and access to participants. The setting provided an opportunity to gain an in-depth understanding and valuable insights of students' learning. Starting with a single group participant setting to test the effectiveness of SBI could help refine and improve the SBI intervention design before conducting larger-scale studies. This approach allowed the researcher to gather initial data, generate hypotheses, and identify areas for further investigation. The researcher explicitly communicated the objectives and procedures of the research to the participants, ensuring they had a clear understanding of the study's goals and procedures.

To strengthen the validity of this research within a single group participant setting, pre- and post-tests measurement was adopted to assess changes over time. This allows for within-group comparisons and enhances the internal validity of the study. The inclusion of a one-week interval between the post-test 1 and post-test 2 was implemented as a deliberate measure to minimize the temporary fluctuations or external factors that could have affected students' procedural fluency, thereby further increasing the reliability and validity of the effectiveness of SBI.

Memory consolidation, the process of strengthening and integrating newly acquired knowledge into long-term memory, occurs over time (McGaugh, 2000). By allowing a one-week interval between the post-tests to measure procedural fluency, we provide sufficient time for students to consolidate the learned procedural fluency skills with FOPS. The one-week interval also provides an opportunity to evaluate the durability and stability of students' procedural fluency in percentage problem solving beyond immediate recall. Assessing retention after a short interval helps determine if the skills learned during SBI intervention are retained over time and can be effectively applied in post-test 2. Additionally, the immediate post-test, i.e., post-test 1 may be affected by potential confounding variable such as the practice effect. Students may rely on recent practice and familiarity with the problems rather than demonstrating true retention and transfer of procedural fluency. Therefore, by conducting two post-tests after SBI, a more accurate evaluation of students' genuine retention and transfer abilities of procedural fluency can be obtained.

Furthermore, based on the pre-test results, the students were categorised into three subgroups, namely, low-achieving, average and high-achieving students. Analysis and comparison were made for each subgroup and as a whole group, enhancing understanding of the effectiveness of SBI on procedural fluency, in students with varying levels of prior knowledge.

The pre- and post-tests assessed participants' procedural fluency related to percentages problems. The pre and post-tests results were evaluated based on the correct and necessary procedural steps with correct method and concept for each question; and not about number of questions that they correctly answer out of the total number of questions. The three tests administered were graded by the researcher and



marks of pre/post-tests are converted into percentage for easier comparison.

Figure 1: SBI Intervention timeline diagram

The purpose of the pre-test in SBI is to assess students' prior knowledge and existing schemas related to the topic of percentage, which were taught previously in primary school curriculum. After establishing students' baseline procedural fluency with percentages problems, the instructor could gauge the starting point of students' understanding and identify any misconceptions or gaps in knowledge (Alreshidi, 2023). Based on the pre-test results, students will be categorized into three subgroups based on the pre-test results, namely, low-achieving, average and high-achieving students (see Appendix III for a sample of students' pre-test).

The following are the variables of study:

The independent variable in this study is the amount of SBI given by the instructor. During the study, the instructor taught 12 lessons with SBI strategies (FOPS), where students were instructed to:

F – find the problem type: Students recognize the type of problem and the problem schema (i.e., is this a change, group, or compare problem?).

O – organize the information by using the diagram: Students translate the information given in the current problem from words into a meaningful, systematic graphic representation (diagram).

P – plan to solve the problem: plan to solve the problem by recalling the action procedures taken when encountering the abovementioned problem type in the past (e.g., multiply, adding).

S – solve it: apply appropriate mathematical procedures and operations that they have learned, such as writing then solving the mathematics equation; they shall check the solution at the end.

The dependent variable in this study is the level of procedural fluency of students. Pre- and post-tests were procedural fluency tests to see how well students (low-achieving, average and high-achieving students) were employing SBI strategies to solve math problems. In additional, homework and classwork were assigned regularly so that students could practice FOPS.

During the SBI intervention, all students engaged in twelve 40-minute sessions of daily SBI lessons for two weeks. The instructor covered fundamental schemas, including the total, difference, change, equal groups, comparison, ratios/proportions, this activated the students' prior mathematical knowledge and linked them with the percentage's concepts. Students' basic skills in arithmetic and mathematical expressions, such as addition, subtraction, multiplication, and division, were also covered. Then, the instructor followed the textbook to guide students through various examples and practice questions using the SBI strategies (FOPS) (see Appendix IV for a sample of lesson plan). In order to develop procedural fluency, students were given chances to practice FOPS with percentages problem during and after lessons, through homework and classwork, each requiring them to provide all procedural steps, including any schema diagram used. Feedback from the instructor were given in a timely manner.

After the SBI intervention, two post-tests were administered to measure any changes in procedural fluency (see Appendix V for a sample of students' post-tests). The post-tests were used to measure the changes of students' procedural fluency after the implementation of SBI. They assessed the new knowledge, skills, or conceptual understanding that students have acquired through the SBI intervention.

To minimize the potential influence of a practice effect, different sets of questions were used for the pre-test and post-tests in this research. However, one of the key considerations in designing the pre- and post-tests for this study was maintaining a similar level of difficulty across the two assessments. Establishing comparable difficulty levels was an important aspect to preserve the internal validity of the study and allow for meaningful comparisons of participant performance before and after the intervention. The researcher reported followed the difficulty levels suggested by the publisher's question bank. The publisher had already labelled the questions with the specific testing objectives and indicated the perceived difficulty level of each item, ranging from easy to moderate to challenging. By leveraging this established framework, the researcher was able to curate pre- and post-tests that were well-matched in terms of the overall difficulty.

Specifically, the researcher selected items that were labelled with a similar distribution of difficulty levels for both the pre- and post-tests. This deliberate approach to aligning the difficulty levels across the two test administrations helps to ensure that any observed changes in participant performance can be more confidently attributed to the effects of the intervention, rather than being confounded by differences in test difficulty.

By using different sets of questions, the research aimed to prevent participants from simply memorizing or becoming familiar with specific question formats, which could potentially inflate their performance on subsequent assessments. This approach ensured meaningful comparisons and evaluation of the impact of SBI on students' learning outcomes since the assessments captured students' genuine procedural fluency and ability to apply percentage concepts before and after SBI, rather than their familiarity with specific question items.

Post-test 1 was administered after the last day of the SBI intervention to evaluate the immediate impact of SBI on students' procedural fluency. Post-test 2 was a delayed post-test scheduled after one week to assess the effects of SBI on students' transfer and retention of procedural fluency in percentage problem solving. The research design allowed the researcher to validate the impact of SBI on students' procedural fluency by measuring their progress from the pre-test to the post-test and delayed post-test. The researcher compared the baseline (pre-test) and the outcomes (post-tests) to assess immediate learning, evaluate transfer, retention, compare learning gains, and validate the effectiveness of SBI.

3.3 Reliability and Validity

To increase measurement reliability, Pre-test and Post-tests were used to measure the students' level of procedural fluency, meanwhile, to ensure test-retest reliability, the the researcher was able to construct pre- and post-tests that maintained a similar level of challenge for the participants, by relying on the publisher's established categorization of question difficulty. This contributes to the internal validity of the study, as it allows the researcher to more accurately assess the impact of the intervention on participant learning and skills.

Due to limited resources, the researcher was the teacher and rater, that ensured the procedural reliability, the research could assesse the fidelity of the intervention implementation to ensure it was delivered as intended across participants. Appropriate statistical analyses that align with the assumptions and requirements of the statistical tests employed ensured the statistical conclusion validity. However, as this experimental intervention study was a small-scale intervention, it had reference value for educators.

3.4 Data Collection and Analysis

Pre/post-tests were used as a data collection tool to assess students' procedural fluency knowledge before and after implementing the intervention plan, examine whether daily SBI enhanced their procedural fluency with percentages problems.

The pre and post-tests results were evaluated based on the correct and necessary procedural steps with correct method and concept for each question; and not about number of questions that they correctly answer out of the total number of questions. The three tests administered were graded by the researcher and marks of pre/post-tests are converted into percentage for easier comparison.

The post-tests marks of students were compared to their marks on the pre-test to evaluate how successfully the intervention plan was implemented. Specifically, the post-tests marks of each subgroup (namely, low-achieving, average and high-achieving students) were compared to the subgroup on the corresponding pre-test to evaluate to result within groups.

Based on the pre-test results, students were categorised into three subgroups, namely, low-achieving, average and high-achieving students. This research defined the low-achieving students to be the 8 students having the pre-test marks below the lower quartile; average students to be the 15 students having the pre-test marks between the lower and upper quartile; and high-achieving students to be the 8 students having the pre-test marks above the upper quartile.

To determine if any significant differences exist between the pre-test and post-test marks, inferential statistics, namely Wilcoxon-Test and Spearman Correlation Analysis were applied to assess different aspects of the data. The Wilcoxon-Test focuses on difference between paired observations (e.g., pre-test and post-test marks) within a group, whereas the Spearman Correlation Analysis examines the relationship between variables.

The Wilcoxon-Test, a non-parametric statistical test used to compare paired data, such as pre-test and post-tests marks, is interpreted based on the calculated test statistic, W, and p-value (Cohen, 1988). W represents the sum of the ranks assigned to the positive or negative differences between paired observations. The sign of the differences is disregarded, and only their magnitudes are considered.

The p-value is a measure of the statistical significance of the observed test statistic. It indicates the probability of obtaining the observed test statistic or a more extreme value, assuming that there is no true difference between the paired observations in the population. A small p-value (e.g., less than the conventional threshold of 0.05) suggests that the observed test statistic is statistically significant.

The following section presents the null and alternative hypotheses for the Wilcoxon-Test.

