# THE USE OF BAR MODEL METHOD FOR ADDITION AND SUBTRACTION WORD PROBLEM ACHIEVEMENT OF GRADE 4 BHUTANESE STUDENTS

BY

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**Abstract**

This study investigated the effectiveness of the Bar Model Method in solving the Addition and Subtraction Word Problem Achievement and Satisfaction levels of Grade 4 Bhutanese students. The study was conducted with a sample group of 30 students selected through a clustered random sampling method from a school in Samdrup Jongkhar, Bhutan. Data collection covered eight sessions over four weeks, incorporating lessons plans, pretest, posttest, and interview questions. Quantitative data was collected through pretest and posttest assessment, revealing a significant increase in mean scores from 12.13 (SD= 4.16) to 18.53 (SD=3.09), leading to a statistically significant difference , the mean improvement of 6.40, further confirmed by a paired sample t-test indicating statistical significance ($p < 0.01$). Qualitative data from semi-structured interview provided further insight into students' experiences, preferences, understanding, collaborative learning impact, and desire to continue using the method.

The study has demonstrated that the Bar Model Method significantly improved students' Addition and Subtraction Word Problem solving skills and it provides alternative method for teachers to teach mathematics Addition and Subtraction Word Problems.

(Total 131 pages)

Keywords: Bar Model Method, Word Problem, Grade 4 Students, Learning Achievement

Student's Signature…….. Thesis Advisor's Signature……..…..

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# ABBREVIATIONS

| Abbreviations | Meaning |
|---|---|
| BCSE | Bhutan Certificate for Secondary Examination |
| BCSEA | Bhutan Council for School Examination and Assessment |
| CAPSD | Curriculum and Assessment Professional Support Division |
| DCPD | Department of curriculum and Profession Development |
| IOC | Item Objective Congruence |
| REC | Royal Education Council |
| MOE | Ministry of Education |
| MoESD | Ministry of Education and Skills Development |
| NCTM | National Council of Teachers of Mathematics |
| NMAP | National Mathematics Advisory Panel |
| PISA-D | Program for International Student Assessment for Development |

# CHAPTER 1

# INTRODUCTION

This chapter describes the background and rational of the study; research objective; research questions; scope of the study; limitations of the study; operational definitions; and the significance of the study.

## 1.1 BACKGROUND AND RATIONALE OF THE STUDY

In Bhutan, it is mandatory for students to include Mathematics in their education curriculum. This subject serves as the foundation, for Mathematics courses for years. There is a consensus that there is an unprecedented need to understand and utilize mathematics in both professional and daily life settings (Department of curriculum and Profession Development [DCPD], 2022). Many students find mathematics to be challenging or demanding. It holds importance for success in the modern era as more as job opportunities than ever before require mathematical skills (National Mathematics Advisory Panel [NMAP], 2008),

One of the hurdles faced in mathematics education, within Bhutanese school lies in effectively teaching and learning Words Problems. Word Problems play a role in connecting concepts to practical situations helping students develop their problem solving abilities and analytical thinking skills. (Lai, Zhu, Chen, & Li, 2015) defined Word Problems as designed to help students apply mathematical concepts to real life situations. Since they involve a narrative of some sort, they are also referred to as story problems. The amount of language used in the question may vary.

In times educators and researchers have emphasized fostering a deep understanding of mathematical concepts among students. Foundational skills, such as Addition and Subtraction are the building blocks of mathematics proficiency and

fluency (National Council of Teachers of Mathematics [NCTM], 2014). Often students struggle with applying their problem solving skills in situation, which can hinder their career progress. The inability to comprehend and solve basic level Addition and Subtraction Problems can hinder a child's progress through higher level mathematics instruction (Confrey et al., 2012).

In Bhutan where students are mandated to study mathematics throughout their primary education, addressing the growing need for mathematical proficiency is crucial. The majority of the students struggle with mathematics in particular with "Word Problem". It was found in Bhutan that PISA-D national highlights a significant performance gap in more demanding mathematical tasks, indicating a challenge faced by students in applying their skills to complex problems (Bhutan Council for School Examination and Assessment [BCSEA], 2019).

Further, in the Bhutanese mathematics curriculum, students encounter challenges with Word Problems due to the difficulty in deducting, generalizing and reasoning out the mathematical patterns presented in these problems. Furthermore, the language complexity of the Word Problems is beyond the language proficiency of the students, making it challenging for them to comprehend and solve these problems (Dorji & Tshering, 2020).

Word Problems are key in Primary math. They help apply concepts to real world situations. Clear communication is vital for student success. However, it has been observed that a considerable number of primary school students encounter difficulties while attempting Word Problems. Researchers (Chan & Foong, 2013; Englard, 2010; Ng & Lee 2009) have been seeking effective teaching methods and believe that the Bar Model Method can address this need.

The process of solving Word Problems is an essential test of one's mathematical abilities. It demands a thorough understanding of the problem, which is contingent upon good reading comprehension skills. Additionally, the proper formula

or operation must be applied to arrive at the intended solution. It is also imperative that he numbers or expressions involved are correctly operated upon.

According to research conducted by Papanastasious in 2008, the teaching method employed in mathematics has a direct impact on the academic achievements of students, as well as their overall outlook towards the subject. It is imperative to acknowledge that the approach to teaching in the 21st century surpasses the conventional method of conveying information. The role of a teacher has evolved significantly, and educators now serve as guides and facilitators in the classroom. It is crucial to note that the traditional model of imparting knowledge through lectures and textbooks no longer meets the requirements of contemporary learners. Teachers must adapt to the changing landscape and embrace modern teaching methodologies to foster student engagement and academic success. The teacher's role has shifted from being a mere instructor to becoming a facilitator who nurtures critical thinking, creativity, and problem solving skills in learners. The significance of the teaching method employed in mathematics cannot be overstated. The current era demands a modernized approach to teaching that promotes student involvement and facilitates academic success. The teacher's changing role in the classroom has created a need for educators to adapt to new methodologies and strategies that will equip students with the skills necessary to succeed in this modern era.

Wangmo (2019) shares that it should be noted that for every problem, there exists a solution. Thus, the challenge for every problem solver is to identify the ways and measures to find the solution to the problem. Researchers do advocate for the use of the Bar Model Method, a visual representation technique originating from Singapore Mathematics. This method involves the use of rectangular bars to represent known and unknown quantities in word problems, facilitating a visual understanding of the relationships between these quantities (Ng & Lee, 2009) and is increasingly used in various other countries worldwide such as the Netherlands (Kaur, 2019)

Employing visual representations would enhance students' comprehension of mathematical concepts, allowing them to establish connections between abstract ideas

and real-life situations. This approach is likely to be effective due to its ability to facilitate a more comprehensive understanding of the subject matter, which can be useful for students in various academic and practical contexts.

In addition to enhancing students' conceptual understanding and problem solving abilities, the integration of the manipulative (Bar Model Method) promotes increased engagement and motivation among Grade 4 Bhutanese students. Choden and Chalermnirundorn (2021) shared that the visual and interactive nature of manipulative captures students' interest and curiosity, making mathematical concepts more accessible and meaningful. By incorporating the Bar Model Method into instruction, educators can create dynamic learning environments that inspire active participation and exploration among students.

The Bar Model Method has gained international recognition for its effectiveness in improving problem solving skills, providing a promising solution for enhancing mathematics education in Bhutan and beyond. Rectangular bars are used because they are easy to draw, divide, represent numbers and display relevant relationships (Ng & Lee, 2009). By visualizing the relationships between these quantities, students can better understand the problem, leading to improved Addition and Subtraction Problem Solving Skills.

In Bhutan, the educational philosophy emphasizes holistic and experiential learning. The Bar Model Method aligns well with this philosophy, providing a tangible and accessible way for students to understand mathematical concepts. By incorporating scenarios from daily Bhutanese life, such as farming, local markets and family activities, mathematics becomes more relevant and engaging for students. This contextual approach not only enhances comprehension but also makes learning more meaningful and connected to students' real world experiences. Research supports the effectiveness of visual learning tools like the Bar Model in improving mathematical understanding and problem solving skills. Van de Walle, Karp, and Bay-Williams (2013) highlight that visual representations help students organize and interpret information more effectively, leading to enhanced learning outcomes. Furthermore,

Ginsburg, Lee, and Boyd (2008) suggest that using culturally relevant contexts in teaching mathematics improves student engagement and retention.

However, no studies have been conducted on the Use of Bar Model Method to solve Addition and Subtraction Word Problems in Bhutanese schools. Therefore, the outcome of the study would positively empower teachers in implementing the strategy to improve the learning outcomes in Mathematics and expect to see more engaging and participatory classroom environment, with students actively involved in visualizing and solving mathematical Addition and Subtraction Word Problem using the Bar Model Method.

In educational research, selecting an appropriate sample group is essential to ensure the validity and reliability of study findings. When investigating the effects of using the Bar Model Method in teaching Addition and Subtractions Word Problems of Grade 4 Bhutanese students, the choice of Grade 4 as the research sample group is strategic and grounded in several considerations.

Piaget (1964) posited that children's cognitive development progresses through stages, with Grade 4 representing a critical juncture where students demonstrate significant advancements in their ability to think abstractly and logically. This development stage aligns with the cognitive readiness necessary for comprehending and applying mathematical concepts, making Grade 4 an ideal stage for studying the effects of instructional interventions like the Bar Model Method.

Moreover, Reys, Lindquist, Lambdin, Smith, and Suydam (2012) noted that Grade 4 is a pivotal year in mathematics education, characterized by the consolidation of foundational arithmetic skills and the transition to more complex problem solving tasks. By focusing on Grade 4 students, researchers can assess the effectiveness of the Bar Model Method in building upon students' existing mathematical knowledge and fostering deeper conceptual understanding.

Furthermore, Carpenter, Fennema, Franke, Levi, and Empson (2015) emphasized the importance of providing cognitively guided instruction in mathematics, particularly through the use of visual representations like the Bar Model Method. Grade 4 students are developmentally ready to engage with such instructional approaches, as they have acquired basic arithmetic skills and are poised to benefit from more sophisticated problem solving strategies.

Additionally, the choice of Grade 4 students as the research sample group was practical and feasible within the context of Bhutanese education. Grade 4 represented a stage where students are sufficiently mature and capable of participating in research activities, while also being early enough in their academic journey to potentially benefit from instructional interventions aimed at improving learning outcomes.

In conclusion, the background and rationale of this study highlighted the significant challenges faced by Bhutanese students in mastering mathematics, particularly Word Problems. Despite the compulsory nature of mathematics education in Bhutan and its crucial role in both academic and professional success, many students struggled with Word Problems due to language complexity and difficulties in understanding mathematical concepts. By selecting Grade 4 students as the research sample, this study capitalized on their developmental readiness for more complex problem solving tasks and visual learning methods. Grade 4 represented a pivotal year in mathematics education, where foundational arithmetic skills were consolidated, and students transitioned to more advanced mathematical concepts.

The integration of the Bar Model Method into the Bhutanese mathematics curriculum aligned with the country's educational philosophy of holistic and experiential learning. This method made mathematical concepts more accessible and relevant to students' real world experiences, potentially transforming their engagement and achievement in mathematics. This study aimed to fill the gap in existing research by examining the impact of the Bar Model Method on solving Addition and Subtraction Word Problems among Grade 4 Bhutanese students. The findings were expected to provide valuable insights and practical recommendations for improving

mathematics education in Bhutan, ultimately leading to better learning outcomes and enhanced problem solving skills for students.

## 1.2 RESEARCH OBJECTIVES

1.2.1 To examine the effectiveness of the Bar Model Method for Addition and Subtraction Word Problem achievement of grade 4 Bhutanese students.

1.2.2 To determine grade 4 Bhutanese students' learning satisfaction towards the use of Bar Model Method for the Addition and Subtraction Word Problem.

## 1.3 RESEARCH QUESTIONS

1.3.1 Did the use of Bar Model Method help to improve the Addition and Subtraction Word Problem achievement in grade 4 Bhutanese students?

1.3.2 Would the grade 4 Bhutanese students be satisfied using Bar Model Method in solving Addition and Subtraction Word Problem?

## 1.4 RESEARCH HYPOTHESIS

1.4.1 The use of the Bar Model Method in grade 4 mathematics instruction would result in a significant improvement in students' achievement for solving Addition and Subtraction Word Problems.

## 1.5 SCOPE OF THE STUDY

### 1.5.1 Population and Sample

Population:

The total population comprised five sections of grade 4 students studying in the year 2024, with mixed genders and mixed abilities, at one of the schools in SamdrupJongkhar, in the eastern part of Bhutan.

Sample:

A clustered random sampling method was used to select one section of 30 Grade 4 students from the five sections as the sample group for the study. To avoid bias in selecting the sample group, a lucky dip was conducted among the five sections of Grade 4 students. From the lucky dip, one section was chosen as the sample group.

### 1.5.2 Content of the Lesson Plans

The researcher conducted two sessions of classes a week for a month, which were eight sessions in total. The lessons began from the first week of May 2023 and ended in the last week of the month. Four lesson plans were designed to administer the Bar Model Method for the targeted group.

The focus of the lesson was on solving Word Problem on Addition and Subtraction using Bar Model Method. The topic word problem was not directly mentioned in the Instructional guide provided to the teachers but the Word Problem was always integrated in all the strands of mathematics and was also a mandatory lesson that every individual deal in daily life.

The first topic was Word Problems involving the relationship of part whole, additive and then comparison structures to trial the Bar Model method. The lesson was taught for the duration of 90 minutes a week according to the instructional hour mandated to have by Royal Education Council. Lessons was delivered using Bar Model Method according to the given schedule below.

Table 1.1 Content of Lesson

| Lesson Plans | Topics | Time |
|---|---|---|
| | Pretest for Addition and Subtraction Word Problem will be administered. | Week 0 |
| 1 | ● Introduction to addition word problems and the Bar Model Method through visual representation. | Week 1 |

Table 1.1 Content of the Lesson (Cont.)

| | | |
|---|---|---|
| 1 | ● Explanation of the part-whole relationship structure within addition problems as the problem solving process. Throughout the process students need to record the information and comprehend by visualizing the scenario through the bar diagrams.<br>● Guided examples through scaffolding as needed of how to identify parts and wholes within addition word problems.<br>● Demonstration of how to represent addition problems visually using bar models.<br>● Interactive activities and exercises for students to practice identifying parts and wholes and solving addition word problems using the Bar Model Method. | |
| 2 | ● Review of the Bar Model Method and part-whole relationship structure.<br>● Practice session focusing on solving addition word problems using bar models.<br>● Application of the Bar Model Method to various addition scenarios, including combining quantities, adding to a whole, and finding missing parts.<br>● Collaborative problem solving tasks to reinforce understanding and build fluency in using the Bar Model Method for addition word problems.<br>● Reflection and discussion on strategies for approaching addition word problems effectively. | Week 2 |
| 3 | ● Introduction to subtraction word problems and the Bar Model Method through visual representation.<br>● Explanation of the comparison structure within subtraction problems. Throughout the process students need to record the information. | Week 3 |

Table 1.1 Content of the Lesson (Cont.)

| | | |
|---|---|---|
| | ● Comprehend by visualizing the scenario through the bar diagrams.<br>● Guided examples through scaffolding as needed of how to represent comparison relationships using bar models in subtraction word problems.<br>Interactive activities for students to practice identifying comparison relationships and solving subtraction word problems using the Bar Model Method. | |
| 4 | ● Review of the Bar Model Method and comparison structure within subtraction problems.<br>● Practice session focusing on solving subtraction word problems using bar models.<br>● Application of the Bar Model Method to various subtraction scenarios, including finding differences, comparing quantities, and solving for unknowns.<br>● Collaborative problem solving tasks to reinforce understanding and build fluency in using the Bar Model Method for subtraction word problems.<br>● Reflection and discussion on strategies for approaching subtraction word problems effectively | Week 4 |
| Posttest | | |

This structure ensured a progressive and scaffolded approach following the five key steps, Visual Representation, Problem Solving Process, Recording Information, Comprehension Aid and Instructional Strategy to exploring and solving Addition and Subtraction Word Problems using the Bar Model Method, allowing students to build upon their understanding and skills throughout the four-week period.

### 1.5.3 Location of the Study

The study was carried out in grade 4 students from one of the primary schools in SamdrupJongkhar District, in eastern Bhutan. The school consisted of Pre Primary level to grade 6.

### 1.5.4 Time Frame

The research was conducted for four weeks. The researcher delivered one lesson in a week. It was two sessions which totals to 90 minutes per lesson. The researcher and the students used the Bar Model Method to solve Addition and Subtraction Word Problem for 8 periods over the course of four weeks. The data was collected in May 2024. Table 1.2 below shows the time frame of the study.

Table 1.2 Time Frame for The Research Process

| Activities | Dec 2023 | Jan 2024 | Feb 2024 | Mar 2024 | Apr 2024 | May 2024 | Jun 2024 | Jul 2024 | Aug 2024 |
|---|---|---|---|---|---|---|---|---|---|
| Literature Review | | | | | | | | | |
| Research | | | | | | | | | |
| Data | | | | | | | | | |
| Data | | | | | | | | | |
| Final Defense | | | | | | | | | |



## 1.6 CONCEPTUAL FRAMEWORK OF THE STUDY

This study was composed of independent variable and dependent variable. The independent variable referred to teaching Mathematics Word Problem using the Bar Model Method, and the dependent variable included students' learning achievement.

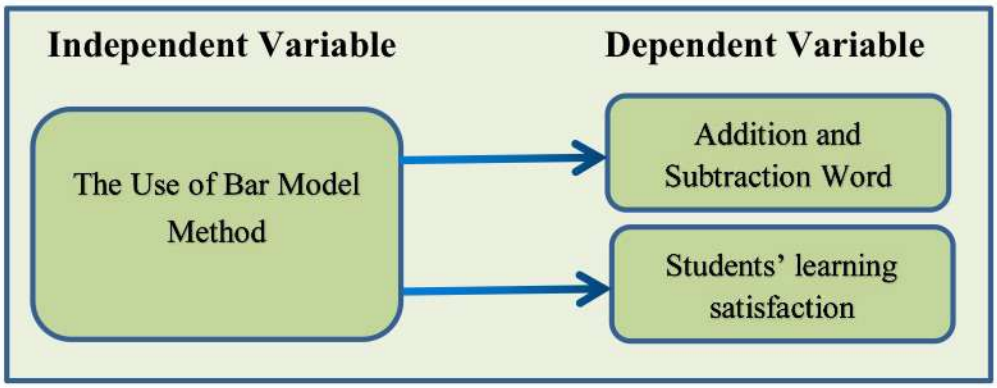



Figure 1.1 Independent Variable and Dependent Variable

## 1.7 LIMITATION OF THE STUDY

1.7.1 The study was carried out only in one section of Grade Four Bhutanese Students in one of the primary schools in Bhutan. Therefore, the finding cannot be generalized to all the Grade Four Bhutanese Students.

1.7.2 The research may provide different data if it was carried out for a longer period of time.

1.7.3 The study was confined to the use of Bar Model Method in teaching Addition and Subtraction Word Problems. Therefore, it would not reveal the performance of complete mathematics curriculum.

## 1.8 SIGNIFICANCE OF THE STUDY

1.8.1 The research expected that employing visual representations would enhance students' comprehension of mathematical concepts, allowing them to establish connections between abstract ideas and real-life situations. This approach was expected to be effective due to its ability to facilitate a more comprehensive understanding of the subject matter, which would be useful for students in various academic and practical contexts.

1.8.2 The study would expect to see more engaging and participatory classroom environment, with students actively involved in visualizing and solving

mathematical Addition and Subtraction Word Problems using the Bar Model Method.

1.8.3 The study anticipated that students who were taught the Bar Model Method would display a significant improvement in their problem solving abilities, particularly in context of Addition and Subtraction of Word Problems.

1.8.4 Potential for improved teaching effectiveness as educators incorporate the Bar Model Method into their instructional practices, leading to more successful student's learning achievement outcomes.

## 1.9 OPERATIONAL DEFINITIONS

**Bar Model Method** in this study referred to a specific instructional approach utilized by grade 4 Bhutanese students to solve Addition and Subtraction Word Problems. The Bar Model Method involves the following key steps:

1) Visual Representation:

Students utilize rectangular bars to create visual diagrams representing the quantities, relationships, and operations presented in the word problems. Each bar corresponds to a specific numerical value or concept within the problem.

2) Problem Solving Process:

Students engage with the word problems by employing the Bar Model Method to systematically analyze and represent the information provided. They manipulate the bars to reflect the given scenario and identify the relevant mathematical operations especially Addition and Subtraction required to solve the problem.

3) Recording Information:

Throughout the problem solving process, students annotate the bars with numerical values, labels, and any additional information necessary to accurately depict the problem context. This step involves recording and organizing the data in a visual format for easier interpretation and analysis.

4) Comprehension Aid:

The Bar Model Method serves as a cognitive aid to enhance students' understanding of mathematical concepts and relationships embedded within the word problems. By visualizing the problem scenario through bar diagrams, students gain clarity and insight into the problem solving process.

5) Instructional Strategy:

Educators utilize the Bar Model Method as a deliberate instructional strategy to support students' learning and mastery of Addition and Subtraction Word Problems. Teachers guide students in the application of this method, providing scaffolding and support as needed to facilitate comprehension and skill development.

Overall, the Bar Model Method in this study encompass a structured approach to problem solving that ropes visual representation and systematic reasoning to enhanced students' mathematical proficiency. It is a pedagogical tool designed to foster conceptual understanding, strategic thinking, and problem solving skills among Grade 4 Bhutanese students in the context of Addition and Subtraction Word Problems.

**Addition and Subtraction Word Problem** for the purpose of this study, an addition and subtraction word problem is defined as a mathematical exercise presented in a narrative form, where students are required to interpret and solve problems that involve combining (addition) or removing (subtraction) quantities. These problems typically require students to read and comprehend a short story or scenario, identify the relevant numerical information, and determine the appropriate operations to find the solution. The problems are designed to reflect real-life situations, helping students apply mathematical concepts to practical contexts.

**Addition and Subtraction Word Problem Achievement** in this study refers to the measurable outcomes pertaining to grade 4 Bhutanese students' proficiency in understanding, interpreting, and solving Addition and Subtraction Word Problems, assessed through learning achievement tests, performance tasks, and teacher evaluations.

**Learning Satisfaction** refers to the grade 4 Bhutanese students' satisfaction towards the use of the Bar Model Method in learning Addition and Subtraction Word Problems, as measured through semi-structured interview feedback mechanisms with the participants after the intervention. A total of five questions developed for the interview. The data collected from the semi-structured interview under the five themes aimed at assessing the students' experiences, preferences, understanding, the impact of collaborative learning, and their desire to continue using the Bar Model Method. The result of the students' interview measures the students' learning satisfaction towards the use of the Bar Model Method in learning mathematical Addition and Subtraction Word Problems.

**Grade 4 Bhutanese Students** in this study refers to the Students enrolled in the fourth grade level within the Bhutanese education system, typically aged 9 to 11 years old, and participating in the study to evaluate the impact of the Bar Model Method on their achievement in Addition and Subtraction Word Problems.

# CHAPTER 2

# LITERATURE REVIEW

This chapter presents the brief review of the literature related to the study to provide the theoretical background of the study. It discusses on; Mathematics Curriculum of Bhutan, Definitions of Mathematical Word Problem, The Challenges in Solving Mathematical Word Problems, Using Bar Model Method as Strategy to Solve Addition and Subtraction Word Problem, Benefits of Using Bar Model Method in Solving Addition and Subtraction Word Problem, Related Learning Theories, and Related Research and Studies to provide with some insights.

## 2.1 MATHEMATICS CURRICULUM IN BHUTAN

Bhutan's commitment to providing a culturally appropriate mathematics curriculum is evident in its educational history. Historically, mathematics education in Bhutan centered on imparting fundamental numeracy skills within monastic settings, deeply influenced by religious philosophy (Wangchuk, 2017). However, significant changes occurred in the mid-20th century with modernization initiatives and the establishment of formal education systems.

Established in 1961, the Royal Education Council has played a pivotal role in shaping the mathematics curriculum and methodology in Bhutan. Over time, the curriculum has evolved while preserving its cultural authenticity and integrating global best practices. Thinley (2010) highlighted the ongoing modifications made to keep the curriculum relevant, reflecting the Royal Education Council's commitment to providing quality education.

Designed to offer a comprehensive and culturally relevant education, the Bhutanese mathematics curriculum caters to students at various academic levels

(Royal Education Council, 2019). At the Grade Four level, there is a focus on developing fundamental mathematical concepts such as Addition and Subtraction to lay a strong foundation for future learning. However, the effectiveness of the curriculum relies not only on its content but also on the instructional strategies employed by teachers.

According to the Bhutanese National Curriculum Framework, mathematics education aims to cultivate critical thinking, problem solving skills, and mathematical literacy among students (Royal Education Council, 2019). While specific learning objectives and competencies are outlined, the pedagogical approaches used in classrooms play a crucial role in achieving these goals. Traditional teaching methods, emphasizing rote memorization and procedural algorithms, may hinder students' ability to comprehend and apply mathematical concepts in real-world contexts (Wangmo & Tenzin, 2019).

## 2.2 DEFINITION OF MATHEMATICAL WORD PROBLEMS

There are numerous definitions of mathematical Word Problems in the literature. Word Problems are any mathematics exercises that don't use mathematical notation and instead provide substantial background information about the problem as text (Pfannenstiel, Bryant, D., Bryant, B., & Porterfield, 2015). Comparably, Pfannenstiel et al. (2015) described a Word Problem as a set of words and numbers where students use the knowledge of mathematics to solve problems.

Johnson (2013) defined mathematics as a foundational scientific discipline exploring structural, sequential, and relational aspects inherent in counting and measurement, grounded in logical reasoning. This characterization highlights mathematics' broad significance in understanding the underlying principles governing the world. Similarly, Smith (2013) described mathematics as the "language of the universe," emphasizing its universal relevance in revealing fundamental laws and patterns governing natural phenomena. Moreover, Johnson (2013) emphasized mathematics as a tool for pattern recognition and logical reasoning, facilitating the

generation of new insights and discoveries. This portrayal underscores mathematics' interdisciplinary nature, showcasing its pivotal role in various fields and its potential to drive innovation and advancement across diverse domains of knowledge.

Moreover, Selter, Verschaffel, Greer, and de Corte (2000), mathematics is seen as a tool for fostering critical thinking skills essential for tackling Word Problems. Selter et al. (2000) argued that Word Problems serve as cognitive puzzles that require individuals to apply mathematical concepts creatively and strategically to arrive at solutions. Mathematics provides a systematic framework for organizing information, formulating hypotheses, and testing solutions, thereby promoting logical reasoning and analytical thinking skills necessary for problem solving in diverse contexts.

The study of mathematics in Bhutan involves analyzing patterns and relationships between variables, time, and space, as noted by Jigme (2015). To excel in this subject, students must develop their mathematical thinking skills through practice and application. This requires a deep understanding of concepts and their real-world applications. The updated mathematics curriculum takes a comprehensive approach, incorporating various perspectives such as humanistic, sociological, psychological, and philosophical viewpoints, as well as basic curriculum design components (Tshewang, 2015). Additionally, the curriculum addresses societal values and the needs of Bhutanese children by including value-centric topics in each chapter. This prepares students to tackle the challenges of a rapidly changing world.

According to Lesh and Zawojewski (2007), mathematical Word Problems are like cognitive puzzles that require critical thinking and problem solving skills. They argue that Word Problems engage students in complex cognitive processes, such as interpreting information, formulating problem solving strategies, and evaluating solutions. This perspective emphasizes the role of mathematical Word Problems in fostering higher-order thinking skills and metacognitive awareness. As students grapple with challenging mathematical tasks within meaningful contexts, they develop skills that go beyond simple calculations and become better at analyzing and solving problems.

Mathematical Word Problems have been approached as multimodal texts, encompassing various forms of representation, including verbal, numerical, and graphical information, as outlined by Ellis et al. (2021). This perspective highlights the importance of visual literacy and mathematical communication skills in comprehending and effectively resolving mathematical Word Problems. By presenting mathematical concepts through multiple modes of representation, Word Problems cater to a variety of learning styles and preferences, and demand a broad range of cognitive abilities. Therefore, the acquisition of visual literacy and mathematical communication skills is paramount in achieving effective problem solving abilities in mathematics.

Mathematical Word Problems are often considered as practical applications of mathematical concepts which can be used in real life. According to studies conducted by Mousley, Choo, and Mulligan (2019), Word Problems provide students with an opportunity to engage with mathematical scenarios that are relevant and authentic. This approach helps in promoting a deeper understanding of mathematical concepts and their real-world applications. Mathematical Word Problems act as a bridge between abstract concepts and practical applications, thereby enhancing students' problem solving skills and mathematical literacy.

## 2.3 CHALLENGES IN SOLVING WORD PROBLEM

Mathematical Word Problems serve as a practical application of mathematical concepts, playing a crucial role in mathematics education. However, students often encounter challenges when solving these problems, particularly in the context of Addition and Subtraction. The Bar Model Method has emerged as a promising instructional strategy for addressing these challenges and improving students' achievement in mathematical Word Problems.

### 2.3.1 Understanding Mathematical Word Problems:

One of the primary challenges in solving mathematical Word Problems lies in understanding the problem statement. Research suggests that students often struggle with interpreting the language used in Word Problems, particularly when faced with unfamiliar vocabulary or complex sentence structures (Hegarty, 2017). Additionally, students may have difficulty discerning relevant information from irrelevant details, leading to errors in problem solving (Verschaffel, Greer, & De Corte, 2017).

The skill to solve mathematical Word Problems stands as a pivotal skill for students, requiring them to interpret problem statements, identify pertinent information, and apply suitable mathematical operations. Extant research indicates that students frequently confront challenges in comprehending the language used in Word Problems, grasping the context of the problem, and choosing the appropriate problem solving strategies (Hegarty, 2017; Verschaffel, 2017). Furthermore, cognitive aspects such as limitations in working memory and cognitive overload may hinder students' problem solving proficiency (Kalyuga, Ayres, Chandler, & Sweller, 2018; Nunes & Bryant, 2019).

### 2.3.2 Cognitive Challenges:

Solving mathematical Word Problems requires various cognitive processes, including comprehension, mathematical reasoning, and strategic problem solving. Grade level students may encounter difficulties in selecting appropriate problem solving strategies and applying them effectively (Nunes & Bryant, 2019). Furthermore, cognitive overload can occur when students are presented with multiple pieces of information simultaneously, hindering their ability to focus on relevant cues (Kalyugaet al., 2018).

Additionally, Word Problems that mix words and numbers can be overwhelming for students, making it difficult for them to extract relevant information and apply appropriate problem solving strategies (Verschaffel et al., 2017).

Furthermore, Word Problems that incorporate visual displays of information, such as charts and graphs, may pose challenges for students who struggle with visual interpretation skills (Saaty & Khamis, 2020). These challenges highlight the complexity of mathematical Word Problems and the diverse cognitive demands they place on students.

To improve students' problem solving abilities and mathematical achievement, educators and curriculum developers must recognize these difficulties and develop strategies to overcome them. These strategies could include providing students with opportunities to practice solving Word Problems, breaking down complex problems into smaller, more manageable parts, and using visual aids to support learning.

The Bar Model Method, also known as the Singapore Bar Model, has gained recognition as a visual problem solving tool. This method involves representing quantities and relationships using bar diagrams, helping students visualize problem structures and relationships (Saaty & Khamis, 2020). Research suggests that the Bar Model Method enhances students' comprehension of Word Problems, facilitates problem solving, and promotes conceptual understanding of mathematical operations (Ng & Lee, 2019).

### 2.3.3 Cultural and Linguistic Factors:

Cultural and linguistic factors have a significant impact on students' proficiency in solving mathematical Word Problems (Gonzalez, Yazejian, Araujo, & Garcia, 2019). Similarly to students worldwide, Bhutanese students come from diverse cultural backgrounds and may speak multiple languages at home. This diversity influences how students approach and understand mathematical Word Problems. For example, when encountering Word Problems in a language other than their primary language of instruction, Bhutanese students may encounter language barriers. Additionally, differences in cultural contexts may present challenges for students in connecting with the scenarios presented in the problems, thus complicating their grasp of fundamental mathematical concepts.

Moreover, language proficiency, especially among English language learners, is crucial for effective problem solving. Students who are still developing their English language skills may face difficulties in understanding the language used in Word Problems, leading to challenges in comprehending problem statements and identifying relevant information for problem solving (Gonzalez et al., 2019).

Considering these factors, educators must be attentive to students' cultural and linguistic backgrounds. Providing appropriate support and accommodations ensures fair access to mathematical learning opportunities (Gonzalez et al., 2019). This could involve utilizing bilingual resources, offering language assistance, and integrating culturally relevant contexts into Word Problems. Addressing these factors allows educators to cultivate an inclusive learning environment where all students, regardless of their cultural or linguistic background, can excel in their mathematical education.

Mathematical Word Problems present significant challenges for Grade 4 Bhutanese students, particularly in the domains of Addition and Subtraction. The Bar Model Method offers a promising approach to address these challenges by providing visual representations of problem structures. By incorporating the Bar Model Method into instruction, educators can enhance students' comprehension, problem solving skills, and achievement in mathematical Word Problems. However, addressing cultural and linguistic factors is also essential to ensure equitable access to mathematical learning opportunities.

## 2.4 BAR MODEL METHOD AS STRATEGY

In the realm of mathematics education, the cultivation of effective problem solving strategies among students is of paramount importance for fostering mathematical proficiency. In particular, the comprehension and mastery of addition and subtraction Word Problems constitute a fundamental aspect of mathematical literacy. This literature review aims to explore recent scholarly research on the utilization and efficacy of the Bar Model Method as a pedagogical intervention to boost the problem solving skills of Grade 4 students in Bhutan.

The method under investigation is a visual representation strategy that employs Bar Models to help students better understand the structure of Word Problems and solve them more efficiently. The review seeks to provide a comprehensive analysis of the research findings on the Bar Model Method's effectiveness in enhancing children's mathematical achievements in Bhutan. The ultimate goal of this review is to offer recommendations for educators on how to optimize the use of the Bar Model Method in teaching addition and subtraction problem solving skills to students in the fourth grade.

### 2.4.1 Importance of Mathematical Prohlem Solving Strategies:

Mathematical problem solving extends far beyond mere procedural execution; it demands the development of conceptual understanding, critical analysis, and the adept utilization of mathematical principles within authentic contexts. This assertion is strongly supported by scholarly literature, notably highlighted by Cai and Knuth (2011) as well as Leikin, Berman, and Zaslavsky (2007). Their research underscores the fundamental significance of early exposure to problem solving tasks in fostering deeper engagement with mathematics and enhancing proficiency throughout students' educational journeys.

Effective problem solving strategies serve as potent instruments for empowering students to navigate mathematical challenges with resilience and precision. Rather than relying solely on memorization or adherence to algorithms, students equipped with proficient problem solving skills demonstrate adaptability and innovation when encountering novel mathematical scenarios. Moreover, the acquisition of robust problem solving skills extends beyond academic excellence, permeating various real-world contexts where mathematical reasoning is indispensable. Whether making informed financial decisions, interpreting complex data sets, or addressing practical challenges in daily life, individuals equipped with adept problem solving abilities are better equipped to navigate the complexities of modern society with confidence and efficacy.

In conclusion, the cultivation of effective problem solving strategies serves as a cornerstone of mathematics education, nurturing not only mathematical proficiency but also equipping students with invaluable skills for academic success and lifelong learning. Through the deliberate cultivation of conceptual understanding, critical thinking, and practical application, educators play a pivotal role in preparing students to excel academically and thrive in an increasingly intricate and dynamic world.

### 2.4.2 The Bar Model Method for Problem Solving:

The Bar Model Method represents a comprehensive approach to problem solving instruction in mathematics education, particularly renowned for its visual and concrete representation of mathematical relationships. This section explores the key components of the Bar Model Method, its implementation in classroom instruction, variations or adaptations, and strategies for effective integration into the curriculum.

The Bar Model Method, which has its roots in the Singapore Math curriculum, represents a pedagogical approach that employs visual aids, notably rectangular bars, to enhance students' mathematical proficiency (Yeap, 2017). By translating mathematical problems into graphical representations, this method facilitates a more tangible understanding of abstract mathematical concepts. Its efficacy is particularly pronounced for students encountering difficulties with grasping abstract mathematical ideas.

Utilizing the Bar Model Method in classroom instruction generally entails a structured and supportive process. Teachers commence by presenting students with Word Problems, assisting them in analyzing the problem and identifying crucial information. Subsequently, students translate the problem into a visual representation employing the Bar Model Method. This step is followed by collaborative discussions aimed at exploring diverse solution strategies (Ng & Lee, 2009). Through guided practice and a gradual transfer of responsibility, students gradually acquire proficiency in independently applying the Bar Model Method to tackle addition and subtraction Word Problems.

While the basic principles of the Bar Model Method remain consistent, educators have developed various adaptations and variations to suit diverse learning needs and preferences. For example, some educators may incorporate color-coded bars or manipulatives to enhance visual differentiation and support students with visual learning preferences. Others may introduce interactive digital tools or software applications to facilitate virtual modeling and exploration of mathematical concepts (Yeap, 2017). Additionally, educators may explore culturally relevant contexts or real-world scenarios to contextualize problem solving tasks and enhance student engagement.

This method uses visuals to help students solve complex math Word Problems and identify relevant mathematical operations. It enhances critical thinking skills and encourages efficient problem solving strategies, allowing students to tackle previously daunting challenges (Saracho & Spodek, 2008).

Educators must effectively implement and strategically plan the use of the Bar Model Method to enhance student outcomes in the classroom. Initially, teachers can employ hands-on learning and interactive lessons to improve students' understanding of mathematics using the Bar Model Method. By incorporating manipulatives and real-world examples, educators can foster student engagement, as emphasized by Ng and Phang (2017). Teachers can utilize tangible or digital tools to create visual representations of math problems, allowing students to interact with models. Moreover, the Bar Model Method can be adapted or refined to accommodate diverse learning objectives and preferences. Educators can promote equality by offering multiple pathways to mathematical content.

Effective integration of the Bar Model Method into teaching can be facilitated through collaborative planning and professional development opportunities for educators. Through collaborative discussions, peer observations, and participation in professional learning communities, educators can share best practices, refine instructional techniques, and address implementation challenges collaboratively, as highlighted by Moseley, Reinke, Burrell, and Smith (2017). Moreover, targeted

professional training sessions focusing on the Bar Model Method can enhance teachers' understanding of instructional techniques and their ability to support student learning, as demonstrated by Frykholm and Glasson (2019).

There are two types of models to be used in this study; the Bar Model Method: the part-whole model and the comparison model (Yeap, 2014). In the Bar Model Method, the rectangular bars represent the quantities that form the 'parts' as illustrated in Figure 2.1 and 2.2.

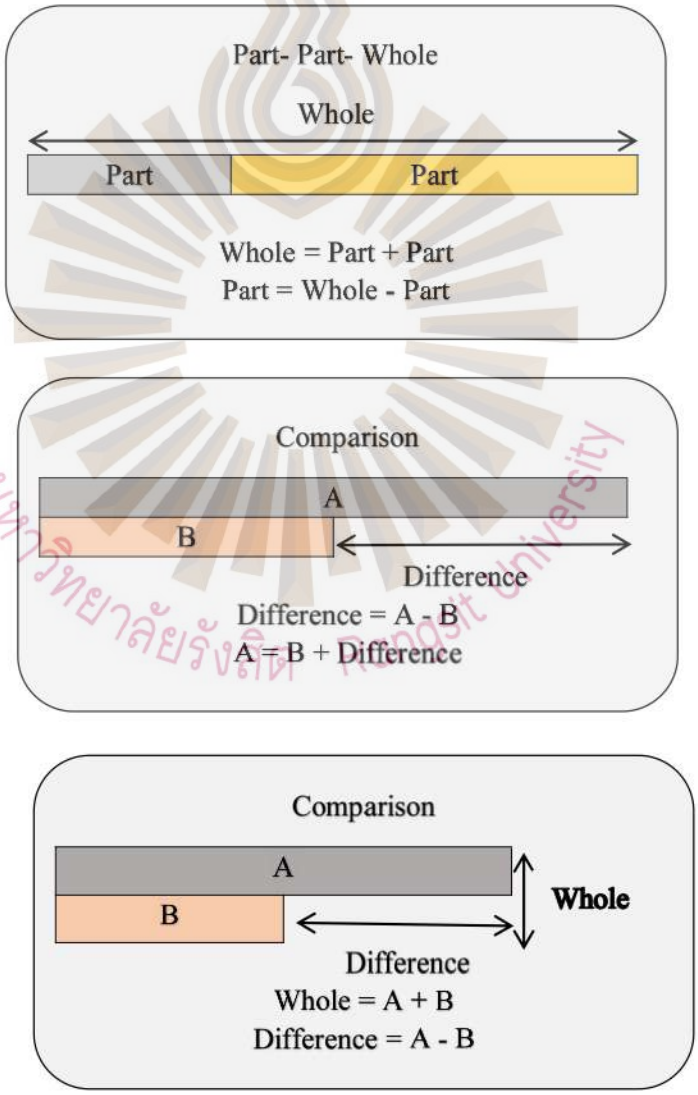



Figure 2.1 The Part-Part-Whole Models and Comparison Models

Source: Kaur, 2019

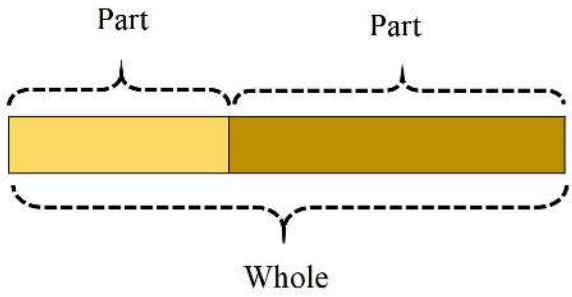



Figure 2.2 Part - whole model taken from Yeap (2014)

Source: Yeap, 2014

While the Bar Model Method has gained global acceptance, its suitability and effectiveness within the Bhutanese educational system have not received thorough examination. Bhutanese students confront specific challenges like language barriers and limited resources, which may impact their mathematical learning process (Ministry of Education, Bhutan, 2017). Hence, it is imperative to explore strategies for tailoring the Bar Model Method to meet the distinct needs of Grade 4 students in Bhutan.

### 2.4.3 Application of the Bar Model Method in Bhutanese Context:

In the educational landscape of Bhutan, unique challenges are present, including limited resources, linguistic diversity, and cultural nuances that significantly impact the mathematical learning experiences of students (Ministry of Education, Bhutan, 2017). Consequently, it is crucial to delve into the customization of the Bar Model Method to align with the particular requirements and cultural contexts of Grade 4 students in Bhutan.

Additionally, Saracho and Spodek (2008) advocate for incorporating cultural diversity into mathematics education. They argue that integrating culturally relevant examples and contexts into instructional materials can deepen students' understanding and appreciation of mathematical concepts. This approach resonates with the principles of culturally responsive teaching, which prioritize acknowledging and valuing students' cultural backgrounds and experiences.

Moreover, research by Yeap (2017) suggests that the Bar Model Method can be adapted to accommodate diverse cultural and linguistic contexts. Yeap highlights the method's flexibility and its potential to transcend language barriers by providing visual representations of mathematical concepts. This adaptability positions the Bar Model Method as a promising tool for addressing the linguistic diversity observed among Bhutanese students.

**2.4.4 Research on the Efficacy of the Bar Model Method:**

Evidence from empirical studies regarding the efficacy of the Bar Model Method in improving students' problem solving skills holds significant weight. In a comprehensive study involving primary school students and the application of the Bar Model Method, Ng and Lee (2009) observed marked improvements in students' problem solving performance. Notably, students demonstrated enhanced proficiency in addressing non-routine mathematical problems with heightened focus, underscoring the method's effectiveness in nurturing problem solving skills development.

Likewise, Ng and Phang (2017) explored the influence of problem solving models on students' conceptual understanding and performance. Their findings revealed positive effects linked with the Bar Model Method, suggesting its contribution to students' augmented comprehension and ability to handle complex problems. Educators utilized the Bar Model Method to augment students' conceptual grasp of mathematical concepts and to foster adeptness in problem solving.

Furthermore, a systematic review and meta-analysis undertaken by Gonzalez, Krawec, and Ouyang (2020) delved into the effectiveness of the Bar Model Method. Their results furnished evidence supporting the method's efficacy in enhancing students' problem solving capabilities across diverse educational contexts, aligning with earlier research findings.

Saracho and Spodek (2008) explored contemporary perspectives on mathematics education, accentuating the adoption of innovative teaching

methodologies like the Bar Model Method, especially within early childhood education frameworks.