Null hypothesis	Alternative hypothesis
There is no difference between the variables Pre-test and Post-test 1	There is a difference between the variables Pre-test and Post-test 1

Null hypothesis	Alternative hypothesis
There is no difference between the variables Post-test 1 and Post-test 2	There is a difference between the variables Post-test 1 and Post-test 2

A significant result in the Wilcoxon-Test indicates that there is a statistically significant difference between the pre-test and post-tests marks within the same group of students. A significant result would suggest that there is a statistically significant change in marks from pre-test to post-test, indicating the effectiveness of the SBI in students' procedural fluency.

The Spearman Correlation Analysis, a non-parametric statistical test used to measure the strength and direction of the relationship between two variables, is interpreted based on the correlation coefficient and its significance level. The Spearman correlation coefficient ranges from -1 to 1, where:

- A value of -1 indicates a perfect negative correlation, meaning that as one variable increases, the other variable decreases in a consistent manner.
- A value of 1 indicates a perfect positive correlation, indicating that as one variable increases, the other variable also increases consistently.
- A value of 0 indicates no correlation or a very weak relationship between the variables.

The p-value indicates the statistical significance of the correlation and helps determine whether the observed correlation is likely due to chance or if it represents a true relationship between the variables. A small p-value (e.g., less than the conventional threshold of 0.05) suggests that the observed correlation is statistically significant.

The following section presents the null and alternative hypotheses for the Spearman correlation analysis.

Null hypothesis	Alternative hypothesis
There is no correlation between Pre-test and Post-test 1	There is a correlation between Pre-test and Post-test 1

Null hypothesis	Alternative hypothesis
There is no correlation between Post-test 1 and Post-test 2	There is a correlation between Post-test 1 and Post-test 2

A significant Spearman correlation indicates a strong relationship between variables, such as pre-test and post-tests marks. Researcher could interpret this as evidence of a significant association between the variables being studied, providing insights into the effectiveness of SBI on students' procedural fluency, but does not necessarily capture the specific differences between pre-test and post-test marks.

To ensure that it is comprehensive in all aspects, quantitative data analysis techniques will be utilized to compare the measures of location and spread of the pre-test and post-test marks within the group. Descriptive statistics, such as means and standard deviations, will be calculated for both the pre-test and post-test marks. The mean marks provided an indication of the central tendency or average performance, while the standard deviations provided an estimate of the variability or spread of marks within the group and subgroups.

In addition, the researcher provided and displayed the statistical data through tables and graphs.

3.5 Ethical Considerations

Since the research was taken place in school, approval from school authority had been obtained. The school authority was aware that this study would be conducted as part of the researcher's master's degree Program and that it would benefit his/her teaching practice in school.

Protection of human subjects participating in research will be assured. Participants were aware that this study would be conducted as part of the researcher's master's degree Program and that it would benefit his/her teaching practice. Students had been informed that the purpose of the study was to evaluate the overall effectiveness of SBI, rather than evaluating their individual performance.

Informed consent means that the parents of participants had been fully informed of the purpose and procedures of the study for which consent was sought and that parents had understood and agreed, in writing, to their child participating in the study. The choice to participate or withdraw at any time were outlined both, verbally and in writing (see Appendix I for a sample of the bilingual Parental Consent form).

The researcher obtained informed consent from thirty-one students' parents and ensured confidentiality and anonymity of their data. The researcher understands the importance of protecting the anonymity and rights of the individuals (students and their parents) who participated in the study. Confidentiality is protected using pseudonyms (e.g., Student 1) without using any identifying information.

The researcher obtained informed consent from the school principal prior to conducting the study (see Appendix II for a sample of the Consent Form from the School Authority). The researcher emphasized the importance of protecting the privacy and rights of the school, its staff, and the students who would be participating. The school authorities were provided with detailed information about the study's purpose, methodology, and intended use of the data, and they granted their approval based on their understanding of the research objectives and safeguards in place to protect the participants. The researcher regularly monitored students' progress and well-being throughout the study by providing support and resources to address any issues or concerns that may arise.

Furthermore, the researcher understands that to meet her ethical and moral commitments to scientific research, she must only use the data and information acquired in the research to answer the research questions.

The following actions are taken to protect privacy of individuals from whom personal information is gathered and the security of the data in general: No one may view the information on the consent forms collected, any personal identifiers obtained, or the data collected. The researcher is responsible for keeping any files or forms containing personally identifiable information secure and destroy the abovementioned data after completion of the research.

3.6 Conclusion

This experimental intervention study was carried out by the researcher who incorporates SBI into daily mathematical instructional setting to investigate the effect of SBI on procedural fluency. As part of this intervention, students must follow SBI strategies (FOPS) to improve their procedural fluency. The study used a single group participant setting, pre/post-test data were collected and analysed. The SBI intervention aimed to enhance students’ mathematical procedural abilities and determine if SBI were an effective way to do so. This study used personal information and data for research with discretion.

Chapter 4 Results

This chapter presents the findings of investigating the effectiveness of schema-based instruction (SBI) on procedural fluency with percentages problems. The study aimed to explore the impact of schema-based instructional strategies (FOPS) on students' ability to solve percentages problems accurately and efficiently with the following research questions:

1. What are the impacts of schema-based instruction (SBI) on students' procedural fluency in solving percentage problems?
2. Does the effectiveness of SBI on procedural fluency with percentage problems vary across different students (i.e., low-achieving, average, and high-achieving students)?
3. What are the effects of SBI on students' transfer and retention of procedural fluency in percentage problem solving?

Based on the pre-test results, students were categorised into three subgroups, namely, low-achieving, average and high-achieving students. This research defined the low-achieving students to be the 8 students having the pre-test marks below the lower quartile; average students to be the 15 students having the pre-test marks between the lower and upper quartile; and high-achieving students to be the 8 students having the pre-test marks above the upper quartile.

4.1 Research Question 1

What are the impacts of schema-based instruction (SBI) on students' procedural fluency in solving percentage problems?

This research investigates the effect of SBI on procedural fluency with percentages problems. The participants underwent a pre-test to assess their baseline procedural fluency with percentages problems. After the SBI intervention, two post-tests were administered to measure any changes in procedural fluency. The pre and post-tests results were evaluated based on the correct and necessary procedural steps with correct method and concept for each question; and not about number of questions that they correctly answer out of the total number of questions. The three tests administered were graded by the researcher and marks of pre/post-tests are converted into percentage for easier comparison. The results section includes descriptive data and details obtained from the Wilcoxon-Test and the Spearman Correlation Analysis.

Table 1 Descriptive Statistics

	Group of 31 students			Subgroup of 8 high-achieving students			Subgroup of 15 average students			Subgroup of 8 low-achieving students		
	Pre-test	Post-test 1	Post-test 2	Pre-test	Post-test 1	Post-test 2	Pre-test	Post-test 1	Post-test 2	Pre-test	Post-test 1	Post-test 2
Mean	58.03	72.84	73.71	79.88	92.13	93.88	60.4	75.6	76	31.75	48.38	49.25
Median	63	78	78	78.5	94	95.5	63	80	78	31	46.5	49
Mode	72	88	87	73	100	98	72	80	70	33	43	46
Sum	1799	2258	2285	639	737	751	906	1134	1140	254	387	394
Std. Deviation	19.47	20.1	18.87	6.42	9.22	5.77	10.23	13.81	12.39	5.15	11.83	5.09
Minimum	26	33	41	73	73	85	41	48	50	26	33	41
Maximum	88	100	100	88	100	100	72	93	91	39	65	57
Range	62	67	59	15	27	15	31	45	41	13	32	16
Quartile 1	40	58	53	74.5	88	90	53	66.5	70.5	27.75	41	46
Quartile 3	72.5	88	88	86.25	100	98.25	68.5	86.5	86.5	34.5	58.5	52.5
Interquartile Range	32.5	30	35	11.75	12	8.25	15.5	20	16	6.75	17.5	6.5
Skew	-0.26	-0.45	-0.31	0.22	-1.37	-0.54	-0.54	-0.73	-0.98	0.55	0.08	-0.06
Number of valid values	31	31	31	8	8	8	15	15	15	8	8	8

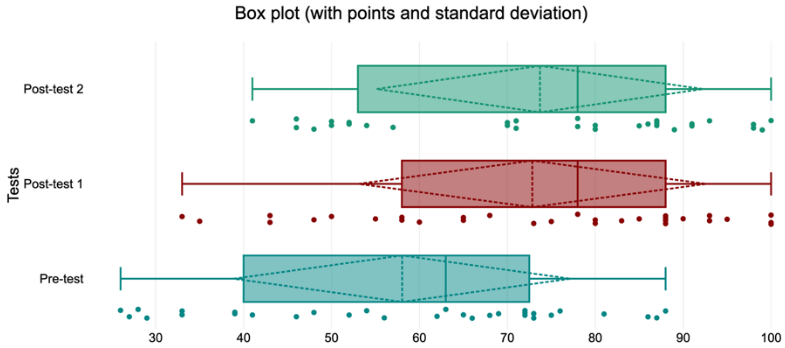


Figure 2 Box plot of marks of 31 students

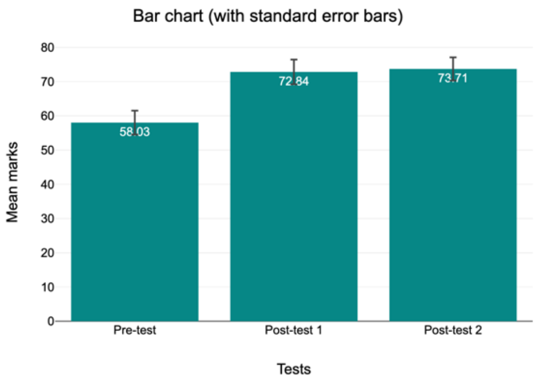


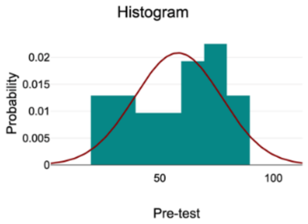
Figure 3 Bar chart of marks of 31 students

Refer to Table 1 Descriptive Statistics and Figure 2 Box plot of marks of 31 students, a significant increase (25.5%) of test marks could be seen between the mean of pre-test and post-test 1, while a relatively small increase (1.20%) of test marks could be seen between post-test 1 and post-test 2. This trend was consistent in all the three subgroups and in the whole group.