Additionally, Hiebert, Morris, Berk, and Jansen (2017) investigated pragmatic approaches to facilitate teachers' professional growth through reflective teaching practices, with a particular emphasis on the effectiveness of pedagogical tools such as the Bar Model Method in refining instructional techniques.

The Bar Model Method emerges as a valuable pedagogical instrument for teaching mathematics, as evidenced by these studies. Its integration into mathematics education is corroborated by a burgeoning body of literature, which underscores its effectiveness and the benefits it affords for teachers' professional advancement.

## 2.5 BENEFITS OF USING BAR MODEL METHOD

In recent educational discourse, the Bar Model Method has garnered attention for its efficacy in aiding students' comprehension of mathematical concepts, particularly in the realm of solving Addition and Subtraction Word Problems. This part of review endeavors to explore the advantages associated with employing the Bar Model Method, specifically concerning the enhancement of Grade 4 Bhutanese students' achievements in tackling Addition and Subtraction Word Problems.



The Bar Model Method, also referred to as the Singapore Bar Model, serves as a visual problem solving strategy that employs rectangular bars to represent mathematical relationships. By offering a tangible representation of abstract mathematical ideas, it enables students to visualize the problem at hand, facilitating a more efficient approach to devising solutions (Suh, 2015). Through the breakdown of complex Word Problems into simplified visual representations, students can grasp the underlying mathematical relationships and concepts more readily (Verschaffel et al., 2009).

Research indicates that the Bar Model Method fosters the development of students' problem solving abilities by encouraging logical reasoning and critical thinking (Hu, Zhang, Chen, & Wu, 2016). Through the systematic organization of information and relationships within the Bar Model, students are better equipped to identify pertinent information, devise a plan, and execute a solution (Khoon, Muthalib, Ng, Fong, & Nair, 2018). Such an approach cultivates a deeper understanding of mathematics and empowers students to tackle a diverse array of Word Problems with confidence (Bobis, Mulligan, & Lowrie, 2011).

Research suggests that the use of manipulatives, such as the Bar Model Method, can lead to improvements in students' retention and recall of mathematical concepts (Choden & Chalermnirundorn, 2021). The visual nature of the Bar Model Method facilitates memory formation and retrieval by providing students with a structured framework for problem solving. Through hands-on manipulation of visual representations, students are better equipped to retain addition and subtraction strategies and apply them effectively in Word Problem contexts.

While the Bar Model Method originated in Singapore, its adoption and effectiveness have been observed in various cultural contexts, including Bhutan. The adaptability of the Bar Model Method to diverse educational settings, including Bhutan, can be attributed to its visual nature, which transcends linguistic barriers and accommodates different learning styles. The Bar Model Method's adaptability to diverse cultural contexts has been highlighted in various studies. For instance, Khoon et al. (2018) conducted research on the effectiveness of the Bar Model Method in Singapore primary schools, demonstrating its positive impact on students' understanding of algebra. This suggests that the method's principles can be applied and beneficial in educational systems beyond Singapore.

Moseley and Brenner (2017) explored the role of the bar model in promoting algebraic reasoning, emphasizing its ability to accommodate diverse learning styles. They argued that the visual nature of the Bar Model Method makes it accessible to students with different backgrounds and aptitudes.

The Royal Education Council of Bhutan (2019) outlines educational policies aimed at fostering holistic learning and nurturing critical thinking skills among Bhutanese students. The Bar Model Method's emphasis on conceptual understanding, visualization, and problem solving aligns with these objectives, making it a valuable pedagogical tool for Bhutanese educators.

While the Bar Model Method shows promise, it's essential to acknowledge potential challenges in its implementation in Bhutanese classrooms. Factors such as teacher training, curriculum alignment, and resource availability may influence the successful integration of the method into Bhutan's educational system.

Further research focusing specifically on the implementation and effectiveness of the Bar Model Method in Bhutanese educational settings would provide valuable insights. Longitudinal studies tracking student performance and perceptions, as well as qualitative investigations into teachers' experiences with the method, could contribute to a more comprehensive understanding of its impact in Bhutan.

In summary, while direct literature on the implementation of the Bar Model Method in Bhutanese schools may be limited, existing research supports its potential effectiveness based on its adaptability to diverse cultural contexts, alignment with educational objectives, and positive outcomes observed in other settings. However, more research specific to Bhutan is needed to fully understand its implications and challenges in this context.

The interactive nature of the Bar Model Method promotes active student participation in mathematics lessons. Shah (2022) noted that students actively engaged with activities associated with the Bar Model Technique, indicating a higher level of interest and involvement in problem solving tasks. This suggests that the method fosters a supportive learning environment where students feel motivated to explore and solve mathematical problems collaboratively.

The Bar Model Method offers educators an alternative approach to teaching

mathematics. By incorporating visual representations and hands-on activities, teachers can create dynamic learning experiences that cater to diverse learning needs and preferences (Shah, 2022). This flexibility in instructional delivery empowers educators to adapt their teaching methods to meet the individual needs of their students effectively.

The Bar Model Method offers numerous advantages for enhancing students' achievement in solving Addition and Subtraction Word Problems. Its emphasis on conceptual comprehension, visualization, and problem solving skills renders it a valuable instructional approach for Grade 4 Bhutanese students. By integrating the Bar Model Method into mathematics instruction, educators can empower students to develop a deeper understanding of mathematical concepts and excel in solving real-world mathematical problems.

## 2.6 RELATED LEARNING THEORIES

The use of effective instructional methods is crucial in enhancing students' understanding and achievement in mathematics, particularly in problem solving skills. This section of literature review explores relevant learning theories that underpin the use of the Bar Model Method for addressing Addition and Subtraction Word Problems among Grade 4 Bhutanese students. The review aims to provide insights into the theoretical foundations supporting the effectiveness of this method and its implications for enhancing students' learning satisfaction.

### 2.6.1 Cognitive Load Theory:

Sweller (1988) introduced the concept of cognitive load, distinguishing between intrinsic, extraneous, and germane cognitive load. Intrinsic load refers to the inherent complexity of the learning task, extraneous load pertains to the cognitive load caused by ineffective instructional design, and germane load involves the cognitive effort devoted to schema acquisition and automation. This framework highlights the importance of managing cognitive load to optimize learning.

Research has demonstrated that instructional methods that effectively manage cognitive load can enhance learning outcomes. For example, Mayer and Moreno (2003) found that reducing extraneous cognitive load through multimedia presentations led to better learning outcomes in students. Similarly, Kirschner, Sweller, and Clark (2006) argued that providing minimal guidance during instruction can overwhelm learners' cognitive resources and hinder learning. These findings underscore the significance of considering cognitive load in instructional design.

Measuring cognitive load is essential for informing instructional design practices. Paas et al. (2003) discussed various methods for measuring cognitive load, highlighting their implications for advancing Cognitive Load Theory (CLT). Accurately assessing cognitive load enables educators to design learning interventions that optimize cognitive resources and facilitate learning.

Cognitive Load Theory has practical implications for educational practice. van Merriënboer and Sweller (2005) discussed the application of CLT to complex learning tasks, emphasizing the importance of aligning instructional strategies with learners' cognitive capabilities. Additionally, Sweller, Ayres, and Kalyuga (2011) provided comprehensive insights into CLT, covering its theoretical foundations, empirical research findings, and practical implications for education and training.

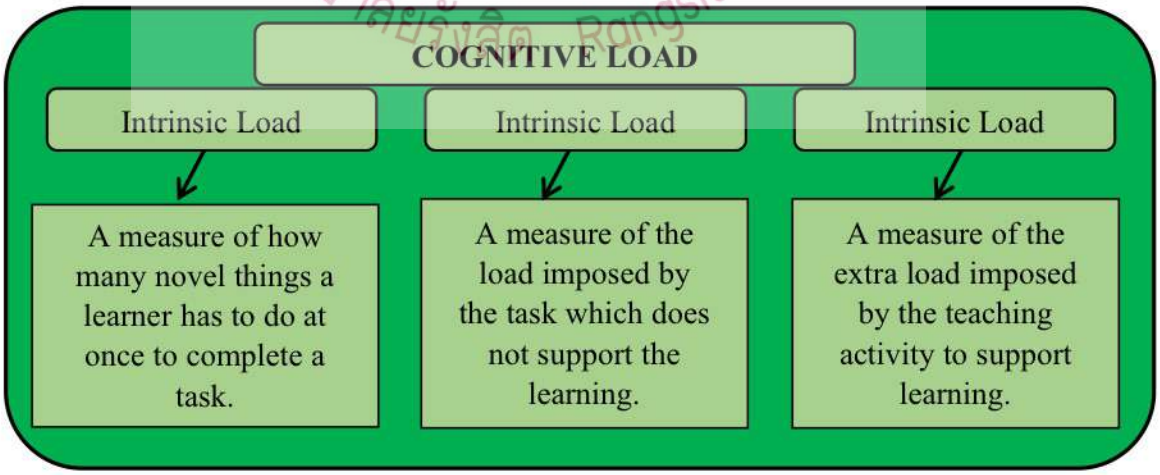



Figure 2.3 Three elements of cognitive load

Source: Clark, Nguyen, & Sweller, 2006

The Bar Model Method aligns with Cognitive Load Theory by effectively managing cognitive load during problem solving tasks. By providing visual representations of mathematical concepts, the method reduces extraneous cognitive load and enhances germane cognitive load (Sweller et al., 2011). This reduction in cognitive load enables students to focus their cognitive resources on understanding mathematical relationships and problem solving strategies.

Research by Yeap, Salleh, and Zakaria (2017) supports the effectiveness of the Bar Model Method in reducing cognitive load and improving problem solving skills among students. Their study demonstrated significant improvements in students' performance on mathematics Word Problems after implementing the Bar Model Method.

Additionally, Lee and Ng (2009) conducted research indicating that the Bar Model Method facilitates better understanding and retention of mathematical concepts, further supporting its alignment with Cognitive Load Theory.

In addition to academic achievement, assessing students' learning satisfaction is crucial for evaluating the effectiveness and acceptance of instructional methods. Chen and Gorrell (2017) highlight the significance of students' satisfaction with instructional approaches, emphasizing its influence on motivation and engagement in learning.

The Bar Model Method presents a promising approach to enhancing Grade 4 Bhutanese students' achievement in addition and subtraction Word Problems. By aligning with principles from Cognitive Load Theory and providing visual representations of mathematical concepts, the method effectively reduces cognitive load and improves problem solving skills. Additionally, assessing students' learning satisfaction offers valuable insights into their overall experience and acceptance of the instructional approach.

### 2.6.2 Jerome Bruner's Constructivist Theory of Learning and Cognitive Development

Jerome Bruner's Constructivist Theory underscores the significance of active learning and visual representations in cognitive development. This part of the literature review investigates the alignment between Bruner's theory and the Bar Model Method's application in mathematics education, specifically its impact on Grade 4 Bhutanese students' proficiency in addition and subtraction Word Problems.

Discovery Learning and the Bar Model Method

Bruner champions discovery learning, where students immerse themselves in materials and concepts to independently construct their own understanding (Bruner, 1961). The Bar Model Method seamlessly integrates with this approach by furnishing students with a visual aid to delve into and decipher mathematical relationships within Word Problems (Khoon et al., 2014). By encouraging students to manipulate bar models to illustrate problem scenarios, Bar Model Method cultivates active engagement and discovery of mathematical concepts.

Scaffolding and Cognitive Development

Moreover, Bruner introduces the concept of scaffolding, wherein knowledgeable individuals provide tailored support to learners as they navigate through new concepts (Wood et al., 1976). In the context of Bar Model Method , educators can scaffold students' comprehension by progressively introducing and guiding them in utilizing bar models to solve increasingly intricate Word Problems (Cheng & Mix, 2014). This scaffolded approach harmonizes with the study's objectives, aiming to scrutinize the efficacy of Bar Model Method in enhancing Grade 4 Bhutanese students' proficiency in Word Problem Solving.

Narrative and Contextualization

Bruner underscores the significance of narrative and context in facilitating meaningful learning, positing that embedding new information within a relevant context fosters deeper understanding (Bruner, 1990). The Bar Model Method facilitates this process by furnishing students with a tangible representation of real-world problem scenarios, thereby contextualizing mathematical concepts (Ng & Lee, 2009). Through the integration of culturally pertinent Word Problems and contextualized examples into Bar Model Method instruction, educators can amplify students' motivation and engagement, which resonates with the study's aim to assess students' satisfaction with the method.

In conclusion, Bruner's Constructivist theory provides a robust theoretical framework for clarifying how the Bar Model Method can augment Grade 4 Bhutanese students' proficiency in tackling Addition and Subtraction Word Problems. By fostering active discovery, scaffolding cognitive development, and contextualizing learning experiences, Bar Model Method presents a promising avenue for mathematics instruction that aligns with the study's objectives.

### 2.6.3 Socio-Cultural Theory

Lev Vygotsky's groundbreaking Socio-Cultural Theory underscores the pivotal role of social interactions, cultural contexts, and tools in molding cognitive development and learning (Vygotsky, 1978). This theory offers invaluable insights into educational practices, accentuating the significance of collaborative learning experiences and cultural tools in facilitating effective learning. Within the realm of mathematics education, the Bar Model Method, alongside other instructional techniques, has demonstrated its efficacy in enhancing students' problem solving skills and mathematical understanding through the lens of Socio-Cultural Theory.

The Bar Model Method, often utilized in mathematics instruction, intricately

aligns with Socio-Cultural Theory. Acting as a visual problem solving approach, it provides students with a tangible representation of mathematical problems, effectively serving as a form of 'cultural mediation' (Looi, Sun, & Wu, 2017). Through this method, students not only learn by example to tackle problems but also explore diverse ways to represent and comprehend concepts. Encouraging collaborative problem solving with peers and teachers, the Bar Model Method fosters learning within simulated social environments, nurturing discussion, collaboration, and negotiation among learners (Looi et al., 2017).

Furthermore, the Bar Model Method facilitates contextualized learning experiences, resonating with Socio-Cultural Theory's emphasis on authentic learning contexts. By tackling real-life Addition and Subtraction Word Problems, students can seamlessly apply the Bar Model Method to their everyday lives, enhancing their ability to transfer knowledge across different domains (Kirschner et al., 2006).

The application of the Bar Model Method in mathematics education gains significant illumination through the lens of Socio-Cultural Theory, which offers a robust and comprehensive framework. By emphasizing social interaction, collaborative learning, and the use of cultural tools, Socio-Cultural Theory enriches the effectiveness of the Bar Model Method in developing students' problem solving skills and mathematical comprehension.



## 2.7 RELATED RESEARCH AND STUDIES

This section of literature review synthesizes relevant studies that have investigated the use of the Bar Model Method in mathematics education and its impact on students' problem solving skills and learning satisfaction.

Yan's (2002) exploration of the Model Method in Singapore offers valuable insights into the historical and pedagogical foundations of the Bar Model Method, which serves as a precursor to the approach studied in this research. Published in The Mathematics Educator, Yan's work provides an in-depth examination of the Model

Method's development and implementation within the Singaporean mathematics education system. By tracing the evolution of this instructional technique, educators gain a deeper understanding of its theoretical underpinnings and practical applications, laying a solid foundation for exploring its efficacy in enhancing Grade 4 Bhutanese students' achievement in Addition and Subtraction Word Problems.

Moreover, Yan's (2002) study sheds light on the key features and instructional strategies associated with the Model method, offering insights into its potential effectiveness in fostering students' mathematical problem solving skills. Through detailed descriptions and illustrative examples, the study elucidates how the model method enables students to visualize and conceptualize mathematical problems, facilitating a deeper understanding of mathematical concepts and relationships. By incorporating these insights into the literature review, educators can gain a clearer understanding of the mechanisms through which the Bar Model Method operates and its potential impact on Grade 4 Bhutanese students' learning outcomes.

Furthermore, Yan's (2002) exploration of the model method in Singapore contributes to the broader discourse on innovative pedagogical practices in mathematics education. By highlighting Singapore's success in implementing the Model Method as a foundational component of its mathematics curriculum, the study underscores the importance of adopting evidence-based instructional strategies that promote conceptual understanding and problem solving proficiency.

Numerous scholarly investigations have explored the efficacy of the Bar Model Method in enhancing students' problem solving skills and mathematical comprehension. For instance, Kho (2016) conducted a study to investigate the use of the Bar Model Method in enhancing problem solving skills among elementary school students. The findings of the study revealed that students who received instruction using the Bar Model Method exhibited significant progress in their ability to solve mathematical Word Problems as compared to their counterparts who received traditional instruction methods.

Hofer's (2015) reflection, published in The STeP Journal: Student Teacher Perspectives, presents a personal narrative of integrating the Singapore bar model into problem solving activities for young learners. Through anecdotal evidence and experiential insights, Hofer discusses the challenges encountered and successes achieved in introducing the Bar Model Method to students at an early stage of their mathematical education.

This reflective study contributes nuanced perspectives to the literature on the Bar Model Method by elucidating practical considerations and pedagogical implications for its implementation. By reflecting on experiences with incorporating the Bar Model into Grade 1 problem solving tasks, Hofer (2015) offers valuable insights into the potential benefits and challenges of utilizing this method in mathematics instruction.

While Hofer's reflection primarily focuses on the introduction of the Bar Model to younger students, it provides instructive lessons and considerations applicable to Grade 4 Bhutanese students. By drawing parallels between the experiences shared in this reflection and the objectives of the present study, educators can gain a deeper understanding of the practical implications and potential adaptations of this instructional approach.

In a similar vein, Sukaviriya (2019) conducted a meta-analysis to scrutinize the effectiveness of using bar models to solve Word Problems among high school students. The meta-analysis results indicated that the Bar Model Method was significantly associated with improvements in students' problem solving abilities across various mathematical domains, including addition and subtraction. Osman et al. (2018) as well contributes to the understanding of the effectiveness of the Bar Model Method in improving students' problem solving skills.

Tan, Gan, and Chang (2018) conducted a longitudinal study to assess the long-term effects of using the Bar Model Method on students' mathematical performance. The results revealed sustained improvements in students' problem solving skills over

time, suggesting the enduring impact of this instructional approach. Furthermore, Lee and Wong (2022) conducted a comparative study to evaluate the effectiveness of different problem solving approaches, including the Bar Model Method, in enhancing students' mathematical performance. The results indicated that students who received instruction using the Bar Model Method exhibited higher levels of problem solving accuracy and efficiency compared to those who used traditional methods.

Various academic studies have explored the effectiveness of the Bar Model Method, an instructional approach aimed at solving mathematical Word Problems, in improving students' attitudes and perceptions towards mathematics. Lim, Chua, and Tan (2020) noted that the visual clarity and systematic nature of the Bar Model Method led to enhanced comprehension and self-assurance in problem solving. Similarly, Ho, Wong, and Wong (2019) observed increased interest and enthusiasm among students when taught through this method, suggesting its potential to cultivate positive learning experiences and attitudes towards mathematics.

Moreover, Wu, Adams, and Feng (2019) investigated pupils' attitudes towards utilizing bar models for solving mathematical Word Problems. Their findings indicated high levels of satisfaction among students with the Bar Model Method, citing its visual clarity and problem representation as key factors contributing to positive experiences. Additionally, Pittalis and Christou (2010) examined students' perceptions of the Bar Model Method within a mathematics classroom context, revealing favorable attitudes towards its use, particularly for understanding and solving complex mathematical problems.

Similarly, Shah, Anjum, Chand, and Tabassum (2021) conducted a study titled "Enhancing Mathematical Word Problem Solving Skills: Using Bar Model Visualization Technique" to explore the efficacy of the Bar Model Method in improving students' ability to solve mathematical Word Problems. The researchers employed the Bar Model Visualization Technique and found significant improvements in students' problem solving skills. The results indicated that the visual representation

provided by the bar models facilitated students' understanding and comprehension of mathematical concepts, leading to enhanced achievement in Word Problem solving.

Further in exploring the effectiveness of the Bar Model Method for Grade 4 Bhutanese students' achievement in Addition and Subtraction Word Problems, recent research offers valuable insights into the impact of similar instructional techniques on students' mathematical problem solving skills. One such study by Shah (2022) examined the effects of the Bar Model Technique on students' mathematical Word Problem solving abilities, contributing pertinent findings to the understanding of this instructional approach. The study is closely aligned with the objectives of the present study, particularly the aim to examine the effectiveness of the Bar Model Method in improving Grade 4 students' achievement in Addition and Subtraction Word Problems.

Shah's (2022) research provided empirical evidence supporting the use of Bar Model Method in facilitating students' problem solving skills which directly informs the investigation into the applicability of this method to Bhutanese students' mathematical learning. Further Shah concluded that the Bar Model Method was an effective method for teaching mathematical Word Problem solving skills and could help students better understand and solve Word Problems. The study also suggested that the Bar Model Method could be used as an alternative method for teaching mathematics, especially in primary education.

# CHAPTER 3

# RESEARCH METHODOLOGY

This chapter outlines the comprehensive methodology to be employed in conducting the study. It would delineate the research design, the study's population and sample, the research instruments utilized for data collection, as well as the assessment of both validity and reliability of the instruments, along with the data analysis procedure. The goal was to offer a thorough comprehension of the approach to be implemented in the study.

## 3.1 RESEARCH DESIGN

In this study, the researcher employed a mixed methodology that integrates both qualitative and quantitative approaches to investigate the learning achievement and satisfaction of Grade 4 Bhutanese students regarding the use of the Bar Model Method for Addition and Subtraction Word Problems.

In contemporary educational research, the integration of qualitative and quantitative methodologies has gained prominence as an effective approach for gaining comprehensive insights into complex phenomena (Creswell & Plano Clark, 2017). This mixed method approach offers researchers the opportunity to measure data from multiple sources, providing a deeper understanding of the research questions under investigation (Tashakkori & Teddlie, 2010). The combination of qualitative and quantitative methods allows researchers to explore both the subjective experiences and objective outcomes related to a particular phenomenon, offering a more holistic perspective (Johnson, Onwuegbuzie, & Turner, 2007).

Qualitative research methods, such as interview and observations, are valuable for capturing the richness and depth of human experiences (Morse, 1991).

Interview provide researchers with the opportunity to delve into participants' perspectives, and beliefs, offering nuanced insights that may not be captured through quantitative measures alone (O'Cathain, Murphy, & Nicholl, 2008). These methods provided a comprehensive understanding of participants' perspectives and emotions, which were often overlooked by quantitative measures alone. Specifically, interview allowed researchers to delve deeply into participants' thoughts and beliefs, offering nuanced insights that were not easily captured through numerical data.

On the other hand, quantitative research methods, including surveys and standardized tests, offer researchers the ability to quantify phenomena and test hypotheses rigorously (Teddlie & Tashakkori, 2009). Standardized tests, when used appropriately, provide objective measures of participants' performance and allow for comparisons across groups (Ivankova, Creswell, & Stick, 2006).

The integration of qualitative and quantitative methodologies in mixed method research presents numerous benefits. By integrating various data sources, researchers can bolster the validity and reliability of their findings, mitigating the limitations inherent in individual methodologies (Greene, Caracelli, & Graham, 1989). Furthermore, mixed method research allows for synergy, wherein qualitative and quantitative data offer distinct yet complementary perspectives on the research questions, fostering a more comprehensive understanding (Creswell & Plano Clark, 2017).

To summarize, the utilization of mixed method research, encompassing both qualitative and quantitative approaches, equipped researchers with a formidable tool for probing complex educational phenomena. By capitalizing on the strengths of the methodology and analyzing data, researcher could delve deeper into the subject matter and formulate more robust conclusions, ultimately propelling comprehension of educational processes and outcomes.

The study aimed to investigate the learning achievement and satisfaction of Grade 4 Bhutanese students regarding the use of the Bar Model Method for teaching

Addition and Subtraction Word Problems of a sample group. Towards the end of this, the researcher would have employed a pretest and posttest approach to gather quantitative data on the learning outcomes of the participants before and after the use of Bar Model Method. The pretest would be administered prior to the intervention, while the posttest would be conducted after the intervention. This would enable the researcher to compare the learning achievements of the sample group before and after the intervention.

In addition, the study used semi-structured interview to gather qualitative data on the satisfaction levels of the students after being taught with the use of Bar Model Method. The interview sessions were conducted with a subset of the sample group and provided insights into how Bar Model Method influenced their learning experiences. Figure 3.1 illustrates the research design of the study, which involved the pretest and posttest methodology and the semi-structured interview.

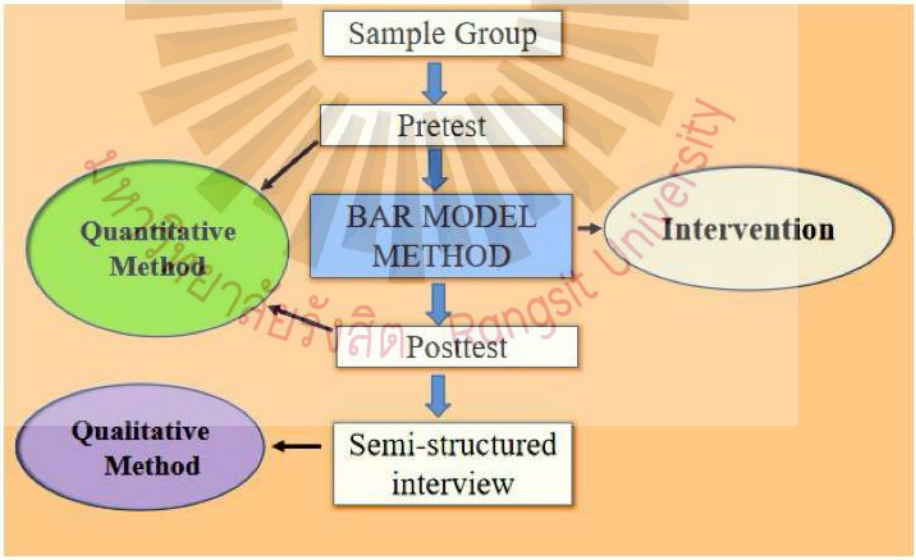



Figure 3.1 Research design of the Study

## 3.2 POPULATION AND SAMPLE OF THE STUDY

### 3.2.1 Population

The study targeted grade four students who were studying mathematics in a school in Bhutan. The school situated in SamdrupJongkhar, located in the eastern region of Bhutan, with diverse grade four students in the academic year of 2024. The student population comprised five sections, consisting of male and female students, who exhibited varying degrees of abilities. The age range of the population were of 9 to 11 years old.

### 3.2.2 Target group/ Research participants

The researcher used clustered random sampling to select 30 students from five grade 4 students as research participants for the study. The target group comprised of 30 Bhutanese grade four students for the study. Table 3.1 provides the detail of the research participants in terms of gender and age.

Table 3.1 Demographic profile of the research participants

| Gender | Male | Female | Total |
|---|---|---|---|
| Number of the students | 17 | 13 | 30 |
| Age group | 9-11 | 9-11 | |



## 3.3 RESEARCH INSTRUMENTS

To evaluate the efficacy of the teaching approach, the researcher employed both qualitative and quantitative data analysis techniques. Qualitative data analysis provided an in-depth understanding of students' satisfaction, while quantitative data analysis enabled statistical analysis and generalization of the findings. By combining

these sources of information with lesson plans, a comprehensive view of the effectiveness of the teaching approach was obtained. The key instruments used for data collection included lesson plans, achievement tests (pretest and posttest) and semi-structured interview.

### 3.3.1 Instructional Instruments

Lesson Plans

A lesson plan is essential for teachers as it provides a structured guide for instruction, ensuring that learning objectives are met efficiently. It helps organize material, allocate time effectively, and accommodate diverse student needs. Furthermore, it facilitates reflection on teaching practices and student outcomes, fostering continuous improvement (Jones, 2015).

The researcher designed four lesson plans of 90 minutes (1 lesson plan = 2 sessions) each, to teach mathematics to grade 4 Bhutanese students for Addition and Subtraction Word Problems. The lessons were taught over four weeks, with two sessions scheduled per week, resulting in a total of eight sessions. The lessons were incorporated with the use of Bar Model Method to solve the Word Problems, The lesson were presented through other media such as PowerPoint presentations, work sheets and short video clips, to provide a thorough and engaging learning experience to the research participants. (Refer Appendix D for detailed lesson plan)

Table 3.2 Lesson Plan Outline

| Lesson | Topics | Activities |
|---|---|---|
| Lesson Plan 1<br>Week 1 | Word problem: Addition of whole numbers.<br>Strategy: Use of Bar Model Method | Session 1<br>Warm up: Discussion about real-life scenarios where addition is involved. Example: Grocery shopping.<br>Lesson: Present step-by-step instructions on how to use the Bar Model Method for addition |

Table 3.2 Lesson Plan Outline (Cont.)

| | | |
|---|---|---|
| | | word problems (through visual representation)<br>Throughout the process students need to record the information and comprehend by visualizing the scenario through the bar diagrams<br>Activity: Guided and Individual Activity<br>Lesson Assessment: To review the lesson. |
| Lesson 2<br>Week 2 | Word problem: Addition of whole numbers.<br>Strategy: Use of Bar Model Method | Session 2<br>Introduction: Review the previous lesson<br>Lesson: Follow representation of Bar Models; Problem solving process. Emphasize the importance of breaking down the problem into smaller parts and representing each part with a separate bar diagram.<br>Activity: Use link to explore Bar Model through interactive game.<br>Independent Activity for more practice.<br>Lesson Assessment: To evaluate the accuracy of students' solution and the use of Bar Model Method. |
| Lesson 3<br>Week 3 | Word Problem: Subtraction of whole numbers.<br>Strategy: Use of Bar Model Method | Session 3<br>Warm up: Discussion about real-life scenarios where subtraction is involved. Example: Grocery shopping.<br>Lesson: Present step-by-step instructions on how to use the Bar Model Method for subtraction word problems (through visual representation)<br>Throughout the process students need to record the information and comprehend by visualizing the scenario through the bar diagrams.<br>Activity: Guided and Individual Activity |

Table 3.2 Lesson Plan Outline (Cont.)

| | | |
|---|---|---|
| | | Lesson Assessment: To evaluate the lesson. |
| Lesson 4<br>Week 4 | Word Problem: Subtraction and addition of whole numbers.<br>Strategy: Use of Bar Model Method | Session 4<br>Introduction: Review the previous lesson<br>Lesson: Follow representation of Bar Models; Problem solving process. Emphasize the importance of breaking down the problem into smaller parts and representing each part with a separate bar diagram.<br>Activity: Use link to explore Bar Model through interactive game.<br>Independent Activity for more practice.<br>Lesson Assessment: To evaluate the accuracy of students' solution and the use of Bar Model Method.<br>Reflection and discussion on strategies for approaching addition and subtraction word problems effectively |



### 3.3.2 Quantitative Data Collection Instrument

Pretest and Posttest

To evaluate the students' progress, a learning achievement test were administered twice: prior to and following the intervention. This assessment comprised both a pretest and a posttest. The pretest was scheduled before the intervention, while the posttest was conducted afterward, utilizing the same set of questions for the identical group of students. To determine the efficacy of the research participants' use of Bar Model Method, the researcher administered a learning achievement test. This test comprised 5 multiple-choice questions valued at 10 marks,

5 true or false questions valued at 5 and 5 short-answer questions valued at 10 marks, which totals up to 25 marks. (Refer Appendix F )

### 3.3.3 Qualitative Instruments

Semi-structured Interview

Semi-structured interview was invaluable in research, providing a flexible yet systematic approach to collecting qualitative data. It allows researchers to explore complex topics, uncover rich insights, and build rapport with participants. Overall, they contribute to the depth and richness of qualitative research findings (Smith, 2017).

Therefore, to assess students' satisfaction with the utilization of the Bar Model Method in learning Addition and Subtraction Word Problems, individual face-to-face interview were conducted with each student following the implementation of this approach. The interview, comprising five questions formulated by the researcher, was anticipated to last approximately 7-10 minutes per student. Students had the liberty to respond in either English or Dzongkha, the national language of Bhutan. The responses were audio recorded during the interview and subsequently translated and transcribed into English by the researcher. Thematic analysis were employed to analyze the collected data. For the data analysis all the questions were categorized into different themes and presented accordingly. Table 3.3 below shows the Semi-structured interview questions and the themes for each question. The 5 questions were categorized into 5 themes depending upon the statement of the question.

Table 3.3 Semi-structured Interview Questions and Themes

| No | Structured Interview Questions | Themes |
|---|---|---|
| 1 | Can you describe your experience using the Bar Model Method to solve Addition and Subtraction Word Problems during the class? | Experience |
| 2 | Can you tell one thing you liked about using the Bar Model to solve addition and Subtraction Word Problems? | Preferences |

Table 3.3 Semi-structured Interview Questions and Themes (Cont.)

| | | |
|---|---|---|
| 3 | Was there anything confusing or hard to understand about using the Bar Model Method? | Understanding and clarity |
| 4 | How did working collaboratively with your friends to solve problems using the Bar Model Method impact your learning experience? | Collaborative learning impact |
| 5 | How do you feel about using the Bar Model Method again to solve other word problems in the future? | Desire to Learn |

## 3.4 VALIDITY AND RELIABILITY OF THE STUDY

### 3.4.1 Content Validity

Ensuring validity is essential for drawing accurate conclusions and making meaningful interpretations based on research findings (Johnson, 2018). Three experts, including a professor from Rangsit University, Thailand, and two seasoned mathematics teachers from Bhutan, validated the research instruments (lesson plans, test items, and semi-structured interview questions). The validation process were employed, the Item Objective Congruence Index (IOC) to assess the alignment of the items with the learning objectives. This evaluation aimed to ascertain the validity of the instruments and ensured their appropriateness for the study. The result of the IOC index ranged from -1 to +1 as described below:

i. +1: Item clearly aligns with the given objectives.
ii. 0: Item's alignment with the objectives is unclear.
iii. -1: Item clearly does not align with the objective.

The IOC were computed using the formula: IOC $\sum = \frac{r}{n}$, where 'r' represents the rating scores provided by individual experts and 'n' signifies the number of experts. Test items with values ranging between 0.67 and 1.00 would be deemed accurate and

acceptable. Conversely, items with values below 0.67 indicated the need for rephrasing based on the suggestions and feedback provided by the experts.

All instruments used in this study were validated and received expert ratings above 0.67, indicating their appropriateness for the study. The lesson plans and test questions for learning achievement received an IOC rating of +1 (see Appendix E for the Validity Report by Experts for Lesson Plan and Appendix G for the Validity Report by Experts for Learning Achievement Test). The semi-structured interview questions received a rating of +1 as well, which exceeds the threshold of 0.67 (see Appendix I for the Validity Report by Experts).

### 3.4.2 Reliability

Establishing reliability ensures that research findings are dependable and can be replicated by other researchers (Smith, 2019). A research instrument is considered reliable if it produces consistent results when administered repeatedly under similar conditions. To check the reliability of the achievement test, the researcher would conduct pilot test. This test comprised 9 multiple-choice questions valued at 9 marks, 5 true or false questions valued at 5 marks, which totals up to 14 marks, with a section (30 students) of grade 5 students from one the school in SamdrupJongkhar district, Bhutan. Kuder- Richardson formula (KR-20) was applied to find out the reliability coefficient of the learning outcome test. The KR-20 coefficient should be equal to or greater than 0.70 for the instruments to be reliable.

In the pilot test conducted in grade 5, the obtained coefficient was 0.71 (see Appendix J for the Reliability Test Report). This indicated that the coefficient of 0.71 exceeds the 0.70 threshold, demonstrating that the test items were reliable.

## 3.5 DATA COLLECTION PROCEDURE

### 3.5.1 Ethical Consideration

3.5.1.1 Approval

The researcher sought approval process from the Research and Development Institute at Rangsit University. Subsequently, official approval was obtained from the Ministry of Education and Skills Development in Bhutan (MoESD, the Chief Thromde Education Officer (CTEO), the Principal, the Head of the subject Department, and the relevant subject teacher at the research school prior to the commencement of data collection. Given that the research participants were minors, it was imperative that the parents of each participant thoroughly reviewed and comprehended the contents of the consent letter before affixing their signature. This precautionary measure was implemented to ensure the protection of the rights of the research participants throughout the duration of the study.

3.5.1.2 Anonymity of the Participants

The confidentiality and anonymity of participants' information, included their personal details, opinions, and interview records, were strictly maintained throughout the study. Participants were not identified by their names but rather by assigned numbers (e.g., STD 001, STD 002, STD 003) to safeguard their confidentiality. This protocol were communicated to the students prior to the commencement of the study.

## 3.6 DATA ANALYSIS

To analyze the data, the following two points were considered:

i. The analysis of test scores to find the impact of Bar Model Method on learning achievement in solving Addition and Subtraction Word Problem.

ii. Content analysis of interview to find the student's satisfaction toward the use of Bar Model Method in solving Addition and Subtraction Word Problem.

### 3.6.1 Analysis for learning achievement

To assess the extent of students' learning achievement, both pretest and posttest were conducted before and after implementing the Bar Model Method in solving Addition and Subtraction Word Problems. The scores obtained from these tests were subjected to analysis using a paired samples T-Test through appropriate software. This analysis involved comparing means, standard deviations, and determining significance values.

### 3.6.2 Analysis for learning satisfaction

Given the mixed method approach employed in this study, a Semi-structured interview was undertaken to explore the nuanced perspectives and enhance comprehension regarding students' satisfaction with the use of Bar Model Method in solving Addition and Subtraction Word Problem. Subsequently, the data collected through these Semi-structured interview underwent through analysis, involving thematic analysis.

# CHAPTER 4

# RESULT AND DATA ANALYSIS

In this chapter, the researcher highlights the findings of the study on the Use of Bar Model Method For Addition And Subtraction Word Problem Achievement Of Grade 4 Bhutanese Students. The data were analyzed in two parts. The first set of data analyzed was data gathered through Pretest and Posttest which responded to Research Question One. The second set of data gathered through Semi-Structured Interview was analyzed through content analysis of which findings were used to respond to Research Question Two.

The findings from the data are presented as follows:

4.1 Analysis of Learning Achievement

4.2 Analysis of Student learning Satisfaction

## 4.1 ANALYSIS OF LEARNING ACHIEVEMENT

The first objective of this research was to examine the effectiveness of the Bar Model Method on Addition and Subtraction Word Problem achievement of Grade 4 Bhutanese students. The pretest and posttest comprising 13 questions were administered with 30 Grade 4 Bhutanese students before and after the intervention was made. The comparison of pretest and posttest scores of the research participants was done using paired sample t-test to determine the effectiveness of using Bar model Method in a Bhutanese classroom. The comparisons were made based on the mean, standard deviation, and significance value (P-Value). The comparison was also done 'within the group' by comparing the pretest and the posttest scores of the sample group.

### 4.1.1 Data Analysis of the Learning Achievement

The data collected from the pretest and posttest scores were analyzed to compare the learning achievements of the Grade 4 Bhutanese students before and after using the Bar Model Method as described in Table 4.1.

Table 4.1 Comparison of Pretest and Posttest

| Pre- Post Test | | | | |
|---|---|---|---|---|
| STD | Pretest | Posttest | Increased in Test score | % Difference |
| STD 001 | 4.00 | 13.50 | 9.50 | 38 |
| STD 002 | 11.50 | 15.00 | 3.50 | 14 |
| STD 003 | 9.00 | 22.00 | 13.00 | 52 |
| STD 004 | 12.00 | 17.00 | 5.00 | 20 |
| STD 005 | 14.50 | 21.50 | 7.00 | 28 |
| STD 006 | 11.00 | 15.00 | 4.00 | 16 |
| STD 007 | 9.00 | 15.50 | 6.50 | 26 |
| STD 008 | 6.00 | 15.00 | 9.00 | 36 |
| STD 009 | 11.00 | 19.00 | 8.00 | 32 |
| STD 010 | 12.50 | 19.50 | 7.00 | 28 |
| STD 011 | 18.00 | 19.00 | 1.00 | 4 |
| STD 012 | 10.00 | 17.50 | 7.50 | 30 |
| STD 013 | 10.00 | 18.50 | 8.50 | 34 |
| STD 014 | 14.00 | 22.00 | 8.00 | 32 |
| STD 015 | 12.00 | 16.50 | 4.50 | 18 |
| STD 016 | 12.00 | 17.50 | 5.50 | 22 |
| STD 017 | 20.00 | 22.50 | 2.50 | 10 |
| STD 018 | 16.00 | 18.50 | 2.50 | 10 |

Table 4.1 Comparison of Pretest and Posttest (Cont.)

| Pre- Post Test | | | | |
|---|---|---|---|---|
| STD | Pretest | Posttest | Increased in Test score | % Difference |
| STD 019 | 11.00 | 17.00 | 6.00 | 24 |
| STD 020 | 9.00 | 14.50 | 5.50 | 22 |
| STD 021 | 13.00 | 18.50 | 5.50 | 22 |
| STD 022 | 5.00 | 18.50 | 13.50 | 54 |
| STD 023 | 11.50 | 19.00 | 7.50 | 30 |
| STD 024 | 19.00 | 22.50 | 3.50 | 14 |
| STD 025 | 14.00 | 23.00 | 9.00 | 36 |
| STD 026 | 17.00 | 20.50 | 3.50 | 14 |
| STD 027 | 15.00 | 22.00 | 7.00 | 28 |
| STD 028 | 6.50 | 14.00 | 7.50 | 30 |
| STD 029 | 20.00 | 24.50 | 4.50 | 18 |
| STD 030 | 10.50 | 17.00 | 6.50 | 26 |

Table 4.1 serves two purposes, it complements the descriptive statistical analysis results and gives a clear view of how each student's scores improved in the posttest compared to the pretest. The student with the greatest improvement was STD 022, who scored 13.5 marks higher in the posttest than the pretest showing the highest improvement percentage as 54%, achieved by 1 student. Student STD 011 showed the lowest improvement, scoring only 1 mark higher in the posttest than the pretest with the improvement percentage of 4 %. It is important to note that all students were able to increase their scores in the posttest compared to the pretest. The finding are further elaborated in figure 4.1 and 4.2 as below.

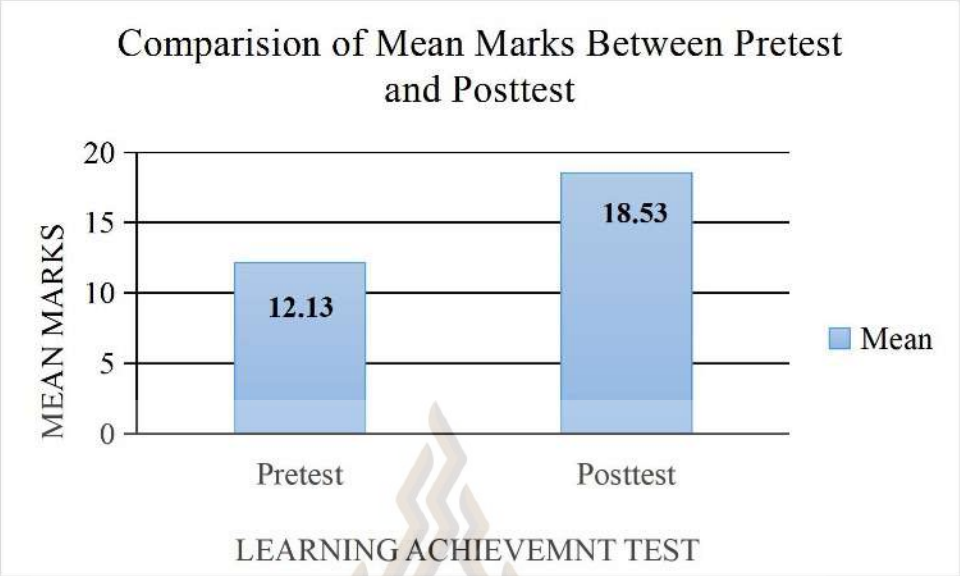



Figure 4.1. Pretest and Posttest Mean Comparison

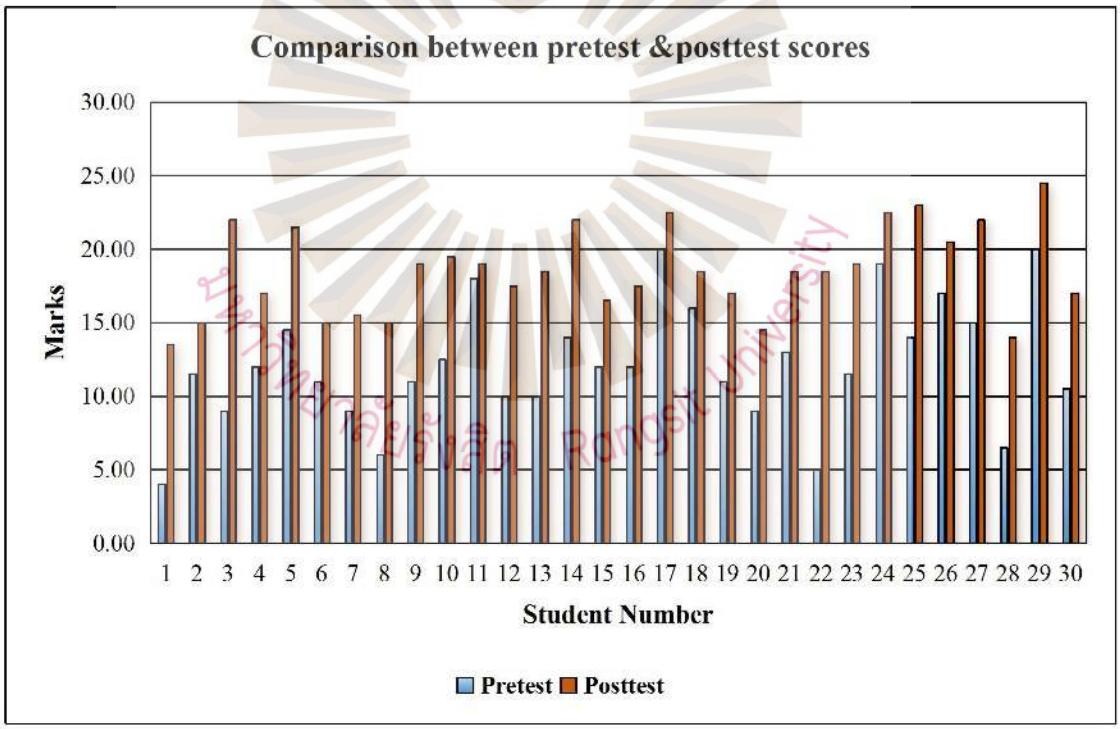



Figure 4.2. Comparison between pretest & posttest scores

The mean scores following the intervention were considerably higher than those before the intervention, with the pretest mean score at 12.13 and the posttest mean score at 18.53. This indicated a significant improvement in participants' learning achievement.