Table 2 Tests for normality

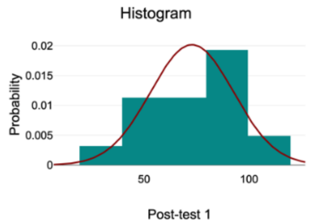
Pre-test

	Statistics	p
Kolmogorov-Smirnov	0.13	.633
Kolmogorov-Smirnov (Lilliefors Corr.)	0.13	.203
Shapiro-Wilk	0.93	.05
Anderson-Darling	0.72	.061



Post-test 1

	Statistics	p
Kolmogorov-Smirnov	0.13	.63
Kolmogorov-Smirnov (Lilliefors Corr.)	0.13	.2
Shapiro-Wilk	0.94	.068
Anderson-Darling	0.63	.098



Post-test 2

	Statistics	p
Kolmogorov-Smirnov	0.14	.492
Kolmogorov-Smirnov (Lilliefors Corr.)	0.14	.098
Shapiro-Wilk	0.91	.013
Anderson-Darling	1.05	.009

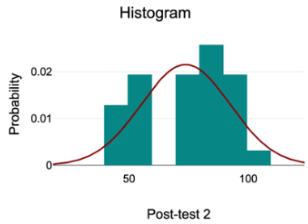


Table 2 shows the results of four different statistical tests used to assess whether the pre-test, post-test 1 and post-test 2 follows a normal distribution. A high p-value (greater than 0.05) suggests that the data obtained from the pre-test, post-test 1 and post-test 2 do not significantly deviate from normality. A prerequisite for a parametric test is that the data must be normally distributed, otherwise, non-parametric tests are used. Since the data gathered for pre-test, post-test 1 and post-test 2 were not normally distributed, this research employed Spearman Correlation Analysis and Wilcoxon-Test for inferential analysis.

4.2 Research Question 2

Does the effectiveness of SBI on procedural fluency with percentage problems vary across different students (i.e., low-achieving, average, and high-achieving students)? (See Appendix VI for details of the Spearman correlation Analysis and the Wilcoxon test)

Table 3 Results of the Spearman correlation Analysis at specified significance level of 0.05

	Pre-test and Post-test 1	Post-test 1 and Post-test 2
Group of 31 students	r(29) = 0.89, p = <.001. very high, positive correlation statistically significant	r(29) = 0.92, p = <.001. very high, positive correlation statistically significant
Subgroup of 8 high-achieving students	r(6) = 0.83, p = .01. very high, positive correlation statistically significant	r(6) = 0.84, p = .009. very high, positive correlation statistically significant
Subgroup of 15 average students	r(13) = 0.71, p = .003 very high, positive correlation statistically significant	r(13) = 0.8, p = <.001 very high, positive correlation statistically significant
Subgroup of 8 low-achieving students	r(6) = 0.16, p = .699 low, positive correlation not statistically significant	r(6) = 0.11, p = .798 low, positive correlation not statistically significant

Refer to Table 3 Results of the Spearman correlation Analysis at specified significance level of 0.05, when considering the group of 31 students, the subgroup of 8 high-achieving students and the subgroup of 15 average students, the high correlation coefficient indicates that as marks on the Pre-test increase, marks on Post-test 1 also tend to increase. Moreover, the statistically significant p-value suggests that this relationship is unlikely to be due to random chance and is likely to hold true in the larger population. This finding implies that the Pre-test can be considered a reliable predictor of performance on Post-test 1, and the two assessments are positively related.

When considering the subgroup of 8 low-achieving students, p-value suggests that the observed correlation coefficient could have occurred by chance alone in the sample of 8 participants, which means there is not enough evidence to conclude there is a meaningful relationship or difference between Pre-test and Post-test 1.

Table 4 Results of Wilcoxon signed-rank test at specified significance level of 0.05

	Pre-test and Post-test 1	Post-test 1 and Post-test 2
Group of 31 students	W = 0, p = <.001. statistically significant different populations	W = 202, p = .737 not statistically significant same population
Subgroup of 8 high-achieving students	W = 0, p = .018 statistically significant different populations	W = 10, p = .496 not statistically significant same population
Subgroup of 15 average students	W = 0, p = .001 statistically significant different populations	W = 49.5, p = .85 not statistically significant same population
Subgroup of 8 low-achieving students	W = 0, p = .012 statistically significant different populations	W = 17.5, p = .944 not statistically significant same population

Refer to Table 4 Results of Wilcoxon signed-rank test at specified significance level of 0.05, between Pre-test and Post-test 1, the test statistic (W) of 0 and the p-value suggested that the likelihood of obtaining such a large difference by chance alone is very low. In simpler terms, the p-value were below the specified significance level of 0.05, indicating that the observed difference is unlikely to have occurred randomly.

Therefore, the null hypothesis, which states that there is no difference between the two groups, is rejected. This means that there is evidence to suggest that there is a meaningful difference between the Pre-test and Post-test 1. The abovementioned trend in Wilcoxon signed-rank tests were consistent in all the three subgroups and in the whole group.

4.3 Research Question 3

What are the effects of SBI on students' transfer and retention of procedural fluency in percentage problem solving?

Refer to Table 3 Results of the Spearman correlation Analysis at specified significance level of 0.05, the high correlation coefficient indicates that as marks on the Post-test 1 increase, marks on Post-test 2 also tend to increase, i.e., Post-test 1 can be considered a reliable predictor of performance on Post-test 2, and the two assessments are positively related.

When considering the subgroup of 8 low-achieving students, p-value suggests that the observed correlation coefficient could have occurred by chance alone in the sample of 8 participants, which means there is not enough evidence to conclude there is a meaningful relationship or difference between Post-test 1 and Post-test 2.

Refer to Table 4 Results of Wilcoxon signed-rank test at specified significance level of 0.05, between Post-test 1 and Post-test 2, the test statistic (W) and the p-value suggest that the likelihood of obtaining such a difference by chance alone is high. In simpler terms, the p-values were above the specified significance level of 0.05, indicating that the observed difference between the groups is likely to have occurred by chance. Therefore, the null hypothesis, which states that there is no difference between the two groups, is not rejected. This suggests that there is no substantial evidence to support the claim that there is a meaningful difference between the Post-test 1 and Post-test 2. The abovementioned trend in Wilcoxon signed-rank tests were consistent in all the three subgroups and in the whole group.

4.4 Conclusion

The results of this study demonstrate the positive impacts of schema-based instruction (SBI) on students' problem-solving strategies and procedural fluency in solving percentage problems. The implementation of SBI led to improvements in students' understanding and application of problem-solving strategies, resulting in increased efficiency and overall procedural fluency. Furthermore, the effectiveness of SBI on procedural fluency with percentage problems was found to vary across different students, including low-achieving, average, and high-achieving students. While some students experienced substantial gains in procedural fluency, others showed more modest improvements. Importantly, SBI exhibited positive effects on students' transfer and retention of procedural fluency in percentage problem solving. By providing students with a structured framework and problem-solving strategies, SBI enhanced their ability to apply these skills to new or unfamiliar problem-solving situations. The use of schemas and organized approaches also contributed to better retention of procedural fluency over time, ensuring consistent application of skills even after a week.

Chapter 5 Discussion and Implications

The previous chapter presented the results of the study, highlighting the impacts of schema-based instruction (SBI) on students' problem-solving strategies and procedural fluency in solving percentage problems. In this chapter, the discussion section aims to provide a comprehensive analysis and interpretation of the study's results, considering each of the research questions outlined. We will examine the key findings in relation to existing literature and theories, shedding light on the significance of SBI in enhancing students' problem-solving abilities and procedural fluency in the domain of percentage problems. Furthermore, we will consider the broader implications of the study's findings for mathematics education to contribute to the ongoing dialogue on effective instructional approaches in mathematics education and inspire further research in this field.

5.1 Discussion

5.1.1 Research Question 1

What are the impacts of schema-based instruction (SBI) on students' procedural fluency in solving percentage problems?

The results of the descriptive post-test data indicated that students who received SBI demonstrated higher level of procedural fluency and achieved better results compared to their performance in the pre-test. By utilizing schemas and applying the instructed techniques with FOPS, students were able to approach percentage problems more systematically and efficiently, SBI facilitated students' conceptual understanding, improving the overall procedural fluency. These findings align with previous research (Fuchs et al.,2004; Jitendra et al., 2014) that highlights the effectiveness of SBI in enhancing problem-solving skills and mathematical performance.

A significant Wilcoxon signed-rank test result indicated a significant difference in pre-test and post-test 1, suggesting the effectiveness of schema-based instruction (SBI), while the Spearman correlation analysis indicated a strong relationship between pre-test and post-test 1. A high correlation between pre-test and post-test 1 does not necessarily negate the effectiveness of SBI (Jennings & Cribbie, 2021). It suggested that the SBI intervention had a positive effect on student performance. Students who performed well on the pre-test tended to continue performing well on the post-test, and vice versa. The intervention may have helped maintain or reinforce existing knowledge and skills.

5.1.2 Research Question 2

Does the effectiveness of SBI on procedural fluency with percentage problems vary across different students (i.e., low-achieving, average, and high-achieving students)? After the SBI intervention, post-test 1 was conducted to assess any changes in procedural fluency among the different student subgroups. The observations of mean test mark from the pre/post tests revealed variations in the effectiveness of SBI across the subgroups.

The group of low-achieving students showed (52.4%) the most significant improvement in their procedural fluency compared to the other subgroups. The structured nature of SBI, with its emphasis on schema development and procedural knowledge, may have provided these students with a sense of security and confidence in their problem-solving abilities (Hughes & Cuevas, 2020). This could have helped these students develop a clearer understanding of the problem-solving process and build confidence in their abilities, led to improved performance and procedural fluency, fostering a mathematical mindset.

The group of average students (25.2%) demonstrated relatively less improvement in their procedural fluency after receiving SBI. The explicit instruction and the use of schemas likely facilitated their ability to link prior knowledge and consolidate their understanding, resulting in improved procedural fluency. The average students may have developed sufficient cognitive capacity to handle moderately complex instructional tasks, making them more receptive to SBI that challenges them without overwhelming their cognitive load. (van Merriënboer & Sweller, 2005), enabling them to apply the FOPS strategies effectively and fostering a mathematical mindset.
The group of high-achieving students (15.3%) showed the least improvement in their procedural fluency. This finding could be attributed to their already high level of fluency before the SBI intervention. As they were already proficient in percentage problem solving, the impact of the SBI intervention may have been less noticeable compared to the other subgroups. However, it is important to note that even though their improvement may have been comparatively smaller, it does not diminish the potential benefits of SBI for high-achieving students (Conley, n.d.), SBI can still provide them with additional opportunities for deepening their understanding, refining their problem-solving strategies, and enhancing their procedural fluency.
Indeed, the focus of the effectiveness of SBI should be on the incremental growth and continued development of students' skills and understanding, rather than solely on the magnitude of improvement. Understanding the variations between the three subgroups is crucial for tailoring instructional approaches to meet the diverse needs of students and provide targeted support for those who may benefit the most from SBI. Low-achieving students, who might require additional support, can benefit from targeted interventions that provide more intensive and individualized instruction. This includes providing extra practice opportunities, additional scaffolding, and personalized

feedback. Average-achieving students can benefit from a balanced approach that combines targeted instruction with opportunities for independent practice and consolidation. High-achieving students, while still benefiting from SBI, may require more opportunities for extension and enrichment to challenge their existing skills and promote further growth. To ensure effective implementation of SBI across different student groups, regular assessment and progress monitoring are essential to help identify students' strengths, weaknesses, and areas requiring additional support.

5.1.3 Research Question 3

What are the effects of SBI on students' transfer and retention of procedural fluency in percentage problem solving?

Spearman Correlation Analysis was utilized to assess the relationship between the marks obtained in post-test 1 and post-test 2 for the whole student group and each subgroup. In general, considering the thirty-one students, the high, positive correlations observed indicate a strong association between the performances in the two post-tests. This finding suggests that the students' procedural fluency remained relatively stable over the one-week interval between the tests. The strong correlation implies that most students who performed well in post-test 1 also performed well in post-test 2, indicating the transfer and retention of procedural fluency.

The results of this study provide compelling evidence to support the effectiveness of SBI in enhancing students' transfer and retention of procedural fluency in percentage problem solving. In contrast to the findings of Hughes and Cuevas (2020), who reported an increase in strategy use and problem-solving accuracy during SBI instruction but limited carryover to posttest and transfer test results. This study reveals that students who received SBI instruction demonstrated an enhanced ability to apply the learned strategies and procedures (FOPS) to new and unfamiliar percentage problem-solving tasks. This suggests that SBI fosters a deeper understanding of the underlying concepts and principles, enabling students to transfer their procedural fluency skills to various problem-solving contexts. The research findings indicate that SBI contributes to the retention of procedural fluency in percentage problem solving over time. After SBI instruction, in post-test 2 after one-week, students displayed retention of the strategies and procedures (FOPS) taught during the intervention, there was a high level of consistency and stability in students' procedural fluency over the one-week interval. These results suggest that the explicit schemas and problem-solving frameworks provided by SBI play a crucial role in facilitating the transfer of knowledge and promoting retention of procedural fluency.

5.2 Implications

Form One students face a common challenge: understanding the percentages problem and completing procedural steps when solving percentages problems. This study aimed to address this issue by implementing daily SBI as an intervention plan. The results showed that the SBI improved students' procedural problem-solving ability after twelve 40-minute Mathematics lesson with SBI.

While the focus of this study was on how SBI might help students in a specific class improve procedural fluency, the findings have significant implications for educational practice.

5.2.1 Implications for Research Question 1

What are the impacts of schema-based instruction (SBI) on students’ procedural fluency in solving percentage problems?

The results of this study provide evidence that SBI is an effective instructional approach for improving students' procedural fluency in solving percentage problems. Educators can incorporate SBI techniques, such as explicitly teaching problem-solving strategies (FOPS), providing structured practice opportunities, and fostering students' schema development, into their instruction. By implementing SBI, teachers can enhance students' ability to efficiently and accurately solve problems, leading to improved mathematical proficiency.

5.2.2 Implications for Research Question 2

Does the effectiveness of SBI on procedural fluency with percentage problems vary across different students (i.e., low-achieving, average, and high-achieving students)?

This research highlights the importance of utilizing appropriate assessment measures to monitor students' procedural fluency with percentages problems. Educators should consider incorporating formative assessments that align with the principles of SBI, such as providing immediate feedback, identifying students' misconceptions, and monitoring progress over time. By utilizing effective assessment and feedback strategies, teachers can identify areas for improvement, tailor instruction to individual student needs, and track students' growth in procedural fluency.

5.2.3 Implications for Research Question 3

What are the effects of SBI on students' transfer and retention of procedural fluency in percentage problem solving?

The findings of this study emphasize the importance of including explicit instruction in procedural fluency within the mathematics curriculum, specifically focusing on percentage problems. Curriculum designers and policymakers should consider integrating SBI principles into the curriculum to ensure that students receive systematic and scaffolded instruction in solving percentage problems. By aligning curriculum objectives with the effective strategies identified in this study, educators can better equip students with the necessary skills for success in working with percentages.

To effectively implement SBI in the classroom, ongoing professional development for teachers is essential. Educators should be provided with training and support to enhance their understanding and implementation of SBI techniques specifically tailored to problem-solving. Professional development programs can focus on providing teachers with the necessary knowledge and skills to effectively deliver SBI lessons, differentiate instruction, and monitor students' progress. By investing in teacher professional development, educational institutions can ensure the successful implementation of SBI and promote students' procedural fluency.

5.3 Recommendations for Further Investigations

It is crucial to acknowledge that further research is needed to explore the long-term effects of SBI on students' procedural fluency and generalize the findings to diverse populations. Additionally, adapting SBI to other mathematical concepts and exploring its integration with other instructional approaches can be areas for future investigation.

1. Replication Studies: Conducting replication studies with a similar methodology but in different educational settings, with diverse student populations, and across various grade levels would enhance the generalizability of the effectiveness of SBI. Replicating the study with multiple groups and control conditions would provide additional evidence regarding the effectiveness of SBI and help validate the results.

2. Long-Term Effects: Investigate the long-term effects of SBI on students' transfer and retention of procedural fluency. Extending the intervention period and implementing follow-up assessments at different intervals would provide valuable insights into the sustainability of the observed effects. Longitudinal studies tracking participants' progress over an extended period could shed light on the long-term benefits of SBI.

3. Comparison with Alternative Instructional Approaches: Compare the effectiveness of SBI with other instructional approaches targeting procedural fluency in percentage problem solving. Implementing control groups receiving different intervention strategies, such as direct instruction or problem-based learning, would allow for a direct comparison and identification of the most effective instructional methods.

4. Professional Development and Teacher Practices: Explore the impact of professional development programs for teachers on the implementation of SBI. Investigate how teachers' knowledge, beliefs, and instructional practices related to procedural fluency influence student outcomes. Understanding the role of teachers and their professional development can inform effective implementation strategies and promote sustainable improvements in instructional practices.

5. Meta-analysis and Systematic Reviews: Conduct meta-analyses or systematic reviews that synthesize the findings of multiple studies on SBI and procedural fluency. These comprehensive reviews would provide a more robust understanding of the effects of SBI across different contexts, student populations, and instructional variations. Meta-analyses can also help identify potential moderators or factors that influence the effectiveness of SBI.

5.4 Conclusion

The discussion and implications presented in this chapter shed light on the significant findings of the study and their broader implications for mathematics education. Through an in-depth analysis of the impacts of schema-based instruction (SBI) on students' problem-solving strategies and procedural fluency in solving percentage problems, this research contributes to the existing body of knowledge in the field.

The findings indicate that SBI has a positive effect on students' problem-solving abilities and procedural fluency in percentage problem solving. Despite the potential limitations suggested by high correlations between pre-test and post-test scores, the study emphasizes that the effectiveness of SBI should not be solely determined by these correlation measures. Instead, it is crucial to consider the qualitative changes in problem-solving approaches, the development of procedural fluency, and the ability to transfer learned skills to new contexts.

Furthermore, the variations in the effectiveness of SBI across different student groups, including low-achieving, average, and high-achieving students, highlight the importance of personalized and targeted instructional approaches. By recognizing the diverse needs and abilities of students, educators can tailor SBI to cater to specific student populations, ensuring equitable access to effective instructional practices.