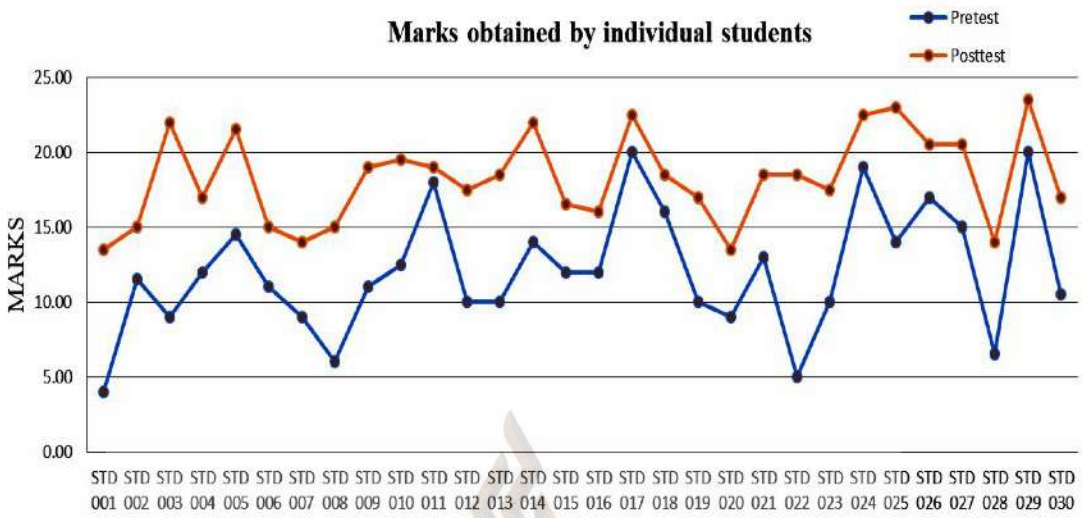



Figure 4.3 Comparative representation of individual student learning achievement scores in Pretest – Posttest

Figure 4.3 clearly demonstrates that the average score post intervention surpassed the pre intervention average score. Overall, these results suggested that employing the Bar Model Method significantly enhanced the Addition and Subtraction Word Problem learning outcomes of Grade 4 Bhutanese students. After the intervention using the Bar Model Method, the posttest scores (red line) showed a noticeable improvement across all students. The scores ranged from 13.5 to 24 marks, with the majority of students scoring closer to the upper end of the scale. This significant shift in the distribution of scores suggested that the Bar Model Method had a positive impact on the students' ability to solve addition and subtraction word problems.

The range of scores in the pretest was broad, highlighting varying levels of prior knowledge and skills. However, in the posttest, the scores were more clustered towards the higher end, indicating that the Bar Model Method helped to elevate the lower-performing students closer to the level of their higher-performing peers.

Students who initially scored lower on the pretest showed some of the most significant improvements in the posttest, suggesting that the visual and structured nature of the Bar Model Method particularly aided those who were struggling. High

performing students in the pretest maintained or slightly improved their scores, indicating that the method also supported continuous learning for students already performing well.

Table 4.2 Paired Samples Correlations

| | | N | Correlation | Sig. |
|---|---|---|---|---|
| Pair 1 | Pretest & Posttest | 30 | .71 | .000 |

Table 4.3 Samples T-Test

| | Mean | Std. Deviation | Mean difference | t | Sig.(2-tailed) |
|---|---|---|---|---|---|
| Pretest | 12.13 | 4.16 | 18.53-12.13=6.4 | 12.006 | .000 |
| Posttest | 18.53 | 3.09 | | | |

The paired sample test was conducted to compare the pretest and posttest scores of 30 Grade 4 Bhutanese students, aiming to evaluate the effectiveness of the Bar Model Method on their performance in Addition and Subtraction Word Problems. The elaborated analysis of table 4.2 and 4.3 are as below.

The Paired Samples Correlations (Table 4.2) showed a strong positive correlation coefficient of .71 between pretest and posttest scores, with a p-value of .01. This significant correlation suggested that students who performed well in the pretest tended to maintain their performance in the posttest, and those who struggled initially showed consistent improvement.

The Samples T-Test (Table 4.3) further confirmed these findings. The mean score for the pretest was 12.13, while the mean score for the posttest increased to 18.53. This indicated an average improvement of 6.40 points, suggesting that the Bar Model Method significantly enhanced students' performance in solving Addition and Subtraction Word Problems. The mean difference of 6.40 represented the average increase in scores from the pretest to the posttest. This substantial improvement

underscored the effectiveness of the Bar Model Method in enhancing students' mathematical problem-solving abilities.

The standard deviation for the pretest scores was 4.16, which decreased to 3.09 in the posttest. This reduction in standard deviation indicated that the scores became less dispersed and more consistent after the intervention. It suggested that the Bar Model Method not only improved overall scores but also helped standardize students' understanding and performance.

In summary, the paired sample test analysis demonstrated a significant improvement in the students' scores after the Bar Model Method intervention. The substantial increase in the mean scores, coupled with the strong positive correlation and highly significant statistical test results, confirmed that the Bar Model Method effectively enhanced the mathematical performance of Grade 4 Bhutanese students for Addition and Subtraction Word Problems. These results supported the hypothesis and objectives of the study, highlighting the Bar Model Method as a valuable teaching strategy in this educational context.

The data clearly indicated that the Bar Model Method is an effective strategy for enhancing students' understanding and performance in solving Addition and Subtraction Word Problems. The method appeared to have leveled the playing field, helping all students, regardless of their initial proficiency, to achieve better results. This improvement suggested that the Bar Model Method could be a valuable addition to the instructional strategies used in Grade 4 mathematics classes in Bhutan.

## 4.2 ANALYSIS OF SEMI-STRUCTURED INTERVIEW

In order to respond to the second research question, the qualitative data was collected through semi-structured interviews. The objective of the study was to determine Grade 4 Bhutanese students' learning satisfaction towards the use of Bar Model Method in the Addition and Subtraction Word Problem. The researcher conducted interview with the research participants at the end of the intervention with

the students of the target group. Due to the time constraint and the convenience of the research participants, randomly selected 20 students out of 30 students. To protect the anonymity and the privacy of the research participants, the research used the same student code which was used during the pretest and posttest.

A total of five questions were developed for the interview after validation and approval by three experts. The data collected from the semi-structured interviews were aimed at assessing the students' experiences, preferences, understanding, the impact of collaborative learning, and their desire to continue using the Bar Model Method.

### 4.2.1 Experience

The semi-structured interview provided insightful responses regarding the students' experiences with the Bar Model Method. Student STD 001 noted, "I found it really helpful because it made the problems easier to understand." Another student STD 002 reflected, "At first, it was a bit confusing, but once I got used to it, I liked using it for solving problems." Additionally, student STD 009 mentioned, "I enjoyed it because it was different from how we usually solve math problems."

Taking into account the opinions shared above, it revealed a varied initial reaction to the Bar Model Method. Initially, some students found it challenging to grasp the new approach, which is expected when a novel method is introduced. However, as they adapted, the majority recognized the benefits, particularly in simplifying complex word problems. This shift from confusion to understanding highlighted the method's effectiveness in enhancing students' cognitive grasp of mathematical concepts. Furthermore, the novelty of the Bar Model Method played a significant role in sustaining student interest and engagement, indicating that innovative teaching techniques can rejuvenate students' enthusiasm for learning. This finding suggests that incorporating new and creative methods in teaching may lead to improved learning outcomes and greater student involvement.

### 4.2.2 Preferences

Students expressed a clear preference for the visual representation provided by the Bar Model Method. The ability to break down word problems into smaller, manageable parts was a significant advantage, as it provided a clear pathway for solving the problems. One student STD 18 mentioned, "I liked that I could see the parts of the problem clearly," which highlighted how the visual segmentation of problems helped in understanding the individual components of the equation. Another student STD 007 said, "It helped me understand where to start and what steps to take," indicating that the Bar Model Method provided a structured approach that guided students through the problem-solving process.

Furthermore, the enjoyment derived from drawing the bars, as noted in the response by STD 15, "I liked drawing the bars because it made the problem look easier," underscored the importance of engaging students through interactive and visual methods. Further another student STD 005, "I enjoyed seeing the problem broken down visually." This method aligned with the cognitive development stage of Grade 4 students, who benefit from visual and hands-on learning aids. The positive reception of drawing bars indicated that integrating visual elements into math instruction could significantly enhance students' understanding and retention of mathematical concepts.



Overall, the responses suggested that the Bar Model Method not only made mathematical problems more approachable and less intimidating for students but also aligned well with their developmental needs. The visual clarity and structured approach provided by the Bar Model Method catered to the students' preference for interactive and visual learning, thereby improving their overall learning experience and outcomes in mathematics. This reinforces the potential of visual learning tools in elementary education, particularly in subjects that students often find challenging, such as mathematics word problems.

### 4.2.3 Understanding and Clarity

The initial responses from students highlighted a common theme of confusion and difficulty in understanding the mechanics of the Bar Model Method. Several students, such as the one STD 017 who said, "At first, I didn't know how to draw the bars correctly," pointed out the challenge in accurately representing the problem visually. This initial struggle is expected when introducing a new and unfamiliar method. Another student STD 011 echoed this sentiment, stating, "Sometimes I got mixed up with where to put the numbers," which indicated that the placement of numerical values within the Bar Model posed a significant challenge.

However, despite these early difficulties, students reported that their understanding improved with practice. Student STD 030 mentioned, "It was confusing at the start, but then it got easier," suggesting that familiarity with the method played a crucial role in overcoming the initial confusion. Another student STD 004 elaborated, "I had trouble understanding how to break down the problems into bars," which underscored the necessity of guided practice to help students internalize the steps involved in using the Bar Model Method.

Further complicating the initial learning process, a student STD 006 noted, "I wasn't sure how long the bars should be," highlighting that visual proportionality and scale could be additional hurdles. This aspect of the method required students to not only understand the concept but also to develop a sense of spatial representation.

Another important aspect was highlighted by a student STD 007 who said, "It took a while to remember which part of the bar represented which number." This indicated the cognitive load involved in keeping track of various components of the Bar Model and their corresponding numerical values. This confusion, however, was largely resolved over time, as indicated by the student who mentioned, "After some practice, it became clear, but the beginning was hard."

The process of moving from confusion to clarity was further emphasized by the response of STD 013, "After some practice, it became clear, but the beginning was hard." This indicated that while the Bar Model Method has a learning curve, it becomes more intuitive with consistent use and practice. The transition from initial difficulty to eventual clarity suggested that students needed time and repeated exposure to master this visual representation technique.

Overall, the feedback indicated that while the Bar Model Method initially presented challenges, these were largely conquerable with adequate practice and instructional support. The positive shift in understanding after overcoming the initial hurdles demonstrated the method's potential for successful integration into the curriculum. This finding highlighted the importance of patience and persistent practice when introducing new educational techniques, as well as the need for teachers to provide ongoing guidance and support to facilitate student comprehension.

### 4.2.4 Collaborative Learning Impact

The theme of collaborative learning impact, based on the responses from the semi-structured interview, revealed both positive and negative experiences among the students. Some students expressed favorable views on working collaboratively. For instance, one student STD 012 stated, "I liked discussing the problems with my friends; it helped me understand better." Another student STD 008 mentioned, "We could help each other when someone didn't understand." One of another positive response was STD 003, "Working together made it more fun and less stressful." These responses highlighted the benefits of collaborative learning, such as enhanced understanding, mutual support, and a more enjoyable, less pressured learning environment.

However, not all students shared this positive experience. One student STD 026 responded negatively, saying, "I don't like working in a team as some friends don't cooperate working together. Some friends don't contribute in the team." This response indicated that while collaborative learning has the potential to improve understanding and make learning more enjoyable, it also poses challenges. These challenges included

issues with team dynamics, such as lack of cooperation and unequal participation, which could hinder the effectiveness of the collaborative learning process.

The analysis of these mixed responses suggested that while the Bar Model Method could foster a positive collaborative learning environment for many students, it is also important to address the dynamics within groups to ensure that all students benefited equally. Strategies such as setting clear expectations for group work, providing guidance on effective collaboration, and ensuring equal participation could help mitigate the negative aspects and enhance the overall collaborative learning experience. This nuanced understanding of collaborative learning highlighted the importance of fostering not only the method but also the environment in which it was implemented, to maximize its benefits for all students.

### 4.2.5 Desire to Learn

The desire to continue using the Bar Model Method was strong among students, reflecting their positive experience with the method. Several students explicitly stated their preference for using the Bar Model Method in future mathematical problems, highlighting its role in making mathematics word problems easier and more accessible. One student STD 014 mentioned, "I would like to use it again because it makes mathematics word problem easier to understand and solve," which underscored the method's ability to simplify complex concepts and enhance understanding.

Another student STD 002 expressed a general willingness to use the method for various problems, saying, "Yes, I want to use it for other problems too." This response indicated that the Bar Model Method has been internalized as a useful tool, extending beyond the specific context of addition and subtraction word problems. The student's readiness to apply the method to different mathematical challenges suggested that it has become a versatile strategy in their problem-solving toolkit.

Moreover, a third student STD 025 highlighted the confidence gained from using the method: "I feel more confident with this method, so I want to keep using it."

This response revealed the empowering effect of the Bar Model Method on students' self-efficacy in mathematics word problems. The structured and visual approach not only aided in understanding but also boosted students' confidence in their mathematical word problem abilities, encouraging them to tackle more challenging problems.

Overall, the positive feedback and enthusiasm for the Bar Model Method suggested that it has successfully instilled a long-term interest in mathematics word problems among students. The method's ability to make solving Addition and Subtraction Word Problems more comprehensible and less intimidating fostered a willingness to engage with mathematical concepts and problems beyond the classroom. This enthusiasm indicated that the Bar Model Method has the potential to provide lasting benefits for students' mathematical development, encouraging continuous learning and application of mathematical word problems.

The semi-structured interview provided valuable insights into the students' experiences with the Bar Model Method. Overall, the method was well-received, with students appreciating its clarity, structure, and visual nature. Initial challenges overcame through practice and collaborative learning, highlighting the importance of peer interactions and consistent instructional support. The students' positive responses and eagerness to continue using the Bar Model Method suggested that it was an effective tool for enhancing mathematical addition and subtraction word problem learning outcomes in Grade 4 Bhutanese students. These findings aligned with educational theories that emphasized the importance of visual learning aids and collaborative learning environments in improving student engagement and achievement.

# CHAPTER 5

# CONCLUSION, DISCUSSION AND RECOMMENDATIONS

This chapter provides a summary of the study's conclusions based on the findings presented in Chapter 4. Following the conclusions, there is a detailed discussion of the findings, and the chapter concludes with recommendations for practice and suggestions for future research.

## 5.1 CONCLUSION

This study aimed to examine the effectiveness of the Bar Model Method in improving the addition and subtraction word problem-solving abilities of Grade 4 Bhutanese students. The findings from both quantitative and qualitative analyses had shown that the Bar Model Method significantly enhances students' mathematical performance and understanding.

### 5.1.1 The Results of Learning Achievement Data Analysis

The quantitative data revealed a substantial increase in the mean scores from the pretest (12.13) to the posttest (18.53), indicating a significant improvement in students' performance after the intervention. The paired sample t-test confirmed that this improvement was statistically significant ($p < .01$), demonstrating the method's efficacy in a measurable way.

This substantial increase in mean scores highlighted the effectiveness of the Bar Model Method in enhancing students' mathematical Word Problem abilities. The improvement in scores suggested that students were able to better understand and solve Addition and Subtraction Word Problems using the visual and structured approach of the Bar Model Method. This method helped students to break down

complex problems into smaller, manageable parts, making it easier for them to identify the necessary steps to find the solutions.

The statistical significance of the results underscored the reliability of the Bar Model Method as an instructional tool. The significant p-value indicated that the observed improvement in students' performance was not due to chance, but rather a direct result of the intervention. This confirmed that the Bar Model Method was an effective teaching strategy for improving mathematical problem solving skills among Grade 4 students in Bhutan.

### 5.1.2 The Results of Students' Learning Satisfaction Questionnaire analysis

The Students' Learning Satisfaction Questionnaire provided valuable qualitative insights into the students' perceptions and attitudes towards the Bar Model Method. The majority of students reported a high level of satisfaction with the Bar Model Method, highlighting its ease of use and effectiveness in making complex problems more understandable.

Students expressed that the visual representation of problems through the Bar Model Method made it easier for them to comprehend and solve Word Problems. They appreciated how the method allowed them to break down problems into smaller parts, providing a clear pathway for solving them. This aligned with the cognitive development stage of Grade 4 students, who benefited greatly from visual aids and hands-on learning activities.

Feedback from the students also indicated that the Bar Model Method helped them identify where to start and what steps to take when solving problems. This structured approach reduced their anxiety and confusion, leading to a more positive learning experience. Many students noted that drawing the bars made the problems look simpler and less intimidating, which boosted their confidence in their mathematical Word Problem abilities.

Furthermore, the collaborative aspect of using the Bar Model Method was highlighted by several students. They reported that working together with their peers to solve problems was enjoyable and beneficial. It allowed them to discuss different strategies, helped each other understand the concepts, and learned from their peers. This collaborative learning environment not only enhanced their understanding but also made the learning process more engaging and enjoyable.

However, it was worth noting that some students found working in teams challenging, especially when some peers did not cooperate or contribute equally. Despite this, the overall feedback was positive, indicating that the Bar Model Method had a favorable impact on students' learning satisfaction.

In conclusion, the analysis of the Students' Learning Satisfaction Questionnaire supported the effectiveness of the Bar Model Method in improving students' mathematical Addition and Subtraction Word Problem performance and enhancing their learning experience. The method's visual and structured approach, combined with its ability to engage students collaboratively, made it a valuable tool in teaching Addition and Subtraction Word Problems to Grade 4 students in Bhutan.

## 5.2 DISCUSSION

Discussions on the major findings are done hereafter according to the research objectives. All the findings of the study would be substantiated by the past studies and research as mentioned in the preceding chapters.

### 5.2.1 Students' Learning Achievement

The findings of this study aligned with existing literature that emphasized the benefits of visual learning tools in mathematics education. The significant improvement in test scores, from a pretest mean score of 12.13 to a posttest mean score of 18.53, suggested that the Bar Model Method effectively supported cognitive development by breaking down complex problems into more manageable parts. This

supported cognitive theories, such as Bruner's Theory of Instruction, which advocate for the use of visual aids to scaffold learning and aid in the retention of new information (Bruner, 1966). The application of the Bar Model Method did encourage greater student engagement and collaboration. Students who previously found word problems challenging became more confident in their approach to solving these tasks, often using the Bar Model to illustrate their reasoning in class discussions. This aligns with Vygotsky's theory of Social Constructivism, which posits that learning is enhanced through social interaction and collaboration (Vygotsky, 1978). The Bar Model Method fostered an environment where students could share and explain their problem-solving strategies, thereby reinforcing their understanding and increasing their overall performance.

Numerous studies had highlighted how visual aids could significantly enhance students' understanding and retention of mathematical concepts (Van Garderen, 2006). The paired sample t-test confirmed that the improvement in test scores was statistically significant ($p < .01$), demonstrating the efficacy of the Bar Model Method in a measurable way. This was particularly beneficial at the Grade 4 level, where students, transitioning from basic arithmetic to more complex problem-solving tasks. According to Mayer's Multimedia Learning Theory, structured visual representations could reduce cognitive load and improve learning outcomes (Mayer, 2009).

However, some challenges were noted, particularly in the initial stages of adopting the Bar Model Method. Some students found the new approach confusing at first. For example, a student mentioned, "At first, I didn't know how to draw the bars correctly," underscored the need for adequate training and gradual implementation. This initial confusion was not uncommon when introducing new teaching methods and highlighted the importance of providing comprehensive instructional support (Sweller et al., 2011). Over time, as students practiced and became more familiar with the method, their ability to use the Bar Model improved, demonstrating the method's potential for long-term integration into the curriculum.

Furthermore, When analyzing the minimal improvement in one student's (Student STD 011) test scores, which increased by only 1 mark from pretest to posttest, several factors need to be considered. According to Vygotsky's theory of the Zone of Proximal Development (ZPD), this slight improvement may suggest that the instructional methods were not sufficiently scaffolded to meet the student's specific learning needs due to the short duration of the research. The minimal score increase could indicate a misalignment between the student's current cognitive development stage, as described by Piaget, and the complexity of the material presented during the intervention.

Moreover, Mayer's cognitive theory of multimedia learning highlights that if instructional strategies do not effectively reduce cognitive load, students might struggle to process and internalize new information, leading to only marginal performance improvements. Additionally, external factors such as test anxiety, as discussed by Cassady and Johnson (2002) could have adversely affected the student's ability to perform, further contributing to the limited score increase.