The study also underscores the significance of SBI in promoting the transfer and retention of procedural fluency in percentage problem solving. The development of schemas and organized problem-solving strategies through SBI enables students to apply their skills beyond the immediate context and retain them over time.

These findings have broader implications for mathematics education. Educators and curriculum developers can incorporate schema-based instruction into their instructional practices to enhance students' problem-solving abilities and procedural fluency.

Chapter 6 Conclusion

6.1 Summary of Key Findings

This study aimed to examine the effects of schema-based instruction (SBI) on procedural fluency in percentage problem solving. The research involved pre-test/post-test observations, subgroup analysis, and statistical analyses using descriptive statistics, Spearman Correlation Analysis and the Wilcoxon-Test. To minimize the potential influence of a practice effect, different sets of questions were used for the pre-test and post-tests in this research. And the one-week interval between the post-test 1 and post-test 2 was implemented as a deliberate measure to minimize the potential confounding effects of short-term influences, allowing the researcher to investigate the transfer and retention of students' procedural fluency after SBI.

The implementation of SBI resulted in improved problem-solving performance, as evidenced by the higher mean marks in the post-tests compared to the pre-test. The high, positive correlations observed between post-test 1 and post-test 2 indicate stability and consistency in students' procedural fluency over the one-week interval, suggesting a high level of retention of the skills learned through SBI. However, when considering the Wilcoxon-Test, the observed changes in procedural fluency between post-test 1 and post-test 2 were relatively small. This could be attributed to factors such as the short time interval between the post-tests, potential ceiling effects, or individual differences within the student group. Subgroup analysis revealed variations in the effectiveness of SBI across different student groups. Low-achieving students showed the most improvement in their procedural fluency, possibly due to the explicit instruction and the opportunity to link prior knowledge. Average students demonstrated the less improvement, benefiting from the independent practice and consolidation. High-achieving students, who already possessed high levels of fluency, showed relatively smaller improvement, indicating a potential ceiling effect. These findings highlight the importance of considering individual differences and tailoring instructional approaches to meet the specific needs of different student subgroups. Overall, the findings provide valuable insights into the potential benefits of SBI in enhancing students' procedural fluency, and the transfer and retention of procedural fluency in percentage problem solving.

6.2 Implications and Significance

Improvements were observed in students' procedural fluency by comparing the pre-test and post-test results, supporting the effectiveness of SBI in improving students' procedural fluency in percentage problem solving. Incorporating SBI techniques (FOPS), providing practice opportunities with FOPS, and fostering students' mathematical schema development, educators can enhance students' ability to solve percentage problems efficiently and accurately.

By conducting subgroup analysis, the study showed varying levels of improvement on procedural fluency across different students (i.e., low-achieving, average, and high-achieving students). The study shed lights on the importance of monitoring students' procedural fluency to identify areas for improvement, tailor instruction to individual student needs, and track growth in procedural fluency among students of different achievement levels.

By integrating SBI principles into the curriculum, students receive systematic and scaffolded instruction, that help to close the gap between teaching and learning, the results of post-test 2 showed that the level of procedural fluency was consistent to post-test 1, showing transfer and retention of procedural fluency.

The implementation of schema-based instruction (SBI) aims to enhance students' procedural fluency by providing them with explicit instruction and practice on different types of schemas and problem-solving strategies. By organizing problem types into schemas and utilizing diagrams, SBI helps students develop a deeper understanding of mathematical concepts and problem-solving procedures. This approach not only improves students' ability to solve word problems but also enhances their procedural fluency by teaching them how to apply mathematical procedures accurately and efficiently in various problem-solving contexts. Therefore, the relationship between SBI and procedural fluency is characterized by SBI's role in fostering a deeper conceptual understanding of mathematical relationships and problem-solving strategies, which in turn contributes to students' proficiency in applying procedures effectively, i.e., higher level of procedural fluency, to solve mathematical problems.

The study provides valuable insights into the impacts of SBI on students' procedural fluency, the variation in effectiveness across different student groups, and the effects on transfer and retention. These findings contribute to the existing knowledge base and provide actionable recommendations to improve instructional practices and promote mathematical proficiency among students.

6.3 Limitations

This research was conducted with a small sample of participants the findings of this experimental intervention study hold significant reference value and valuable resource for educators, practitioners, and researchers working with similar student populations or facing similar instructional challenges. While the study's focus was on the specific context of procedural fluency with percentages problems, its contributions extend to the broader field of mathematics education and supports evidence-based approaches, i.e. SBI, to enhance students' procedural fluency. Educators can leverage these insights to enhance students' mathematical proficiency and promote effective teaching practices.

Supplement the quantitative findings with qualitative research methods could gain a deeper understanding of students' experiences with SBI. In this study, for measuring procedural fluency, students must show all problem-solving steps, including SBI schema diagrams. However, even with SBI strategies (FOPS), some students, especially low achieving students, may have difficulties in their critical reasoning and abstract thinking abilities, thus procedural fluency could not be completely shown in their attempt in mathematical problem solving. Therefore, using a variety of data collection tools such as oral response, performance tasks, surveys, observations, and interviews, could provide a more comprehensive view of students' learning and understanding and development of procedural fluency.

Ultimately, the goal is to provide students with the necessary tools and strategies to become confident and proficient problem solvers, cultivating their mathematical mindset, equipping them with the skills they need for success in mathematics and beyond. Through ongoing research and collaborative efforts, we can continue to improve instructional approaches and contribute to the advancement of mathematics education.

References

Alreshidi, N. A. K. (2023). Enhancing topic-specific prior knowledge of students impacts their outcomes in mathematics. *Frontiers in Education*, *8*. https://doi.org/10.3389/feduc.2023.1050468

Asmida, A., Sugiatno, S., & Hartoyo, A. (2018). Developing the mathematics conceptual understanding and procedural fluency through didactical anticipatory approach equipped with teaching AIDS. *JETL (Journal of Education, Teaching and Learning)*, *3*(2), 367. https://doi.org/10.26737/jetl.v3i2.796

Awofala, A. O. A. (2017). Assessing senior secondary school students' mathematical proficiency as related to gender and performance in mathematics in nigeria. *International Journal of Research in Education and Science*, 488–488. https://doi.org/10.21890/ijres.327908

Berger, A. (2017). *Using number talks to build procedural fluency through conceptual understanding*.

Boaler, J., Dieckmann, J. A., LaMar, T., Leshin, M., Selbach-Allen, M., & Pérez-Núñez, G. (2021). The Transformative Impact of a Mathematical Mindset Experience Taught at Scale. *Frontiers in Education*, *6*. https://doi.org/10.3389/feduc.2021.784393

Cagape, W. E., MAEd Harajene S. Batao, MAEd Flordeliza F. Atillo, Gloria, Ma., MAEd Chrisyl T. But-ay, & MAEd JadeB. Malnegrof. (2023). Differentiated Instruction Practices: A Disclosure of Receiving Teachers. *International Journal of Research Publications*, *127*(1). https://doi.org/10.47119/ijrp1001271620235131

Capraro, R. M., Capraro, M. M., & Rupley, W. H. (2011). Reading-enhanced word problem solving: a theoretical model. *European Journal of Psychology of Education*, *27*(1), 91–114. https://doi.org/10.1007/s10212-011-0068-3

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction*, *8*(4), 293–332.

Chapman, O. (2015). Mathematics teachers' knowledge for teaching problem solving. *Lumat: International Journal of Math, Science and Technology Education*, *3*(1), 19–36. https://doi.org/10.31129/lumat.v3i1.1049

Clinch, A. (2018). Factoring for roots. *The Mathematics Teacher*, *111*(7), 528–534. https://doi.org/10.5951/mathteacher.111.7.0528

Conley, L. (n.d.). *Mastery learning: A mixed-methods study of teacher efforts mastery learning: A mixed-methods study of teacher efforts implementing key components of the mastery learning implementing key components of the mastery learning framework framework*. https://digitalcommons.gardner-webb.edu/cgi/viewcontent.cgi?article=1001&context=education-dissertations

Conway, M. A., Cohen, G., & Stanhope, N. (1992). Very long-term memory for knowledge acquired at school and university. *Applied Cognitive Psychology*, *6*(6), 467–482. https://doi.org/10.1002/acp.2350060603

Corral, D., Quilici, J. L., & Rutchick, A. M. (2019). The effects of early schema acquisition on mathematical problem solving. *Psychological Research*. https://doi.org/10.1007/s00426-019-01164-8

Daly, I., Bourgaize, J., & Vernitski, A. (2019). Mathematical mindsets increase student motivation: Evidence from the EEG. *Trends in Neuroscience and Education*, *15*, 18–28. https://doi.org/10.1016/j.tine.2019.02.005

Dossey, J. A. (2017). Problem solving from a mathematical standpoint. *Educational Research and Innovation*, 59–72. https://doi.org/10.1787/9789264273955-6-en

Fraivillig, J. L., Murphy, L. A., & Fuson, K. C. (1999). Advancing children's mathematical thinking in everyday mathematics classrooms. *Journal for Research in Mathematics Education*, *30*(2), 148. https://doi.org/10.2307/749608

Fuchs, L. S., Fuchs, D., Prentice, K., Hamlett, C. L., Finelli, R., & Courey, S. J. (2004). Enhancing mathematical problem solving among third-grade students with schema-based instruction. *Journal of Educational Psychology*, *96*(4), 635–647. https://doi.org/10.1037/0022-0663.96.4.635

Fuchs, L. S., Powell, S. R., Seethaler, P. M., Cirino, P. T., Fletcher, J. M., Fuchs, D., Hamlett, C. L., & Zumeta, R. O. (2009). Remediating number combination and word problem deficits among students with mathematics difficulties: a randomized control trial. *Journal of Educational Psychology*, *101*(3), 561–576. https://doi.org/10.1037/a0014701

Hansen, A. (2011). Children′s errors in mathematics. In *Google Books*. SAGE Publications.

Hembree, R. (1992). Experiments and relational studies in problem solving: a meta-analysis. *Journal for Research in Mathematics Education*, *23*(3), 242. https://doi.org/10.2307/749120

Hott, B., Bcba-D, Peltier, C., Heiniger, S., Palacios, M., Le, M., & Chen, M. (2021). Using schema-based instruction to improve the mathematical problem solving skills of a rural student with EBD. *Learning Disabilities: A Contemporary Journal*, *19*(2), 127–142. https://files.eric.ed.gov/fulltext/EJ1314840.pdf

Hughes, S., & Cuevas, J. (2020). The effects of schema-based instruction on solving mathematics word problems. *Georgia Educational Researcher*, *17*(2), 1–50. https://doi.org/10.20429/ger.2020.170202

Jennings, M. A., & Cribbie, R. A. (2021). Comparing pre-post change across groups: Guidelines for choosing between difference scores, ANCOVA, and residual change scores. *Journal of Data Science*, *14*(2), 205–230. https://doi.org/10.6339/jds.201604_14(2).0002

Jitendra, A. (n.d.). *TeachingLD.org teaching tutorial 3: Teaching mathematics problem solving using schema-based strategy instruction*. https://s3.amazonaws.com/cmi-teaching-ld/assets/attachments/41/math_tutorial.pdf

Jitendra, A. K., Dupuis, D. N., Star, J. R., & Rodriguez, M. C. (2014). The effects of schema-based instruction on the proportional thinking of students with mathematics difficulties with and without reading difficulties. *Journal of Learning Disabilities*, *49*(4), 354–367. https://doi.org/10.1177/0022219414554228

Jitendra, A. K., Harwell, M. R., Dupuis, D., & Karl, S. R. (2015). A randomized trial of the effects of schema-based instruction on proportional problem-solving for students with mathematics problem-solving difficulties. *Journal of Learning Disabilities*, *50*(3). https://doi.org/10.1177/0022219416629646

Jitendra, A. K., & Star, J. R. (2011). Meeting the needs of students with learning disabilities in inclusive mathematics classrooms: The role of schema-based instruction on mathematical problem-solving. *Theory into Practice*, *50*(1), 12–19. https://doi.org/10.1080/00405841.2011.534912

Jitendra, A. K., Star, J. R., Starosta, K., Leh, J. M., Sood, S., Caskie, G., Hughes, C. L., & Mack, T. R. (2009). Improving seventh grade students' learning of ratio and proportion: The role of schema-based instruction. *Contemporary Educational Psychology*, *34*(3), 250–264. https://doi.org/10.1016/j.cedpsych.2009.06.001

Julius, E., Abdullah, A., & Suhairom, N. (2018). Attitude of students towards solving problems in algebra: A review of nigeria secondary schools. *IOSR Journal of Research & Method in Education*, *8*(1), 26–31. https://doi.org/10.9790/7388-0801032631

Jupri, A., Sispiyati, R., & Chin, K. E. (2021). An investigation of students' algebraic proficiency from a structure sense perspective. *Journal on Mathematics Education*, *12*(1), 147–158. https://doi.org/10.22342/jme.12.1.13125.147-158

Kalyuga, S. (2006). Rapid cognitive assessment of learners' knowledge structures. Learning and Instruction, 16, 1-11. doi:10.1016/j.learninstruc.2005.12.002

Kasap, C., & Ergenekon, Y. (2017). Effects of a schema approach for the achievement of the verbal mathematics problem-solving skills in individuals with autism spectrum disorders. *Educational Sciences: Theory & Practice*. https://doi.org/10.12738/estp.2017.6.0660

Killen, P., & Hindhaugh, S. (2018). How big is a big number?: Learning to teach mathematics in the primary school. In *Google Books*. Learning Matters.

Kilpatrick, J. (1969). Problem solving in mathematics. *Review of Educational Research*, *39*(4), 523. https://doi.org/10.2307/1169713

Kilpatrick, J., Swafford, J., & Findell, B. (2001). *Adding It Up*. National Academies Press. https://doi.org/10.17226/9822

Koichu, B. (2014). Reflections on problem-solving. *Advances in Mathematics Education*, 113–135. https://doi.org/10.1007/978-94-007-7473-5_8

Lester, F. K., & Cai, J. (2016). Can mathematical problem solving be taught? Preliminary answers from 30 years of research. *Posing and Solving Mathematical Problems*, 117–135. https://doi.org/10.1007/978-3-319-28023-3_8

Lyle, K. B., Bego, C. R., Hopkins, R. F., Hieb, J. L., & Ralston, P. A. S. (2019). How the amount and spacing of retrieval practice affect the short- and long-term retention of mathematics knowledge. *Educational Psychology Review*, *32*(1), 277–295. https://doi.org/10.1007/s10648-019-09489-x

Marshall, S. P. (2012). Schema-Based Instruction. *Encyclopedia of the Sciences of Learning*, 2945–2946. https://doi.org/10.1007/978-1-4419-1428-6_261

Mayer, R. E. (1999). The promise of educational psychology Vol. I: Learning in the content areas. Upper Saddle River, NJ: Merrill Prentice Hall.

Mayer, R. E. (2002). Rote versus meaningful learning. *Theory into Practice*, *41*(4), 226–232. https://doi.org/10.1207/s15430421tip4104_4

McGaugh, J. L. (2000). Memory--a century of consolidation. *Science*, *287*(5451), 248–251. https://doi.org/10.1126/science.287.5451.248

Morales, R. V., Shute, V. J., & Pellegrino, J. W. (1985). Developmental differences in understanding and solving simple mathematics word problems. *Cognition and Instruction*, *2*(1), 41–57. https://doi.org/10.1207/s1532690xci0201_2

Narode, Ronald, Jill Board, and Linda Ruiz Davenport. 1993. “Algorithms Supplant Understanding: Case Studies of Primary Students’ Strategies for Double-Digit Addition and Subtraction.” *Proceedings of the 15th Annual Meeting of the North American Chapter of the International Group for the Psychology of*

Mathematics Education (Vol. 1), pp. 254–60. San Jose, CA: Center for Mathematics and Computer Science Education, San Jose State University.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. The National Council of Teachers of Mathematics.

Niemi, D. (1996). Assessing conceptual understanding in mathematics: Representations, problem solutions, justifications, and explanations. *The Journal of Educational Research*, *89*(6), 351–363. https://www.jstor.org/stable/27542057

Osana, H. P., & Pitsolantis, N. (2011). Addressing the struggle to link form and understanding in fractions instruction. *British Journal of Educational Psychology*, *83*(1), 29–56. https://doi.org/10.1111/j.2044-8279.2011.02053.x

Pedler, M., Yeigh, T., & Hudson, S. (2020). The teachers' role in student engagement: a review. *Australian Journal of Teacher Education*, *45*(3), 48–62. https://doi.org/10.14221/ajte.2020v45n3.4

Peltier, C., Lingo, M. E., Autry, F., Deardorff, M. E., & Palacios, M. (2020). Schema-Based Instruction Implemented under Routine Conditions. *Journal of Applied School Psychology*, *37*(3), 246–267. https://doi.org/10.1080/15377903.2020.1821273

Powell, A. B., Borge, I. C., Fioriti, G. I., Kondratieva, M., Koublanova, E., & Sukthankar, N. (2008). Challenging tasks and mathematics learning. *Challenging Mathematics in and beyond the Classroom*, 133–170. https://doi.org/10.1007/978-0-387-09603-2_5

Powell, S. R. (2011). Solving word problems using schemas: A review of the literature. *Learning Disabilities Research & Practice*, *26*(2), 94–108. https://doi.org/10.1111/j.1540-5826.2011.00329.x

Powell, S. R., & Fuchs, L. S. (2018). Effective word-problem instruction: Using schemas to facilitate mathematical reasoning. *Teaching Exceptional Children*, *51*(1), 31–42. https://doi.org/10.1177/0040059918777250

Quilici, J. L., & Mayer, R. E. (1996). Role of examples in how students learn to categorize statistics word problems. Journal of Educational Psychology, 88, 144– 161. doi:10.1037/0022-0663.88.1.144

Reys, R., Lindquist, M., Lambdin, D. V., & Smith, N. L. (2014). Helping children learn mathematics. In *Google Books*. John Wiley & Sons.