In conclusion, the modest improvement in this student's score may be attributed to a combination of inadequate instructional alignment with the student's developmental stage, cognitive overload, and potential external influences. These findings underscore the need for more personalized and supportive instructional approaches to address the specific challenges faced by individual students.

### 5.2.2 Students' Learning Satisfaction

Semi-structured interview was the instrument used for collecting the data pertaining to the second objective.

Students' qualitative feedback regarding their satisfaction with the Bar Model Method provided valuable insights into its practical application and acceptance in the classroom. The majority of students reported a positive experience, expressing that the visual and structured nature of the Bar Model made Word Problems more

approachable and less intimidating. This was consistent with findings from previous studies that suggested visual learning tools could enhance student engagement and motivation (Boaler, 2016).

For instance, students expressed their preferences with comments like, "It helped me understand where to start and what steps to take," and "I liked drawing the bars because it made the problem look easier." These responses highlighted the method's ability to break down complex tasks into simpler steps, thus improving students' confidence in their problem solving abilities. This aligned with the cognitive development stages of Grade 4 students, who benefited significantly from visual and hands on learning aids (Mayer, 2009).

The analysis also revealed some challenges related to understanding and clarity. A few students initially struggled with the mechanics of the Bar Model Method, such as correctly drawing the bars and placing the numbers. One student noted, "Sometimes I got mixed up with where to put the numbers." These difficulties, however, were largely mitigated with practice and proper instructional support. This underscored the importance of providing sufficient training and gradual implementation when introducing new teaching methodologies (Sweller et al., 2011).

The impact of collaborative learning was also notable. While many students reported positive experiences working with their peers, such as, "I liked discussing the problems with my friends; it helped me understand better," and "We could help each other when someone didn't understand," some students faced challenges due to varying levels of cooperation. For instance, one student remarked, "I don't like working in a team as some friends don't cooperate." This feedback suggested that while collaborative learning can enhance the effectiveness of the Bar Model Method, it required careful management to ensure that all students actively participate and contribute (Johnson, D., Johnson, R., & Stanne, 2000).

Overall, students expressed a strong desire to continue using the Bar Model Method. Responses like, "I feel more confident with this method, so I want to keep

using it," indicated that the method not only improved immediate learning outcomes but also fostered a long-term interest and confidence in mathematics Addition and Subtraction Word Problems. This enthusiasm suggested that the Bar Model Method could have lasting benefits for students' mathematical development and engagement.

## 5.3 RECOMMENDATIONS

Based on the findings of this study, the following recommendations were proposed to enhance the effectiveness and implementation of the Bar Model Method in improving mathematical problem solving skills among Grade 4 Bhutanese students. These recommendations are divided into two categories: Recommendations for Practice and Recommendations for Future Research.

### 5.3.1 Recommendations for Practice

1) To Incorporate Bar Model Method in Grade 4 Mathematics:

It is recommended that teachers and educators formally integrate the Bar Model Method into the Grade 4 mathematics curriculum. This integration could offer a structured approach to solving word problems, making complex mathematical concepts more accessible to students. Aligning this method with existing curriculum standards and ensuring it complements other teaching methods could be beneficial.

2) To Implement Professional Development Programs:

To ensure effective implementation, it is recommended that schools organize comprehensive training sessions for teachers. These programs could focus on the fundamentals of the Bar Model Method, practical applications, and strategies to overcome common challenges. Continuous professional development might help teachers stay updated with best practices and innovations in teaching methodologies.

3) To Adopt a Phased Introduction Strategy:

Schools might consider introducing the Bar Model Method gradually to mitigate initial confusion and resistance. Initially, the method could be used alongside traditional problem-solving techniques. Over time, as students become more familiar and comfortable with the approach, its usage could be increased. This phased approach

allows students to adapt at their own pace, potentially reducing anxiety and improving proficiency.

4) To Promote Teamwork and Peer Learning:

It is advisable for schools to create an environment that encourages collaborative learning. Activities and assignments that require students to work in groups using the Bar Model Method can be particularly beneficial. Facilitating group discussions and peer tutoring sessions, where students can learn from each other and clarify doubts collectively, might enhance understanding and build communication and teamwork skills.

### 5.3.2 Recommendations for Future Research

1) Longitudinal Studies:

To conduct longitudinal studies to investigate the long-term effects of the Bar Model Method on students' mathematical achievement. To examine the sustained impact of the Bar Model Method over multiple academic years and its influence on overall academic performance.

2) Applicability Across Different Grade Levels:

To explore the applicability of the Bar Model Method across different grade levels and diverse student populations. To assess the effectiveness of the Bar Model Method in early and later stages of primary education to determine its broad applicability.

3) Impact on Other Mathematical Areas:

To carryout research the impact of the Bar Model Method on other areas of mathematics beyond addition and subtraction word problems. To study how the method can be adapted to support learning in multiplication, division, fractions, and other mathematical concepts.

4) Comparative Studies:

To conduct comparative studies to evaluate the Bar Model Method against other visual and non-visual problem-solving strategies. To determine the relative effectiveness of different methods in enhancing students' problem-solving skills and mathematical understanding.

5) Experimental Research:

Future researcher could employ an experimental design to evaluate the Bar Model Method's effectiveness in enhancing word problem-solving skills. Specifically, researchers could compare the performance of students taught using the Bar Model Method with those using traditional problem-solving techniques over a longer duration.

By implementing these recommendations, educators could maximize the benefits of the Bar Model Method in practice while future research could continue to explore and expand its potential in mathematics education.

In conclusion, this study underscored the significant challenges faced by Bhutanese students in mastering Addition and Subtraction Word Problems due to language complexities and difficulties in understanding mathematical concepts. It highlighted the effectiveness of the Bar Model Method, a visual representation technique, in enhancing comprehension and Addition and Subtraction problem solving abilities among Grade 4 students.

By focusing on this pivotal developmental stage, the study demonstrated that integrating the Bar Model Method into the Bhutanese mathematics curriculum could significantly improve students' Addition and Subtraction mathematical performance and engagement. The findings provided valuable insights and practical recommendations for educators, contributing to the broader goal of enhancing mathematics education in Bhutan and fostering better learning outcomes for students.

# REFERENCES


Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability, 21*(1), 5-31. doi:10.1007/s11092-008-9068-5

Bhutan Council for School Examination and Assessment. (2019). *Launch of Bhutan PISA-D national report*. Retrieved from http://www.bcsea.bt

Boaler, J. (2016). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages, and innovative teaching.* San Francisco, CA: Jossey-Bass.

Boaler, J., Chen, L., Williams, C., & Cordero, M. (2016). Seeing as Understanding: The Importance of Visual Mathematics for our Brain and Learning. *Journal of Applied & Computational Mathematics, 5*(5), 1-6. Retrieved from https://www.youcubed.org/wp-content/uploads/2017/04/JACmaths-seeing-article.pdf

Bobis, J., Mulligan, J., & Lowrie, T. (2011). *Mathematics for children: Challenging children to think mathematically.* Australia: Pearson.

Boonen, A. J. H., van der Schoot, M., van Wesel, F., de Vries, M. H., & Jolles, J. (2013). What underlies successful word problem solving? A path analysis in sixth grade students. *Contemporary Educational Psychology, 38*(3), 271–279. https://doi.org/10.1016/j.cedpsych.2013.05.001

Bruner, J. S. (1966). *Toward a theory of instruction.* Cambridge, MA: Harvard University Press.

Carpenter, T. P., Fennema, E., Franke, M. L., Levi, L., & Empson, S. B. (2015). *Children's mathematics: Cognitively guided instruction.* Portsmouth, NH: Heinemann.

Cassady, J. C., & Johnson, R. E. (2002). Cognitive test anxiety and academic performance. *Contemporary Educational Psychology, 27*(2), 270–295. https:// doi.org/10.1006/ceps.2001.1094

Chan, C. M. E., & Foong, P. Y. (2013). A conceptual framework for investigating pupils' model development during the mathematical modelling process. *The Mathematics Educator, 15*(1), 1–29.

# REFERENCES (CONT.)

Choden, P., & Chalermnirundorn, N. (2021). The Integration of Manipulatives and Cooperative Learning in the Learning Measurement of Grade Four Bhutanese Students. *Asia Social Issues, 14*(5), Article 249108. Retrieved from https://so06.tci-thaijo.org/index.php/asi/article/view/249108

Clement, L. A. (2008) A problem-solving alternative to using key words. *Mathematics teaching in the middle school, 14* (6), 360-365.

Confrey, J., Nguyen, K. H., Lee, K., Panorkou, N., Corley, A. K., & Maloney, A. P. (2012). *Turn-on Common Core Math: Learning Trajectories for the Common Core State Standards for Mathematics.* Retrieved from http://www. turnonc cmath.net.

Creswell, J. W., & Plano Clark, V. L. (2017). *Designing and conducting mixed methods research.* Thousand Oaks, CA: Sage.

Department of Curriculum and profession Development [DCPD]. (2022). *Mathematics curriculum framework: Classes PP-XII*. Thimphu: Ministry of Education.

Dorji, C. (2019). *The use of project-based learning approach in teaching science to grade VI students in a Bhutanese classroom* (Master's thesis). Retrieved from https://rsuirlibrary.rsu.ac.th/handle/123456789/173

Englard, L. (2010). Raise the bar on problem solving. *Teaching Children Mathematics, 17*(3), 156–164.

Frykholm, J., & Glasson, G. E. (2019). Professional development for teachers implementing model-based inquiry: A review of the literature. *Journal of Science Teacher Education, 30* (3), 251-275.

Gani, M.A., Tengah, K.A., & Said, H. (2019). Bar Model as Intervention in Solving Word Problem Involving Percentage. *International Journal on Emerging Mathematics Education,3*(1), Article 11093. https://doi.org/10.12928/IJEME. V3I1.11093

Ginsburg, H. P., Lee, J. S., & Boyd, J. S. (2008). Mathematics education for young children: What it is and how to promote it. *Social Policy Report*, *22*(1), 3-22.

# REFERENCES (CONT.)

Gonzalez, R. A., Krawec, J. L., & Ouyang, F. (2020). The effectiveness of the bar modeling method: A systematic review and meta-analysis. *Educational Psychology Review, 32*(1), 183-210.

Gonzalez, T., Yazejian, N., Araujo, M. C., & Garcia, E. E. (2019). English learners' mathematics problem-solving performance: The role of language proficiency and problem context. *International Journal of Bilingual Education and Bilingualism, 22*(8), 913-930.

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a conceptual framework for mixed-method evaluation designs. *Educational evaluation and policy analysis, 11*(3), 255-274.

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81-112.

Hegarty, M. (2017). Understanding the role of working memory in reasoning and problem solving. *Trends in Cognitive Sciences, 21*(8), 567-575.

Hiebert, J., Morris, A. K., Berk, D., & Jansen, A. (2017). Preparing teachers to learn from teaching. *Journal of Teacher Education, 68*(5), 484-497.

Ho, W. K., Wong, N. Y., & Wong, S. L. (2019). Enhancing primary students' motivation and engagement in mathematics learning through the bar model method. *International Journal of Mathematical Education in Science and Technology, 50*(8), 1185-1201.

Hofer, C. (2015). The introduction of the Singapore bar model in year 1 problem solving: A personal reflection. *The STeP Journal: Student Teacher Perspectives,2*(2), 107- 117.

Hom, J. E. (2013). *What is Mathematics?* Retrieved from www.livescience.com/ 38936- mathematics.html

Hurmerinta-Peltomäki, L., & Nummela, N. (2006). Mixed methods in international business research: A value-added perspective. *Management International Review, 46*(4), 439-459.

# REFERENCES (CONT.)

Hu, W., Zhang, X., Chen, Z., & Wu, X. (2016). The effect of the bar model method on Chinese children's word problem solving. *ZDM Mathematics Education, 48*(1-2), 169-181.

Hwang, G. J., & Wu, P. H. (2012). Advancements and trends in digital game-based learning research: A review of publications in selected journals from 2001 to 2010. *British Journal of Educational Technology, 43*(1), E6-E10.

Ivankova, N. V., Creswell, J. W., & Stick, S. L. (2006). Using mixed-methods sequential explanatory design: From theory to practice. *Field methods, 18*(1), 3-20.

Johnson, A. (2013). Mathematics: A fundamental scientific field. *Journal of Mathematical Sciences, 25*(3), 45-59.

Johnson, A. (2018). Ensuring validity in research studies. *Journal of Research Methodology, 7*(2), 45-58.

Johnson, D. W., Johnson, R. T., & Stanne, M. E. (2000). *Cooperative learning methods: A meta-analysis*. Minneapolis:University of Minnesota.

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a definition of mixed methods research. *Journal of mixed methods research, 1*(2), 112-133.

Jones, A. (2015). The importance of lesson planning. *Journal of Teacher Education, 10*(2), 45-58.

Kalyuga, S., Ayres, P., Chandler, P., & Sweller, J. (2018). The expertise reversal effect in cognitive load theory. *Educational Psychology Review, 30*(2), 591-601.

Kaur, B. (2019). The why, what and how of the 'Model' method: A tool for representing and visualising relationships when solving whole number arithmetic word problems. *ZDM-Mathematics Education, 51*, 151–168. https://doi.org/10.1007/s11858-018- 1000-y

Kho, J. L. (2016). Enhancing problem solving skills in mathematics through the use of the bar model. *Journal of Education and Learning, 10*(2), 107-115.

# REFERENCES (CONT.)

Khoon, K. S., Muthalib, S. A., Ng, S. F., Fong, P. Y., & Nair, S. M. (2018). The bar modelling method: Enhancing Singapore primary school students' understanding of algebra. *Eurasia Journal of Mathematics, Science and Technology Education, 14*(1), 303-314.

Kilpatrick, J., Swafford, J., & Findell, B. (2001). *Adding it up: Helping children learn mathematics*. Washington, DC: National Academy Press.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75-86.

Lai, Y., Zhu, X., Chen, Y., & Li, Y. (2015). Effects of mathematics anxiety and mathematical metacognition on word problem solving in children with and without mathematical learning difficulties. *PLoS one10*(6), e0130570. doi:10.1371/journal.pone.0130570

Lee, J., & Yeung, A. S. (2017). The effects of bar model method on primary students' problem-solving performance in mathematics. *The Asia-Pacific Education Researcher, 26*(5-6), 243-250.

Lesh, R., & Zawojewski, J. (2007). *Problem solving and modeling.* In F. Lester Jr. (Ed.), *Second Handbook of Research on Mathematics Teaching and Learning* (pp. 763-804). Charlotte, NC: Information Age Publishing.

Lim, S. H., Chua, S. H., & Tan, J. (2020). Students' experiences in solving word problems using the bar model method: A qualitative analysis. *Educational Studies in Mathematics, 104*(3), 383-402.

Looi, C. K., Sun, D., & Wu, L. (2017). A situated learning approach to facilitating students' understanding of bar modeling in mathematics. *Journal of Educational Technology & Society, 20*(1), 238-248.

Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). New York: Cambridge University Press.

McKim, C. A. (2017). The value of mixed methods research: A mixed methods study. *Journal of Mixed Methods Research, 11*(2), 202-222.

# REFERENCES (CONT.)

Mcleod, S. (2024). *Child Psychology.* Retrieved from https://www.simplypsychology.org/bruner.html

Ministry of Education. (2017). *Education in Bhutan: A review of the education system.* Thimphu, Bhutan: Author.

Morin, L. L., Watson, S. M. R., Hester, P., & Raver, S. (2017). The Use of a Bar Model Drawing to Teach Word Problem Solving to Students With Mathematics Difficulties. *Learning Disability Quarterly, 40*(2), 91-104. https://doi.org/10.1177/0731948717690116

Morse, J. M. (1991). Approaches to qualitative-quantitative methodological triangulation. *Nursing research, 40*(2), 120-123.

Moseley, B., & Brenner, M. E. (2017). The role of the bar model in promoting algebraic reasoning: A study of elementary preservice teachers' understanding of tape diagrams. *School Science and Mathematics, 117*(5-6), 177-188.

Moseley, C., Reinke, W. M., Burrell, L. M., & Smith, A. N. (2017). Building effective collaborative partnerships in education: *A practice-based framework. School Mental Health, 9*(2), 143-154.

Mousley, J., Choo, F., & Mulligan, J. (2019). Making sense of real-world mathematical problems. *Mathematics Education Research Journal, 31*(4), 517–536. doi:10.1007/s13394-019-00262-5

National Council of Teachers of Mathematics. (2014). *Principles to actions: Ensuring mathematical success for all*. Reston, VA: NCTM.

National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the national mathematics advisory panel.* Retrieved from https://hdl.loc.gov/loc.gdc/gdcebookspublic.2023692157

Ng, S. F., & Lee, K. (2009). The model method: Singapore children's tool for representing and solving algebraic word problems. *Journal for Research in Mathematics Education, 40*(3), 282–313.

# REFERENCES (CONT.)

Ng, S. F., & Lee, K. (2009). Fostering primary students' problem-solving skills through non- routine problem-solving instruction. *Educational Studies in Mathematics, 71*(2), 163-177.

Ng, S. F., & Phang, F. A. (2017). A comparison of two problem-solving models: The effects on students' problem-solving performance and conceptual understanding. *Eurasia Journal of Mathematics, Science and Technology Education, 13*(8), 4817-4835.

Nunes, T., & Bryant, P. (2019). Children's difficulties in solving mathematical word problems. *Journal of Educational Psychology, 111*(3), 303-316.

O'Cathain, A., Murphy, E., & Nicholl, J. (2008). The quality of mixed methods studies in health services research. *Journal of health services research & policy, 13*(2), 92-98.

Osman, S., Che Yang, C. N. A., Abu, M. S., Ismail, N., Jambari, H., & Kumar, J. A. (2018). Enhancing students' mathematical problem-solving skills through Bar Model Visualisation Technique. *International Electronic Journal of Mathematics Education, 13*(3), 273-279. https://doi.org/10.12973/iejme/3919

Pfannenstiel, K. H., Bryant, D. P., Bryant, B. R., & Porterfield, J. A. (2015). Cognitive Strategy Instruction for Teaching Word Problems to Primary-Level Struggling Students. *Intervention in School and Clinic, 50*(5), 291-296. doi:10.1177/1053451214560890

Piaget, J. (1952). *The origins of intelligence in children* (M. Cook, Trans.). New York, NY: W.W. Norton & Co.

Piaget, J. (1964). Development and learning. *Readings on the development of children, 23*(3), 12-23.

Pittalis, M., & Christou, C. (2010). Visual representations in solving mathematics word problems: The case of a semiotic rectangle. *Educational Studies in Mathematics, 73*(3), 255-273.

Reys, R. E., Lindquist, M. M., Lambdin, D. V., Smith, N. L., & Suydam, M. N. (2012). *Helping children learn mathematics.* n.p.: John Wiley & Sons.

# REFERENCES (CONT.)

Royal Education Council of Bhutan. (2012). *National Education Framework*: *Shaping Bhutan's Future*. Thimphu, Bhutan: Author.

Royal Education Council of Bhutan. (2019). *National Education Policy Draft.* Retrieved from http://www.education.gov.bt/wp-content/downloads/publications/publication/National-Education-Policy.pdf

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*(1), 54–67. https://doi.org/10.1006/ceps.1999.1020

Salemeh, Z., & Etchells, M.J.(2016). A case study: Sources of difficulties in solving word problems. *Electronic International Journal of Education, Arts and Science, 2*(1), 149-163.

Saracho, O. N., & Spodek, B. (2008). *Contemporary perspectives on mathematics in early childhood education.* Charlotte, NC: IAP/Information Age Publishing.

Selter, C. Verschaffel, L., Greer, B., & de Corte, E. (2000). Making Sense of Word Problems. *Educational Studies in Mathematics 42*, 211–213. https://doi.org/10.1023/A:1004190927303

Shah, M. N., Anjum, F., Chand, S., & Tabassum, P. D. R. (2021). Enhancing Mathematical Word Problem Solving Skills: Using Bar Model Visualization Technique. *International Research Journal of Education and Innovation, 2*(3), 119–128. https://doi.org/10.53575/irjei.v2.03(21)11.119-128

Shah, M. N. (2022). Determining the Effect of Bar Model Technique on Students' Mathematical Word Problem Solving Skills. *Journal of Contemporary Teacher Education, 6*(1), 145–156.

Smith, B. (2013). Mathematics: The language of the universe. *Journal of Mathematical Communication, 12*(2), 112-125.

Smith, J. (2017). The importance of semi-structured interviews in qualitative research. *Journal of Qualitative Inquiry, 5*(2), 112-126.

Suh, J. M. (2015). Developing mathematical modeling ability: The role of visual representation. *The Journal of Mathematical Behavior, 39,* 132-147.

# REFERENCES (CONT.)

Sukaviriya, P. (2019). The effectiveness of using bar models to solve word problems in algebra among high school students. *Journal of Mathematics Education, 12*(1), 1-14.

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive load theory*. New York, NY: Springer.

Tan, P. L., Gan, Y. Y., & Chang, M. H. (2018). Longitudinal effects of the bar model method on students' mathematical performance. *ZDM Mathematics Education, 50*(1-2), 307-318.

Tashakkori, A., & Teddlie, C. (Eds.). (2010). *Handbook of mixed methods in social and behavioral research.* Thousand Oaks, CA: Sage.

Teddlie, C., & Tashakkori, A. (2009). *Foundations of mixed methods research: Integrating quantitative and qualitative approaches in the social and behavioral sciences.* London: Sage.

Thinley, J. (2010). Bhutan's Educational Reform: A Historical Account. *Journal of Bhutan Studies, 23,* 1-36.

Van de Walle, J. A., Karp, K. S., & Bay-Williams, J. M. (2013). *Elementary and Middle School Mathematics: Teaching Developmentally*. Upper Saddle River, NJ: Pearson.

Van Garderen, D. (2006). Spatial visualization, visual imagery, and mathematical problem solving of students with varying abilities. *Journal of Learning Disabilities, 39*(6), 496-506.

Verschaffel, L., Greer, B., & De Corte, E. (2017). Whole-number concepts and operations. In *Second Handbook of Research on Mathematics Teaching and Learning* (pp. 557-628). Charlotte, NC: Information Age Publishing Inc.

Verschaffel, L., Luwel, K., Torbeyns, J., & Van Dooren, W. (2009). Conceptualizing, investigating, and enhancing adaptive expertise in elementary mathematics education. *European Journal of Psychology of Education, 24*(3), 335-359.

Verschaffel, L., Schukajlow, S., Star, J., et al. (2020). Word problems in mathematics education: a survey. *ZDM Mathematics Education, 52*, 1–16. https://doi.org/10.1007/s11858-020-01130-4

# REFERENCES (CONT.)

Vula, E., & Kurshumlia, R. (2015). Mathematics word problem solving through collaborative action research. *Journal of Teacher Action Research, 1*(2), 34-46. Retrieved from http://www.practicalteacherresearch.com/uploads/5/6/2/4/56249715/vula_34-46.pdf

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Massachusetts: Harvard University Press.

Wangchuk, K. (2017). Mathematics Teaching and Learning at the Primary Level in Bhutan: A Qualitative Study. *International Journal of Education in Mathematics, Science and Technology, 5*(3), 183-197.

Wangmo, K., & Tenzin, P. (2019). Assessment of Mathematics Education in Bhutan. *Journal of Educational and Social Research, 9*(4), 77-86.

Wu, M. L., Adams, T. L., & Feng, S. (2019). The effectiveness of bar models for teaching word problems to students with and without learning disabilities: A meta-analysis. *The Journal of Special Education, 53*(4), 245-257.

Xin, Y. P., Kim, S. J., Lei, Q., Liu, B. Y., Wei, S., Kastberg, S. E., & Chen, Y. V. (2023). The Effect of Model-Based Problem Solving on the Performance of Students Who are Struggling in Mathematics. *The Journal of Special Education, 57*(3), 181-192. https://doi.org/10.1177/00224669231157032

Yan, K. C. (2002). The model method in Singapore. *The Mathematics Educator, 6,* 47–64.

Yeap, B. H. (2017). *The bar model method: A cognitive and pedagogical tool for school mathematics*. New York, NY: Springer.

Yeap, L. L., Salleh, S. R., & Zakaria, E. (2017). Using bar modeling to solve non-routine mathematics word problems: An exploratory study. *International Journal of Instruction, 10*(1), 195-208.

Zyga, L. (2013). *Mathematics: The language of the universe.* Retrieved from https://phys.org/news/2013-09-mathematics-effective-world.html

# APPENDICES

# APPENDIX A
# LETTER OF APPROVAL

RSU มหาวิทยาลัยรังสิต RANGSIT UNIVERSITY

มหาวิทยาลัยรังสิต
เมืองเอก ก.พหลโยธิน
จ.ปทุมธานี 12000

Rangsit University
Muang-Ake, Paholyothin Rd.
Pathumthani 12000, Thailand

T. (66) 2997 2200-30
F. (66) 2791 5757
E. info@rsu.ac.th

Director General

Department of School Education

Ministry of Education

Thimphu, Bhutan

Date: April 12, 2024

Subject: Request for Permission to Collect Data for Master of Education Thesis

Dear Sir, /Madam,

Master of Education Program in Curriculum and Instruction, Suryadhep Teachers College would like to request your permission for five Master of Education candidates to collect data for thesis in Bhutan in the period of May 3, 2024 to June 15, 2024. The details of the candidates are shown as follows:

| Name | Research title | Research School |
|---|---|---|
| MISS TSHERING DOLKAR | THE USE OF BAR MODEL METHOD FOR ADDITION AND SUBTRACTION WORD PROBLEM ACHIEVEMENT OF GRADE 4 BHUTANESE STUDENTS | Dewathang Primary School, Samdrup Jongkhar Bhutan |

Thank you for your kind consideration.

Truly yours,

Nipaporn Sakulwongs

Assistant Professor Nipaporn Sakulwongs, Ed.D.

Director of Master of Education Program in Curriculum and Instruction

Suryadhep Teachers College, Rangsit University

Muang-Ake, Paholyothin Road, Lakhok, Pathum Thani 12000 Thailand Telephone: Number: +66-868846226

Telephone: +662997-2222 ext. 1275

དཔལ་ལྡན་འབྲུག་གཞུང་། ཤེས་རིག་དང་རིག་རྩལ་གོང་འཕེལ་ལྷན་ཁག།

**Royal Government of Bhutan**

**Ministry of Education and Skills Development**

**Department of School Education**

DSE/SLCD (05)2024/ 508

April 24, 2024

Chief Dzongkhag/Thromde Education Officers
Paro and Wangdue Dzongkhags
Thimphu and Samdrupjongkhar Thromdes

**Subject: Approval to collect data for research studies.**

Dear Sirs/Madams,

The Director of the Master of Education Program in Curriculum and Instruction at Suryadhep Teachers College, Rangsit University in Thailand, has approached the Department of School Education seeking permission for the following five M.Ed candidates to collect data for their research study:

| Candidates | Research title | Location |
|---|---|---|
| Tshering Dolkar | The use of Bar Model Method for addition and subtraction word problem achievement of grade 4 Bhutanese students | Dewathang Primary School, Samdrupjongkhar Thromde |
| Chimi Seldon Dorji | The effectiveness of experiential learning approach on science learning achievement for grade 6 Bhutanese students | Jigme Losel Primary School, Thimphu Thromde |
| Pema Choden | The effectiveness of virtual field trips on learning achievement of social studies for grade 6 Bhutanese students | Dechencholing Higher Secondary School, Thimphu Thromde |
| Kuenzang Namgay | The development of English reading comprehension skill using flipped classroom with poems among grade 6 Bhutanese students | Gaselo Primary School, Wangdue Dzongkhag |
| Chimi Selden | The effectiveness of using differentiated instructions on science learning achievement for grade 5 Bhutanese students | Taju Primary School, Paro Dzongkhag |

The Department of School Education is pleased to accord approval to collect data as proposed, considering the positive impact of the research to elevate teaching methods at the primary level. However, the researchers are requested to avoid any disturbances to the normal instructional hours.

Hence, you are kindly requested to allow the researchers to conduct the data collection for their research project please.

(Karma Galay)
**Director General**

Cc: 1. Dasho Dzongdag/Thrompoen, Paro, Wangdue Dzongkhags and Thimphu, Samdrupjongkhar Thromde for kind information.
2. Director, Master of Education Program in Curriculum and Instruction, Suryadhep Teachers College, Rangsit University, Thailand for kind information
3. Chief Program Officer, School Liaison and Coordination Division, DSE for kind information

# APPENDIX B

# CONSENT LETTER

Date: 3rd May, 2024

**CONSENT FORM**

Sir,

I am currently enrolled in the Master of Education in Curriculum and Instruction at Rangsit University, Thailand. In order to fulfill the requirement of my Masters' degree, I am undertaking a research on "The Use Of Bar Model Method For Addition And Subtraction Word Problem Achievement Of Grade 4 Bhutanese Students". I will be teaching grade four from 1st May till 31st May during schools hours. The content of the teaching will be no different from what they are supposed to learn. I believe it will surely help students to improve their academic performance in solving word problems. The questionnaire, classroom observations and interviews will be conducted towards the end and will be used solely for research purposes.

Therefore I would like to seek permission to let one section of grade four students to participate in this study. Their names, identifications and school will not be used in the research paper or presentations. It is important to note that all information provided will be confidential.

Thanking you.

Sincerely,

Tshering Dolkar
Student, Rangsit University, Thailand,

I acknowledge the content of this research study has been thoroughly explained to me and any questions have been answered. I have read the letter provided by Ms. Tshering Dolkar and agree to let one section of grade four students to participate in the research as described.

Principal
Dewathang Primary School
SamdrupJongkhar Thromde

Principal
Dewathang Primary School
Samdrup Jongkhar

Subject Teacher
Dewathang Primary School
SamdrupJongkhar Thromde

**Date:**

**Parents' Consent Letter**

Dear Parents,

I am currently enrolled in the Master of Education in Curriculum and Instruction, at Rangsit University, Thailand. I am conducting a research study on "The Use Of Bar Model Method For Addition And Subtraction Word Problem Achievement Of Grade 4 Bhutanese Students". This research requires student participation.

The instruments involved during the study are pretest and posttest, and semi-structured interview for obtaining the required data. Therefore, I would like to seek your permission to let your child participate in this study. Their names, identifications, and schools will be kept confidential and anonymous. I look forward to your cooperation in approving your child to participate in this research study.

Thanking you

Yours sincerely



Tshering Dolkar
Student
Rangsit University
Thailand.

I acknowledge that the content of this research study has been thoroughly explained to me and any questions have been answered. I have read the letter provided by Mrs.Tshering Dolkar and have agreed to let my child (……) participate in the research as described.

Name: …… Signature: ……..
Date: ……

# APPENDIX C

# EXPERTS WHO VALIDATED THE RESEARCH INSTRUMENT

## Details of three expertise who validated the instruments

**Three Experts are:**

1) **Expert 1:** Gary Torremucha, Associate Professor, Rangsit English Language Institute (RELI), Rangsit University, Thailand.

2) **Expert 2:** Mr. Norbu Kezang, M.Ed, Teacher, SamdrupJongkhar Primary School, SamdrupJongkhar Thromde.

3) **Expert 3:** Mrs. Tenzin Pema, Phuntsholing Primary School, Phuntsholing Thromde.

**Consent Form for Disclosure of Validator's Name in Research Paper**

To

The Graduate School

Rangsit University

Thailand

I, Gary Torremucha, a professor of Rangsit English Language Institute, Rangsit University, hereby give my consent to the researcher Tshering Dolkar (6510235), a student of Master in Curriculum and Instruction, Suryadhep Teachers College, Rangsit University to disclose my name as a research Instrument validator in her thesis paper titled "The Use of Bar Model Method for Addition and Subtraction Word Problem of Grade 4 Bhutanese Students". I respect the terms and regulations of the Graduate School; thus, I also give my consent to the Graduate School, Rangsit University to contact me in case of any clarification regarding my consent.

Gary Torremucha

Signature

Date: 24 April 2024

**Consent Form for Disclosure of Validator's Name in Research Paper**

To

The Graduate School

Rangsit University

Thailand

I, Norbu Kezang, a teacher of Samdrup Jongkhar Primary School, Bhutan, hereby give my consent to the researcher Mrs. Tshering Dolkar (6510235), a student of Master in Curriculum and Instruction, Suryadhep Teachers College, Rangsit University to disclose my name as a research Instrument validator in her thesis paper titled - The Use of Bar Model Method for Addition and Subtraction Word Problem Achievement of Grade 4 Bhutanese Students. I respect the terms and regulations of the Graduate School; thus, I also give my consent to the Graduate School, Rangsit University to contact me in case of any clarification regarding my consent.

Norbu Kezang

Signature

Date 26th April, 2024

To **24th April 2024**

The Graduate School

Rangsit University

Thailand

This is to confirm that I have read and validated all the lesson plans, learning achievement test items and structured interview questions that you have developed. I hereby give my consent to the researcher Tshering Dolkar (6510235), a student of Master in Curriculum and Instruction, Suryadhep Teachers College, Rangsit University to disclose my name as a research Instrument validator in her thesis paper titled "The Use of Bar Model Method for Addition and Subtraction Word Problem of Grade 4 Bhutanese Students".

Thanking you,

Yours Sincerely,

Tenzin Pema
Teacher
Phuntsholing Primary School
Phuntsholing Thromde

# APPENDIX D

# LESSON PLANS

# Lesson Plan 01 (sessions 1&2)

**Class:** IV **Date: 7th May 2024**

**Subject:** Mathematics **Time:** 90 minutes

**Number of students: 30** **Period:1&2nd Period**

**Topic:** Addition of whole number (Word Problems)

**Strategy:** Use of the Bar Model Method

**Vocabulary Encountered:** part-whole model , mathematical statements

**Previous knowledge of the students:** Have concept of addition and subtraction of whole numbers, Recognize actual value of each digit of a number (Place value).

**Teaching learning materials:** power point slide (Addition), worksheet, whiteboard, addition word problem cards, Bar Model Method visual aids (e.g: printed diagrams)

**Lesson Objectives:** By the end of the lesson, each student will be able to

- ✓ demonstrate a clear understanding of addition concepts accurately by constructing Bar Models to represent given addition scenarios after the teachers demonstration.
- ✓ apply the Bar Model Method to solve addition word problems independently.
- ✓ actively engage in Addition problem solving tasks

**Lesson abstract:**

Students are introduced to the Bar Model Method with the part-whole Bar Model through this lesson. Students learn how to construct the part-whole bar model and how it can help to represent addition contexts through worked examples with simple numbers and tasks with larger numbers. Two types of addition contexts are used in these 2 sessions:

1. one set of items made up of 2 parts
2. the whole being formed from two distinct sets of items

**Lesson Introduction / warming up activity (10 minutes )**

- Greet the children and gain their attention.
- Begin the lesson by engaging students in a discussion about real-life scenarios where addition is used. Examples: Grocery shopping. Measuring ingredients, planning trips, planting seeds.

- Prompt students to share examples from their own experiences, such as adding money, counting items, or combining quantities.
- Introduce the concept of addition word problems and explain their relevance in everyday life. Emphasize that addition word problems involve finding the total when two or more quantities are combined.,

Transition to the topic of problem-solving strategies by discussing different approaches students may use to solve addition word problems.

**Warm-Up Activity (10 minutes):**

- ✓ Display a simple addition word problem on the board without using the Bar Model Method.
- ✓ Ask students to solve the problem individually or in pairs using traditional methods.
- ✓ After a few minutes, invite students to share their solutions with the class and discuss the strategies they used.

**Lesson Development (15 Minutes)**

- ✓ Present step-by-step instructions on how to use the Bar Model Method for addition word problems.
- ✓ Begin by explaining the key components of the Bar Model Method, such as identifying the quantities, representing them with bars, and finding the sum.
- ✓ Model the process by solving a sample addition word problem using the Bar Model Method using Power point presentation. Think aloud as working through each step, explaining reasoning and decision-making process. (Throughout the examples, emphasize how the part-whole models demonstrated in this lesson help students to visualise the relationships between the parts and the whole)

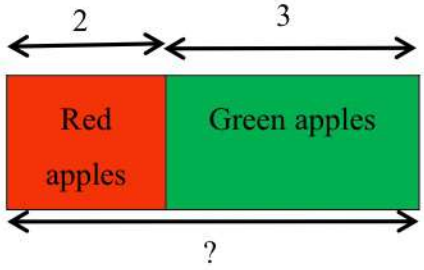
**Example 1:** Read with the class and discusses how to draw and label the model, using the PPT slide show

Sonam has 2 red apples and 3 green apples. How many apples does she have altogether?

**Sample Solution**

2 + 3 = 5

Sonam has 5 apples altogether.



**Bar Model Solution:**

1. Draw a bar to represent the 2 red apples Sonam already possesses.
2. Draw an additional bar to represent the 3 green apples.
3. Combine the two bars to determine the total number of apples.

**Calculation:**
2 (initial red apples) + 3 (additional green apples) = 5 apples

This visual representation helps students easily see the two quantities that need to be added together to find the total. Explain the process to the class.

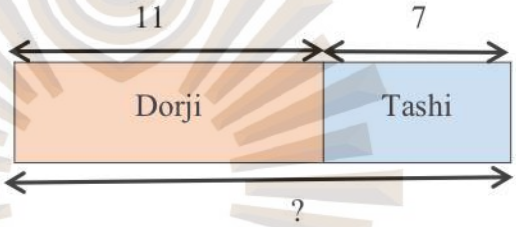
**Example 2:** Students could try this simple example for themselves before the teacher discusses the solution. Use the PPT slide as a prompt, and highlight how the Bar Model can help students come up with the mathematical statements.

Dorji has 11 books. Tashi has 7 books. How many books do they have between them?

**Sample Solution**

11 + 7 = 18

Dorji and Tashi have 18 books altogether.




**Activity: I**

**Guided Practice (20 minutes):**

- ✓ Divide the class into small groups and distribute addition word problem cards.
- ✓ Instruct students to work together to solve the problems using the Bar Model Method.

**Monitoring:** Go around the classroom, providing guidance and support as needed. Encourage students to discuss their problem solving strategies and share their Bar Model diagrams with the group.

**Follow up:** After the guided practice session (Give CHEERS), and then gain attention as a class and review the solutions to selected problems. Discuss any common misconceptions or challenges encountered during the activity.

**Activity: II**

**Independent Practice (20 minutes):**

- ✓ Distribute worksheets with a set of addition word problems for individual practice.

- ✓ Instruct students to solve at least 2 problems independently using the Bar Model Method.
- ✓ Allow students to refer to visual aids or previous examples if needed.

**Monitoring:** Go around the classroom to provide assistance and monitor student progress.

Collect the worksheets for assessment of student understanding.

**Follow up:** Get few children to present their solution to the class. **Give CHEERS**

**Lesson Closure (15 minutes)**

Summarize the learning points for the lesson, asking students to add their own observations:

- ✓ Bar models are used as a way to help organize the information in a problem into a diagram, to help us see how to solve it.
- ✓ The length of the bars represent the size of the quantities in the problem, but they do not need to be drawn exactly in proportion.
- ✓ There is no exactly right way of drawing bars – the aim is to draw a model that helps you to solve the problem.

**"3-2-1"**: Students write down on a note card: 3 things they learned from today's lesson, 2 questions they have about the topic and 1 thing [they] want the teacher to know from today's lesson.

**Assessment (Throughout the lesson):**

- ✓ Assess students' (Random) understanding through observation during guided and independent practice.
- ✓ Review completed worksheets to evaluate the accuracy of students' solutions and their use of the Bar Model Method.
- ✓ Provide feedback to students on their problem-solving strategies and offer additional support as needed.

| | Area of Assessment and Performance Descriptions | | Feedback (s)/ Intervention (s) |
|---|---|---|---|
| Student | Organize the information in a problem into Bar Models correctly | Participates in the activity and class discussion actively | |

| | Yes | No | Yes | No | |
|---|---|---|---|---|---|
| **STD _ _** | | | | | |

**Reflection (Self):**

- ✓ After the lesson, reflect on the effectiveness of the instructional strategies used and identify any areas for improvement.
- ✓ Consider students' engagement levels, understanding of the Bar Model Method, and their ability to apply it to addition word problems.

**Addition word problem cards**

In a school there are 458 boys and 524 girls. Find the number of students in this school.

a. 876 students b. 974 students c. 982 students d. 928 students

**Addition word problem cards**

In a restaurant, on Monday, 130 plates of momos were sold. On Tuesday, 168 plates of momos were sold. On Wednesday, 283 plates of momos were sold. What was the total plates of momos sold in the first two days?

**Addition word problem cards**

There are 108 lions and 345 tigers in a forest. If these are the only wild animals in the forest. Find the total number of wild animals in the forest.

a. 370 animals b. 453 animals c. 256 animals d. 376 animals

**Worksheet**

1. Some boys are working in the garden. 302 potatoes, 612 beans, 146 chillies and 426 cabbage saplings were planted. Then in another garden 649 potatoes and 267 beans were planted.

a. How many potatoes are planted in the gardens?

b. How many beans were planted in the gardens?

c. What is the total number of cabbages and chillies planted in the gardens?

2. There are different types of books in the library. There are 745 fiction books, 550 animal books, 1219 children's books and 147 comics.

   a. How many fiction books and animal books are there?

   b. Select two of your favourite types of books. Find the total.

3. 436 girls and 209 boys took part in an art competition. How many children took part in the competition?

4. Wangmo's mother is a teacher. Out of her salary for March, her mother spent Nu. 2545 on vegetables, Nu. 2008 on books, Nu.4500 on clothes and Nu. 900 as pocket money for Wangmo.

   a. How much did her mother spend on vegetables and books in March?

   b. Her mother spent Nu. 635 more on vegetables in the month of April. What is the amount spent on vegetables in the month of April?

# Lesson Plan 04 (sessions 7&8)

**Class:** IV **Date: 28th May 2024**

**Subject:** Mathematics **Time:** 90 minutes

**Number of students: 30** **Period:1&2nd Period**

**Topic:** Subtraction of whole number (Word Problems)

**Strategy:** Use of the Bar Model Method

**Vocabulary Encountered:** part-whole model , mathematical statements, 'take away', compare.

**Previous knowledge of the students:** Have concept of addition and subtraction of whole numbers, Recognize actual value of each digit of a number (Place value).

**Teaching learning materials:** power point slide (Subtraction), worksheet, whiteboard, subtraction word problem cards, Chart paper, Bar Model Method visual aids (e.g: printed diagrams), Web link "*https://www.mathplayground.com/tb_addition_jr/index.html*" *"https://www. Math Video | Solving Word Problems with Thinking Blocks | Math Playground"*

**Lesson Objectives:** By the end of the lesson, each student will be able to

- ✓ Identify key information in subtraction word problems accurately.
- ✓ Apply the bar model method effectively to represent subtraction word problems visually.
- ✓ Demonstrate perseverance and resilience in solving challenging subtraction word problems.

**Lesson abstract:**

This section of the lesson uses the part-whole model to solve word problems involving subtraction of whole numbers. Emphasis is placed on how the part-whole model can be used to help students visualise the relationships between the quantities in the word problems, as an important aspect for students learning to use the models effectively.

Two subtraction situations are illustrated through the 2 examples and the consolidation tasks:

Example 1: One part is 'taken away' from the whole - to find the part that remains.

Example 2: One part is 'taken away' from the whole - find the part that is taken away.

**Lesson Introduction / warming up activity (10 minutes )**

- Greet the children and gain their attention.
- Begin the lesson by reviewing the concept of subtraction and the bar model method introduced in the previous lesson.
- Explain to students that today they will explore two different subtraction situations using the bar model method.
- Display the objectives for the lesson and discuss with students what they will be learning today.

**Lesson Development (15 Minutes)**

**Example 1:**

✓ Present the first subtraction situation: one part is taken away from the whole, and students need to find the remaining part.

Work through an example problem on the whiteboard or chart paper, demonstrating how to use the bar model method to represent the situation.

Sonam had 15 apples. She gave away 7 apples to her friends. How many apples are left with Sonam?

**Solution:**

Draw a bar to represent the whole quantity of apples (15 apples).

Draw another bar to represent apples given to friends.

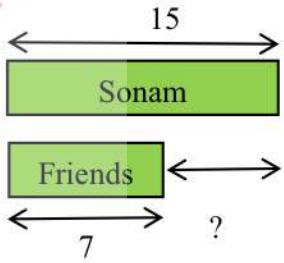
Label the parts: Sonam had and the apples given to friends.

Now, find the remaining part, which is represented by the other part of the bar.

Count the remaining apples represented by the other part of the bar.

15 - 7 = 8

In this case, Sonam has 8 apples left.



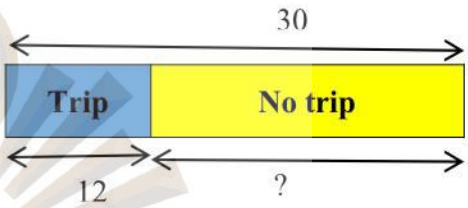

Sonam = 15
Friends = 7
Apples left = 15 - 7 = 8
Sonam has 8 apples left

**Example 2:**

- ✓ Introduce the second subtraction situation: one part is taken away from the whole, and students need to find the part that is removed.
- ✓ Work through another example problem, this time focusing on identifying the part that is taken away using the bar model method.
- ✓ Distribute additional practice problems for students to solve, either individually or in pairs.