Riccomini, P. J., Stocker, J. D., & Morano, S. (2017). Implementing an effective mathematics fact fluency practice activity. *TEACHING Exceptional Children*, *49*(5), 318–327. https://doi.org/10.1177/0040059916685053

Rittle-Johnson, B., & Alibali, M. W. (1999). Conceptual and procedural knowledge of mathematics: Does one lead to the other? *Journal of Educational Psychology*, *91*(1), 175–189. https://doi.org/10.1037/0022-0663.91.1.175

Rittle-Johnson, B., Schneider, M., & Star, J. R. (2015). Not a one-way street: Bidirectional relations between procedural and conceptual knowledge of mathematics. *Educational Psychology Review*, *27*(4), 587–597. https://doi.org/10.1007/s10648-015-9302-x

Siswono, T. Y. E., Kohar, A. W., Kurniasari, I., & Astuti, Y. P. (2016). An investigation of secondary teachers' understanding and belief on mathematical problem solving. *Journal of Physics*, *693*, 012015–012015. https://doi.org/10.1088/1742-6596/693/1/012015

Son, J.-W., & Senk, S. L. (2010). How reform curricula in the USA and Korea present multiplication and division of fractions. *Educational Studies in Mathematics*, *74*(2), 117–142. https://doi.org/10.1007/s10649-010-9229-6

Star, J. R., & Rittle-Johnson, B. (2009). It pays to compare: An experimental study on computational estimation. Journal of Experimental Child Psychology, 102, 408–426. doi: 10.1016/j.jecp.2008.11.004

Sun, K. L. (2018). The Role of Mathematics Teaching in Fostering Student Growth Mindset. *Journal for Research in Mathematics Education*, *49*(3), 330–355. https://eric.ed.gov/?id=EJ1178088

van Merriënboer, J. J. G., & Sweller, J. (2005). Cognitive load theory and complex learning: Recent developments and future directions. *Educational Psychology Review*, *17*(2), 147–177. https://doi.org/10.1007/s10648-005-3951-0

Woodward, J., Beckmann, S., Driscoll, M., Franke, M., Herzig, P., Jitendra, A. K., Koedinger, K. R., & Ogbuehi, P. (2012). Improving mathematical problem solving in grades 4 through 8: A practice guide (NCEE 2012–4055). Washington, DC: National Center for Education PROPORTIONAL PROBLEM SOLVING 42 Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. Retrieved from http://ies.ed.gov/ncee/wwc/PracticeGuide.aspx?sid=16

Xin, Y. P., Jitendra, A. K., & Deatline-Buchman, A. (2005). Effects of mathematical word problem—solving instruction on middle school students with learning problems. *The Journal of Special Education*, *39*(3), 181–192. https://doi.org/10.1177/00224669050390030501

Xiong, X., & Beck, J. E. (2014). A study of exploring different schedules of spacing and retrieval interval on mathematics skills in ITS environment. *Intelligent Tutoring Systems*, 504–509. https://doi.org/10.1007/978-3-319-07221-0_63

Yuan Anisa, Rizka Fahruza, & Hafiz, M. (2023). Students' mathematical communication skills in mathematics learning. *International Journal of*

Innovative Research in Computer Science & Technology, *11*(6), 39–43. https://doi.org/10.55524/ijircst.2023.11.6.7

Appendix

Guardian Consent Form

This is a guardian consent form for my daughter, to be a participant in the research titled **Effectiveness of Schema-Based Instruction on Procedural Fluency with Percentages Problems**, which is being conducted by ____________________ , who can be reached at ____________________.

1. The purpose of this study is to determine if integrating Schema-based Instruction in the math curriculum will improve procedural fluency with percentages problems.
2. The procedures are as follows:
   - My daughter will be asked to participate in lessons and complete/solve percentages problems in math lessons.
   - My daughter will also participate in a regular assessment.
   - My daughter's name will not appear on the data sheet; therefore, the information gathered will be completely confidential.
3. No physical, psychological, social or legal risks exist in this study.

This participation is entirely voluntary; I can withdraw my consent at any time and have the results of the participation returned to me, removed from the research records, or destroyed.

The results of this participation will be anonymous and will not be released in any individually identifiable form without my prior consent unless required by law.

監護人同意書

以下是一份 題為 "基模教學對百分比問題之程序流暢程度的有效性"研究 的監護人同意書，該研究由 ____________________ 女士進行，聯繫電話：____________________ 。

1. 本研究的目的是確定在數學課程中整合以基模為基礎的教學是否會提高解決百分比問題之程序流暢性。
2. 研究程序如下：
   - 我的女兒將被要求參與課堂並完成/解決數學課中的百分比問題。
   - 我的女兒也將參加定期評估。
   - 我女兒的名字不會出現在資料表上；因此，所收集的資訊將完全保密。
3. 本研究不存在任何身體、心理、社會或法律風險。

參與本研究完全是自願；我可以隨時撤回我的同意，並將參與結果退還、從研究記錄中刪除或銷毀。

本次參與的結果將是匿名的，除非法律要求，未經本人事先同意，不會以任何可識別個人身份的形式發布。

Research title: Effectiveness of Schema-Based Instruction on Procedural Fluency with Percentages Problems

研究標題：基模教學對百分比問題之程序流暢程度的有效性

☐ I give consent for my daughter to participate in the research.
本人同意 女兒參與這項研究。

☐ I DO NOT give consent for my daughter to participate in the research.
本人不同意 女兒參與這項研究。

Student Name 學生名字：__________________________

Guardian signature 監護人簽名：__________________________

Date 日期：__________________________

Consent Form from the School Authority

This is a consent form for the school to acknowledge that research titled **Effectiveness of Schema-Based Instruction on Procedural Fluency with Percentages Problems**, which is being conducted by ____________________, who can be reached at ______________________.

1. The purpose of this study is to determine if integrating Schema-based Instruction in the math curriculum will improve procedural fluency with percentages problems.
2. The procedures are as follows:
   - The students will be asked to participate in lessons and complete/solve percentages problems in math lessons.
   - The students will also participate in a regular assessment.
   - The students' name will not appear on the data sheet; therefore, the information gathered will be completely confidential.
3. No physical, psychological, social or legal risks exist in this study.

The results of this participation will be anonymous and will not be released in any individually identifiable form unless required by law.

School Name：____

Signature of School Authority：_____________________________

Date：___________________

Pre-test

Q1. Basic Operations on Percentages

88% + 12% =	69% – 49% =
80% × 30% =	35% ÷ 70% =

Q2. 200 people attended an English test yesterday. 40 people passed the test.

(a) What percentage of people passed the test?

(b) What percentage of people failed the test?

Q3. Among all 500 pupils in a school, 5% went travelling on a holiday.
What percentage of the pupils did not go travelling on the holiday?

Q4. Bowie scored 39 out of 50 for her English test and 46 out of 100 for her Mathematics test. Which test did she perform better?

Q5. Pupils of the Happy School went to Coloane for a study trip last Sunday. They had to meet at school at 9:00 that morning. They either arrived on time, were late or did not come.

(a) 87% of the pupils arrived on time. Write the percentage as a decimal.

(a) $\frac{1}{20}$ of the pupils did not come.

What percentage of the pupils were ill?

(c) What percentage of the pupils were late?

Q6. There are 30 students in a class. 18 of them wear glasses.

What percentage of students wear glasses?

Q7. On a bookshelf, there are 30 Chinese books and 20 English books. What percentage of the books in the library are English books?

Q8. There are 140 watermelons in a supermarket. 5% of the watermelons have gone bad. How many watermelons in the supermarket have gone bad?

Q9. There are 50 tables in a restaurant. 96% of the tables are occupied. How many tables are available?

Q10. There were 40 kg of oranges in a fruit shop. 15% of the oranges were sold in the morning and 20% were sold in the afternoon. How many kg of oranges were sold altogether?

Objectives:

By the end of this lesson, students will be able to:

1. Define and understand the concept of percentage change.

2. Calculate percentage increase and decrease.

3. Apply percentage change in real-life scenarios.

Procedure:

1. Introduction (5 minutes)

- Begin the lesson by asking students if they have ever heard the term "percentage change" and if they have any prior knowledge about it.

- Explain that percentage change is a way to measure the increase or decrease of a value in terms of a percentage.

- Provide examples of real-life scenarios where percentage change is commonly used, such as price changes, population growth, or test score improvements.

2. Definition and Calculation of Percentage Change (10 minutes)

- Connect to prior knowledge:

The percentage change formula can be derived using the concept of relative change. Let's consider two values: the initial value (Original Value) and the final value (New Value). We want to calculate the percentage change between these two values.

Step 1: Find the Difference {the difference schema}

Calculate the difference between the new value and the original value:

Difference = New Value - Original Value.

Step 2: Calculate the Relative Change {the comparison schema}

To express the change as a proportion relative to the original value, divide the difference by the original value:

Relative Change = Difference / Original Value.

Step 3: Convert to Percentage {the percentage schema}

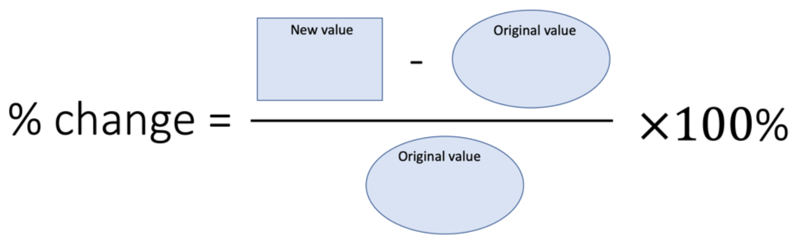
To express the relative change as a percentage, multiply it by 100%:

Percentage Change = Relative Change * 100%.

Therefore, the derived formula for percentage change is:

Percentage Change = (New Value - Original Value) / Original Value * 100%.

This formula calculates the change as a proportion of the original value and expresses it as a percentage. It is commonly used to measure the increase or decrease between two values and is helpful in analyzing various scenarios.



Introduce {the percentage change schema} and the above visual diagram.

** Positive percentage change means percentage increase.

** Negative percentage change means percentage decrease.

- Demonstrate examples on the board, calculating both percentage increase and percentage decrease. Encourage students to participate and ask questions.

If 5 cm is changed to 8 cm, find the

(i) percentage change, (ii) percentage increase.

solution:

$$\% \text{ change} = \frac{\overset{\text{New value}}{8} - \overset{\text{Original value}}{5}}{\underset{\text{Original value}}{5}} \times 100\%$$

$$= \frac{3}{5} \times 100\% = +60\%$$

(i) The percentage change is +60%.

(ii) The percentage increase is 60%.

If 16 L is changed to 12 L, find the

(i) percentage change, (ii) percentage decrease.

$$\% \text{ change} = \frac{\overset{\text{New value}}{12} - \overset{\text{Original value}}{16}}{\underset{\text{Original value}}{16}} \times 100\%$$

$$= \frac{-4}{16} \times 100\% = -25\%$$

(i) The percentage change is -25%.

(ii) The percentage decrease is 25%.

3. Practice Problems (20 minutes)

- do practice problems related to percentage change.

- Instruct students to work individually or in pairs to solve the problems. Encourage them to show their work and explain their reasoning.

- Circulate the classroom to provide assistance and guidance as needed.

4. Summary and Reflection (5 minutes)

- Summarize the key points covered in the lesson, emphasizing the definition and calculation of percentage change.

- Ask students to reflect on their understanding of percentage change and how they can apply it in various situations.

- Address any remaining questions or concerns.

Extensions and Differentiation:

- For advanced students, introduce more complex problems involving multiple percentage changes.
- Offer extra practice worksheets or online resources for further reinforcement.

Assessment:

- Monitor students' participation and engagement during class discussions and activities.
- Assign homework problems to evaluate individual mastery of the topic.

Post-test 1

1. There are some fruits in a box. It is given that 50 of the fruits are apples, which is 25% of the fruits.
    a. What is the total number of fruits in the box?
    b. If 45% of the fruits in the box are oranges, how many oranges are there in the box?

2. In an examination, Jen got 80 marks in Mathematics. The score she got in Chinese language is 20% more than that in Mathematics. Find the score that Jen got in Chinese language.

3. The population of a town is 44 thousands this year. The population this year is 10% more than that in last year. Find the population last year.

4. Alice is 20% taller than Betty, while Betty is 20% shorter than Charlie. Who is the tallest? Explain your answer.

5. The price of a stock is decreased from $70 to $63.
    a. Find the percentage decrease in the price of the stock.
    b. In the following week, the price of the stock is increased by 50%, find the new price of stock.

6. The sales of a cafe was $1000 yesterday. It is changed by +35% today.
    a. Find the change in the sales of the cafe today.
    b. Find the sales of the cafe today.

7. The marked price of an iten is $320. It is sold at a discount of $48.
   a. Find the selling price.
   b. Find the discount percent.

8. A factory produces LED monitors. The factory sells an LED monitor at a profit of $480 and the profit percent is 64%.
   a. Find the production cost of an LED monitor.
   b. For how much is an LED monitor sold?

9. Kim owns two farms. Last year, each of the farms produced 3,000 apples. This year Farm A produces 20% more of apples while Farm B produces 30% less apples compared to last year. Find the overall change in the number of apples produces this year.

10. In a toy shop, the marked price and the cost price of a doll are $240 and $150 respectively. If the doll is sold with 30% off, find the profit percent or loss percent.

Post-test 2

1. Ann and Ben share an amount of money. It is given that Ann gets $140, which is 70% of the whole amount of money that they share.
    a. Find the whole amount of money that they share.
    b. What is Ben's share?

2. There were 70 visitors to a website last month. This month, 30% more visitors visit the website. Find the number of visitors this month.

3. There are 30 students in Class 1B. The number of students in Class 1B is 20% more than that in Class 1A. Find the number of students in Class 1A.

4. The daily wage of Alice is 25% lower than that of Betty while the daily wage of Betty is 25% higher than that of Charlie. Who has the lowest daily wage? Explain your answer.

5. The weight of a pregnant woman is changed from 50 kg to 60 kg.
    a. Find the percentage increase in her weight.
    b. After giving birth to a baby, her weight is decreased by 15%, find the weight of the woman after giving birth.

6. The amount of rainfall was 220 mm yesterday. It is changed by –10% today.
    a. Find the change in the amount of rainfall today.
    b. Find the amount of rainfall today.

7. In a shop, a jacket is sold at a discount of 40%.

   If the marked price of the jacket is $2000, find

   a. the discount,

   b. the selling price of the jacket.

8. Miss Chan bought a painting for $1600. She then sold it at a discount of 25% and made a profit of $400.

   a. Find the selling price of the painting.

   b. Find the marked price of the painting.

9. Dan sells two watches for $300 each. He gains 20% on one and loses 20% on the other. Find the overall profit or loss.

10. Kenny bought 300 oranges for $1000. It is known that 5% of the oranges were rotten and discarded. He sold all the remaining oranges for $5 each. Find the profit per cent or loss per cent.

In the group of 31 students:

The result of the Spearman correlation showed that there was a very high, positive correlation between Pre-test and Post-test 1. The correlation between Pre-test and Post-test 1 was statistically significant, $r(29) = 0.89$, $p = <.001$.

The result of the Spearman correlation showed that there was a very high, positive correlation between *Post-test 1* and *Post-test 2*. The correlation between *Post-test 1* and *Post-test 2* was statistically significant, $r(29) = 0.92$, $p = <.001$.

The *Pre-test* group had lower values (*Mdn* = 63) than the *Post-test 1* group (*Mdn* = 78).

A Wilcoxon Test indicated that this difference was statistically significant, $W = 0$, $p = <.001$.

The p-value of <.001 is below the specified significance level of 0.05. The result of the Wilcoxon test was therefore significant for the present data and the null hypothesis was rejected. Therefore, it is assumed that both samples were from different populations.

The *Post-test 1* group had values (*Mdn* = 78) than the *Post-test 2* group (*Mdn* = 78).

A Wilcoxon Test indicated that this difference was not statistically significant, $W = 202$, $p = .737$.

The p-value of .737 is above the specified significance level of 0.05. The result of the Wilcoxon test was therefore not significant for the present data and the null hypothesis was not rejected. Therefore, it is assumed that both samples were from the same population.

In the subgroup of 8 high-achieving students:

The result of the Spearman correlation showed that there was a very high, positive correlation between *Pre-test* and *Post-test 1*. The correlation between *Pre-test* and *Post-test 1* was statistically significant, $r(6) = 0.83$, $p = .01$.
The result of the Spearman correlation showed that there was a very high, positive correlation between *Post-test 1* and *Post-test 2*. The correlation between *Post-test 1* and *Post-test 2* was statistically significant, $r(6) = 0.84$, $p = .009$.
The *Pre-test* group had lower values (*Mdn* = 78.5) than the *Post-test 1* group (*Mdn* = 94).
A Wilcoxon Test indicated that this difference was statistically significant, $W = 0$, $p = .018$.
The p-value of .018 is below the specified significance level of 0.05. The result of the Wilcoxon test was therefore significant for the present data and the null hypothesis was rejected. Therefore, it is assumed that both samples were from different populations.
The *Post-test 1* group had lower values (*Mdn* = 94) than the *Post-test 2* group (*Mdn* = 95.5).
A Wilcoxon Test indicated that this difference was not statistically significant, $W = 10$, $p = .496$.
The p-value of .496 is above the specified significance level of 0.05. The result of the Wilcoxon test was therefore not significant for the present data and the null hypothesis was not rejected. Therefore, it is assumed that both samples were from the same population.

In the subgroup of 15 average students,

The result of the Spearman correlation showed that there was a very high, positive correlation between *Pre-test* and *Post-test 1*. The correlation between *Pre-test* and *Post-test 1* was statistically significant, $r(13) = 0.71$, $p = .003$.

The result of the Spearman correlation showed that there was a very high, positive correlation between *Post-test 1* and *Post-test 2*. The correlation between *Post-test 1* and *Post-test 2* was statistically significant, $r(13) = 0.8$, $p = <.001$.

The *Pre-test* group had lower values (*Mdn* = 63) than the *Post-test 1* group (*Mdn* = 80).

A Wilcoxon Test indicated that this difference was statistically significant, $W = 0$, $p = .001$.

The p-value of .001 is below the specified significance level of 0.05. The result of the Wilcoxon test was therefore significant for the present data and the null hypothesis was rejected. Therefore, it is assumed that both samples were from different populations.

The *Post-test 1* group had higher values (*Mdn* = 80) than the *Post-test 2* group (*Mdn* = 78).

A Wilcoxon Test indicated that this difference was not statistically significant, $W = 49.5$, $p = .85$.

The p-value of .85 is above the specified significance level of 0.05. The result of the Wilcoxon test was therefore not significant for the present data and the null hypothesis was not rejected. Therefore, it is assumed that both samples were from the same population.

In the subgroup of 8 low-achieving students,

The result of the Spearman correlation showed that there was a low, positive correlation between *Pre-test* and *Post-test 1*. The correlation between *Pre-test* and *Post-test 1* was not statistically significant, $r(6) = 0.16$, $p = .699$.

The result of the Spearman correlation showed that there was a low, positive correlation between *Post-test 1* and *Post-test 2*. The correlation between *Post-test 1* and *Post-test 2* was not statistically significant, $r(6) = 0.11$, $p = .798$.

The *Pre-test* group had lower values (*Mdn* = 31) than the *Post-test 1* group (*Mdn* = 46.5).

A Wilcoxon Test indicated that this difference was statistically significant, $W = 0$, $p = .012$.

The p-value of .012 is below the specified significance level of 0.05. The result of the Wilcoxon test was therefore significant for the present data and the null hypothesis was rejected. Therefore, it is assumed that both samples were from different populations.

The *Post-test 1* group had lower values (*Mdn* = 46.5) than the *Post-test 2* group (*Mdn* = 49).

A Wilcoxon Test indicated that this difference was not statistically significant, $W = 17.5$, $p = .944$.

The p-value of .944 is above the specified significance level of 0.05. The result of the Wilcoxon test was therefore not significant for the present data and the null hypothesis was not rejected. Therefore, it is assumed that both samples were from the same population.