There are 30 students in a class. 12 students went on a field trip. How many students are not going on the field trip?

**Solution:**

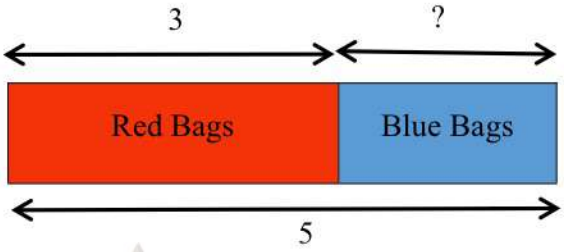



- ✓ Begin by drawing a bar to represent the whole quantity of students (30 students).
- ✓ Divide the bar into two parts: one part representing the students going on the field trip and the other part representing the students who are not going.
- ✓ Label the part representing the students going on the field trip as 12 (since 12 students went on the field trip).
- ✓ Now, we need to find the part that is taken away, which is represented by the other part of the bar.
- ✓ Count the students not going on the field trip represented by the other part of the bar. In this case, there are 30 - 12 = 18 students not going on the field trip.

Total stds. = 30
Trip = 12
No trip = 30-12=18
18 students didnot go on the field trip.

**Example 3:** Read with the class and discusses how to draw and label the model, using the PPT slide show

Yeshi has 5 bags. 3 are red bags. The rest are blue bags. How many blue bags are there?




**Sample Solution**

5-3 = 2

There are 2 blue bags.

**Bar Model Solution:**

1. Draw a bar to represent the 5 bags Yeshi originally had.
2. Indicate a segment within this bar to show the 3 red bags, effectively subtracting from the total.
3. The remaining part of the bar indicates the number of blue bags.

**Calculation:**
5 (Total bags) - 3 (Red bags) = 2 blue bags.

Using the bar model, students can visually understand subtraction as taking a part away from the whole.

**Activity: I**

**Independent Practice (20 minutes):**

- ✓ Distribute worksheets with a set of addition word problems for individual practice.
- ✓ Instruct students to solve at least 2 problems independently using the Bar Model Method.
- ✓ Allow students to refer to visual aids or previous examples if needed.

Worksheet

1. Amit had 20 marbles. He lost 6 marbles while playing. How many marbles left?
2. Samten had 25 stickers. He used 10 stickers to decorate his notebook. How many stickers does he have now?
3. There are 40 sweets in a jar. If 15 sweets are taken out for a party. How many sweets are left in the jar?
4. A shop had 50 shirts for sale. If 20 shirts were sold, how many shirts are still in the shop?

5. Dechen has 49 toys. Dorji gives her some toys. Dechen has 73 toys now. How many toys does Dorji give to Dechen?

6. In an agricultural fair, there were 150 farmers present. After the first group of farmers left for a training session on mushroom plantation, there were 50 farmers remaining at the fair. Then when the second group of farmers left for a demonstration on organic farming, there remained 30 farmers at the fair. Finally, 10 farmers left after receiving certificates of participation.

a. How many farmers for mushroom plantation training?

b. How many farmers left for the organic farming demonstration?

**Monitoring:** Go around the classroom to provide assistance and monitor student progress. Collect the worksheets for assessment of student understanding.

**Follow up: (10 minutes)**

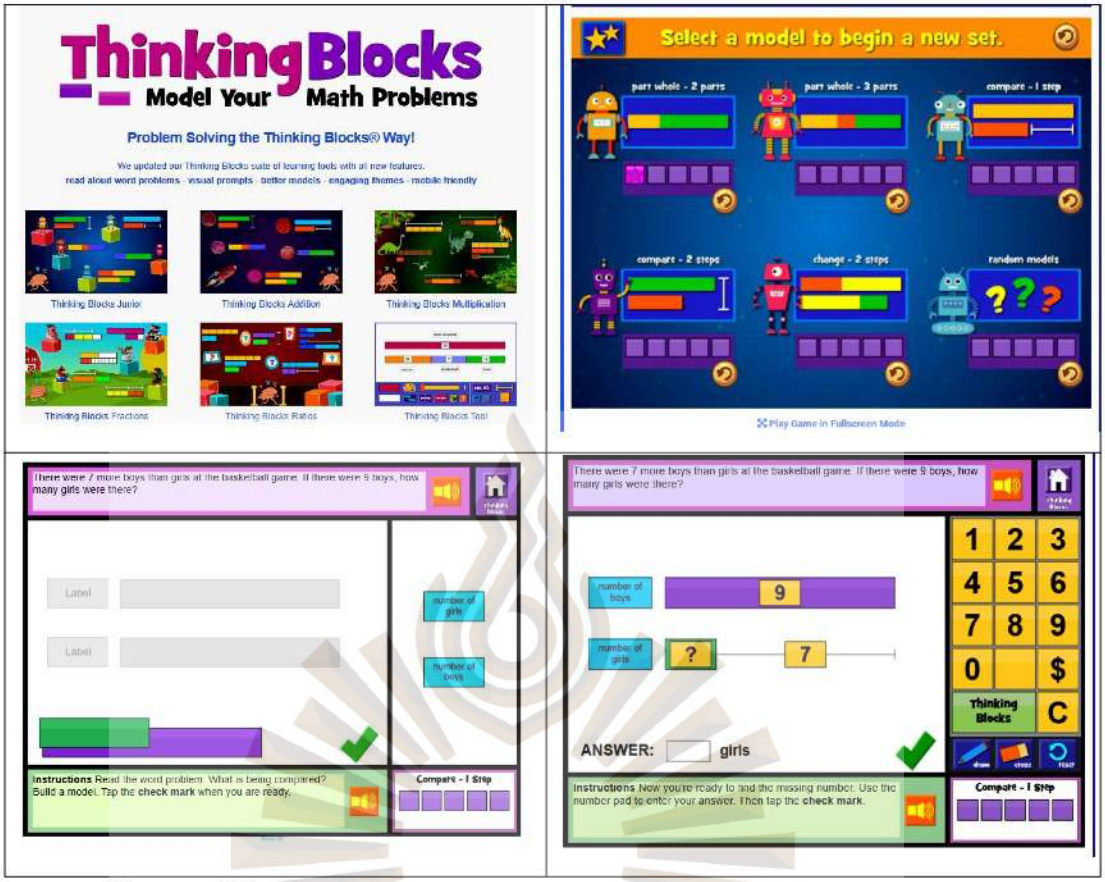
After the activity, get the class back together for discussion. Review the solutions as a class.

Discuss different strategies used by students and address any misconceptions.

Emphasize the use of the Bar Model Method to visually represent the subtraction situation and find the remaining part.

**Extension Activity: Online interactive Video (10 minutes)**

Use the link *"Thinking Blocks Junior | Math Playground"/ "https://www. Math Video | Solving Word Problems with Thinking Blocks | Math Playground"* to watch and explore Bar Model through interactive video.




**Lesson Closure (10 minutes)**

- Gain the attention of the class. Have brief reflection on the lesson.
- Review the key concepts covered in the lesson, emphasizing the two subtraction situations and the use of the bar model method.
- Encourage students to apply what they have learned in real-life situations outside of the classroom.
- End the lesson on a positive note, praising students for their effort and participation

**Assessment (Throughout the lesson):**

- ✓ Assess students' (Random) understanding through observation during guided and independent practice.
- ✓ Provide feedback to students on their problem-solving strategies and offer additional support as needed.

**Rubric**

| Criteria | **Presentation** |
|---|---|
| **Beginning** | Bar model diagrams lack clarity and organization, hindering understanding with unclear labels and inaccurate proportions. |
| **Approaching** | Bar model diagrams show effort but lack consistency, with basic labels and partially accurate proportions. |
| **Meeting** | Adequately constructed bar model diagrams provide a basic understanding with understandable labels and mostly accurate proportions. |
| **Advancing** | Well-executed bar model diagrams effectively support comprehension through accurate representation and clear labeling. |
| **Exceeding** | Clear, precise, and consistent bar model diagrams facilitate understanding with accuracy and visual clarity. |

**Reflection:**

- ✓ Reflect on the effectiveness of the Bar Model Method in facilitating students' understanding of addition and subtraction word problems.
- ✓ Consider whether the method provided a clear and systematic approach for students to visualize and solve the problems.
- ✓ Were students able to apply the method accurately and confidently? What evidence of learning outcomes were observe as a result of using the Bar Model Method?

# APPENDIX E

# IOC FOR LESSON PLANS

**Direction**

**Item-Objective Congruence for Lesson Plan**

The index of IOC score ranges from -1 to +1.

- ✓ +1 indicates that the item clearly matches the stated objectives.
- ✓ 0 indicates that the item is unclear whether the measures meet the stated objectives.
- ✓ -1 indicates that the item is clearly not measuring the stated objectives.

**IOC FOR LESSON PLAN BY EXPERTS**

| Item No. | Attributes | Expert 1 | Expert 2 | Expert 3 | Average | Congruence |
|---|---|---|---|---|---|---|
| 1 | Lesson Plan 1 | +1 | +1 | +1 | +1 | Congruent |
| 2 | Lesson Plan 2 | +1 | +1 | +1 | +1 | Congruent |
| 3 | Lesson Plan 3 | +1 | +1 | +1 | +1 | Congruent |
| 4 | Lesson Plan 4 | +1 | +1 | +1 | +1 | Congruent |
| **Overall Average** | | +1 | | | | Congruent |

# APPENDIX F

# LEARNING ACHIEVEMENT TEST

**Learning Achievement Test**

Class: IV Total Marks: 25

Subject: Mathematics

Name: …… Roll No: …….

**SECTION A**

**Answer ALL the questions**

**Direction:** Each question in this section is followed by four possible choices of answers. Choose the most correct answer and **circle** it. Each question carries 2 marks.

**Question 1** **[5 X 2= 10 Marks]**

i. If there are 15 bananas in a basket and 7 bananas are taken out, how many bananas are left in the basket?

   a. 7

   b. 8

   c. 15

   d. 22

ii. If a shop sold 327 shirts on Monday and 282 shirts on Tuesday, how many shirts did they sell in total?

   a. 45

   b. 509

   c. 609

   d. 5109

iii. What operation should you use to find the total number of books if there are 345 books in one basket and 217 books in another?

   a. Multiplication

   b. Subtraction

   c. Division

   d. Addition

iv. What is the result of subtracting 245 from 689?

   a. 344

   b. 394

   c. 444

   d. 524

v. In a garden, there are 357 red flowers and 248 blue flowers. If 193 more red flowers are added to the garden. How many flowers are there in total?

a. 412

b. 592

c. 793

d. 798

## SECTION B

**(Answer ALL the questions in this section)**

**Question 2** **[5 X 1= 5 Marks]**

Circle the word YES or NO against each statement in the table given below

| Sl.No | Statement | |
|---|---|---|
| i. | If there are 758 Mangoes and 329 are given away, the number of mangoes remaining would be 429.- | YES / NO |
| ii. | In subtraction, the result is called the difference. | YES / NO |
| iii. | In addition, the larger number is always placed first before adding the smaller number. | YES / NO |
| iv. | Borrowing is necessary when the digit in the minuend is smaller than the subtrahend. | YES / NO |
| v. | If Dorji has 12 pen and buys 8 more. The sum of the pen would be 4. | YES / NO |

**Question 3** **[2+2= 4 Marks]**

The table shows the number of people visiting a temple over 3 months.

| | January | February | March |
|---|---|---|---|
| Boys | 28 | 34 | 56 |
| Girls | 59 | ? | 55 |
| Adult | 15 | 22 | 20 |
| Total | ? | 139 | ? |

a. Compared to January, how many more children go to the museum in February?

b. Which month had the highest number of visitors? Show your work.

**Question 4** **[2+2= 4 Marks]**

A farmer harvested some vegetables from his field. He had a total of 784 potatoes and 526 carrots.

a. If the farmer then harvested 312 more potatoes from another field, how many potatoes does he have in total?

b. If the farmer wants to keep an equal number of potatoes and carrots in his storage, how many potatoes should he give away or sell to match the number of carrots he has left after giving some away?

**Question 5** **[4 Marks]**

Lhendup had 18 tins. He gave 7 tins to his friend. How many tins are left with Lhendup?

**Test Blueprint for Learning Achievement Test**

| Questions | Knowing | Understanding | Applying | Analyzing | Evaluating | Creating | **Total** |
|---|---|---|---|---|---|---|---|
| **MCQ** | Q1.iv.(2) | Q1.iii.(2) | Q1.ii.(2) | Q1.i.(2) Q1.v.(2) | | | **10** |
| **True / False** | Q2.ii.(1) | Q2.iii.(1) | Q2.i.(1) Q2.v.(1) | Q2.iv.(1) | | | **5** |
| **Short Answer** | | Q4.a.(2) | Q5.(2) | Q3.a.(2) | Q3.b. (2) | Q4.b. (2) | **10** |
| **Total** | **3** | **5** | **6** | **7** | **2** | **2** | **25** |

# APPENDIX G

# IOC FOR LEARNING ACHIEVEMENT TEST

**Direction**

**Item-Objective Congruence to Validate the Learning Achievement Test**

The index of IOC core ranges from -1 to +1.

- ✓ +1 indicates that the item clearly matches the stated objectives.
- ✓ 0 indicates that the item is unclear whether the measures meet the stated objectives.
- ✓ -1 indicates that the item is clearly not measuring the stated objectives.

## IOC FOR LEARNING ACHIEVEMENT TEST QUESTIONS BY THE EXPERTS

| Sl.No. | ITEM TEST NO. | Expert 1 | Expert 2 | Expert 3 | Average | Congruence |
|---|---|---|---|---|---|---|
| **Section A** | | | | | | |
| 1 | **Q.1.i.** | +1 | +1 | +1 | +1 | Congruent |
| 2 | **Q.1.ii.** | +1 | +1 | +1 | +1 | Congruent |
| 3 | **Q1.iii.** | +1 | +1 | +1 | +1 | Congruent |
| 4 | **Q1.iv.** | +1 | +1 | +1 | +1 | Congruent |
| 5 | **Q1.v.** | +1 | +1 | +1 | +1 | Congruent |
| **Section B** | | | | | | |
| 6 | **Q2.i.** | +1 | +1 | +1 | +1 | Congruent |
| 7 | **Q2.ii.** | +1 | +1 | +1 | +1 | Congruent |
| 8 | **Q2.iii.** | +1 | +1 | +1 | +1 | Congruent |
| 9 | **Q2.iv.** | +1 | +1 | +1 | +1 | Congruent |
| 10 | **Q2.v.** | +1 | +1 | +1 | +1 | Congruent |
| 11 | **Q3.a.** | +1 | +1 | +1 | +1 | Congruent |
| 12 | **Q3.b.** | +1 | +1 | +1 | +1 | Congruent |
| 13 | **Q4.a.** | +1 | +1 | +1 | +1 | Congruent |
| 14 | **Q4.b.** | +1 | +1 | +1 | +1 | Congruent |
| 15 | **Q5** | +1 | +1 | +1 | +1 | Congruent |
| **Overall Average** | | +1 | | | | Congruent |

# APPENDIX H
# SEMI-STRUCTURED INTERVIEW

***Student:*** ***Date of interview:***

***Time of the interview:*** ***Venue: School Conference Hall/Library***

***Age:*** ***Gender: Male/Female***

| Semi-structured Question | Remarks |
|---|---|
| **1.** Can you describe your experience using the Bar Model Method to solve Addition and Subtraction Word Problems during the class? | |
| 2. Can you tell one thing you liked about using the Bar Model to solve addition and Subtraction Word Problems? | |
| 3. Was there anything confusing or hard to understand about using the Bar Model Method? | |
| 4. How did working collaboratively with your friends to solve problems using the Bar Model Method impact your learning experience? | |
| 5. How do you feel about using the Bar Model Method again to solve other word problems in the future? | |

(Adapted from Dorji, 2019)

# APPENDIX I

# IOC FOR SEMI-STRUCTURED INTERVIEW QUESTIONS

**Direction**

**Item-Objective Congruence for Semi-Structured Interview Validation**

The index of IOC core ranges from -1 to +1.

- ✓ +1 indicates that the item clearly matches the stated objectives.
- ✓ 0 indicates that the item is unclear whether the measures meet the stated objectives.
- ✓ -1 indicates that the item is clearly not measuring the stated objectives.

| Sl. No | Semi-structured Question | Expert 1 | Expert 2 | Expert 3 | Average | Congruence |
|---|---|---|---|---|---|---|
| 1 | Can you describe your experience using the Bar Model Method to solve Addition and Subtraction Word Problems during the class? | +1 | +1 | +1 | +1 | Congruent |
| 2 | Can you tell one thing you liked about using the Bar Model to solve addition and Subtraction Word Problems? | +1 | +1 | +1 | +1 | Congruent |
| 3 | Was there anything confusing or hard to understand about using the Bar Model Method? | +1 | +1 | +1 | +1 | Congruent |
| 4 | How did working collaboratively with your friends to solve problems using the Bar Model Method impact your learning experience? | +1 | +1 | +1 | +1 | Congruent |
| 5 | How do you feel about using the Bar Model Method again to solve other word problems in the future? | +1 | +1 | +1 | +1 | Congruent |
| **Overall Average** | | +1 | | | | Congruent |

# APPENDIX J

# RELIABILITY TEST SCORE

| SOLUTION METHOD | |
|---|---|
| K | 14 |
| Σpq | 1.96 |
| Var ( $\sigma^2$) | 5.70 |
| KR 20 | 0.71 |

$$\text{KR}{-}20 = \frac{K}{K-1}\left(1 - \frac{\Sigma pq}{\sigma 2}\right)$$

# APPENDIX K

# PAIRED SAMPLE T-TEST

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Included | | Excluded | | Total | |
| | N | Percent | N | Percent | N | Percent |
| Prestest | 30 | 100.0% | 0 | 0.0% | 30 | 100.0% |
| Posttest | 30 | 100.0% | 0 | 0.0% | 30 | 100.0% |

**Report**

| | Prestest | Posttest |
|---|---|---|
| Mean | 12.13 | 18.53 |
| N | 30 | 30 |
| Std. Deviation | 4.158 | 3.093 |

**One-Sample Test**

Test Value = 0

| | t | df | Sig. (2-tailed) | Mean Difference | 95% Confidence Interval of the Difference | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| Prestest | 15.982 | 29 | .000 | 12.133 | 10.58 | 13.69 |
| Posttest | 32.818 | 29 | .000 | 18.533 | 17.38 | 19.69 |

```
T-TEST PAIRS=Prestest WITH Posttest (PAIRED)
  /CRITERIA=CI(.9500)
  /MISSING=ANALYSIS.
```

Table 4.2 Paired Samples Statistics

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | Pretest | 12.13 | 30 | 4.16 | .76 |
| | Posttest | 18.53 | 30 | 3.09 | .57 |

**Paired Samples Correlations**

| | | N | Correlation | Sig. |
|---|---|---|---|---|
| Pair 1 | Prestest & Posttest | 30 | .713 | .000 |

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference Lower | Upper | | | |
| Pair 1 | Prestest - Posttest | -6.400 | 2.920 | .533 | -7.490 | -5.310 | -12.006 | 29 | .000 |

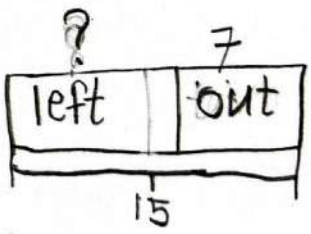
# APPENDIX L

# USE OF BAR MODEL METHOD (CHILDREN'S WORK)

If there are 15 bananas in a basket and 7 bananas are taken out. how many bananas are left in the basket?

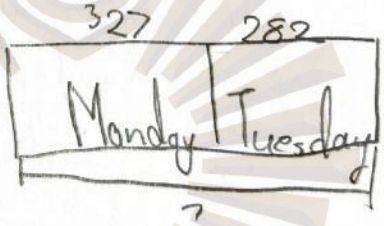
a. 7
b. 8
c. 15
d. 22

15-7=8




If a shop sold 327 shirts on Monday and 282 shirts on Tuesday, how many shirts did they sell in total?

a. 45
b. 509
c. 609
d. 5109

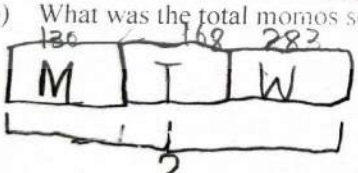



327
+282
609

i. In a restaurant, on Monday, 130 plates of momos were sold. On Tuesday, 168 plates of momos were sold. On Wednesday, 283 plates of momos were sold.

a) How many momos were sold altogether?

b) What was the total momos sold on Monday and Wednesday?




130 + 168 + 283 = 581

130 + 283 = 413

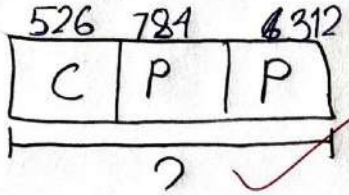
They sold 581 momo, altogether

The tottal momo Sold on Monday and wednesdy is 413.

**Question 4** **[2+2= 4 Marks]**

A farmer harvested some vegetables from his field. He had a total of 784 potatoes and 526 carrots.

a. If the farmer then harvested 312 more potatoes from another field, how many potatoes does he have in total?

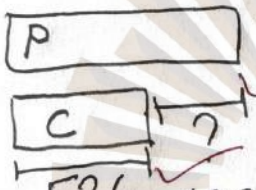



784
+312
1096

∴ 784 + 312 = 1096
There are 1096 Potatoes in total.

(2)

b. If the farmer wants to keep an equal number of potatoes and carrots in his storage, how many potatoes should he give away or sell to match the number of carrots he has left after giving some away?




1096
-526
570

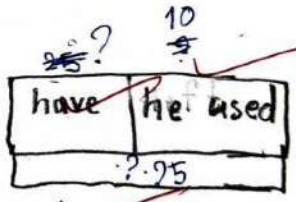
526 ∴ 1096 - 526 = 570
570 potatoes to give away.

(2)



2. Samten had 25 stickers. He used 10 stickers to decorate his notebook. How many stickers does he have now?

25 - 10 = 15
Samten ~~us~~ have 15 stickers.




25
-10
15

# BIOGRAPHY

| | |
|---|---|
| Name | Tshering Dolkar |
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