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

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ABSTRACT

The study aimed to compare students' achievement before and after studying through the use of the Bar model method in enhancing grade 4 students' achievement in solving addition and subtraction word problems and their overall satisfaction with the method. The sample group was 30 students of mixed abilities and genders from a school in Samdrup Jongkhar, Bhutan and the research employed a clustered random sampling method. The instruments included structured lesson plans, pretest and posttest assessments, and semi-structured interviews. Quantitative analysis revealed a significant improvement of students' achievements, with mean scores increasing from 12.13 (SD = 4.16) to 18.53 (SD = 3.09), a mean gain of 6.40, confirmed as statistically significant by a paired-sample t-test ($p < .01$). Qualitative data from the interview provided insights on students' experiences, showing a positive reception towards the Bar model method. The students appreciated its role in enhancing collaborative learning and expressed a desire to continue using the method in future mathematics lessons. The findings indicated that the Bar Model method not only significantly improved students' problem-solving achievements but also boosted engagement and satisfaction in mathematics learning. This results provided further evidence of an overall improvement in students' achievements in word problems related to addition and subtraction after the use of Bar Model method.

Keywords: Bar Model Method, Addition and Subtraction Word Problem Solving, Grade 4 Students

INTRODUCTION

Mathematics is a key component of education globally, including in Bhutan, where it is compulsory throughout primary schooling. Despite its significance, many Bhutanese students struggle with mathematics, particularly word problems, which are essential for applying mathematical concepts in real-world contexts but present challenges due to their complex language and abstract reasoning (Dorji & Tshering, 2020). The PISA-D national report highlights this issue, showing a significant gap in students' performance on complex tasks (Bhutan Council for School Examinations and Assessment, 2019). Mastery of foundational skills, such as addition and subtraction is critical for advancing in mathematics, yet, many students struggle to apply these skills in practical situations (Boaler, 2016).

The Bar Model method, a visual representation technique from Singapore Mathematics, has shown potential in enhancing students' understanding and problem-solving abilities (Kho, 2019). This method uses rectangular bars to visualize mathematical relationships, simplifying complex problems and fostering deeper conceptual understanding. Research suggests that visual tools can enhance student engagement and comprehension, making mathematical concepts more accessible. However, research on the Bar model method in Bhutan is limited. This study addresses this gap by examining its impact on Grade 4 students' ability to solve addition and subtraction word problems, a critical stage where foundational skills are consolidated, and more complex strategies are introduced. The Bar model method aligns with Bhutan's holistic learning philosophy by incorporating familiar scenarios from daily life, making instruction more relevant and effective (Ginsburg et al., 2008).

This research was motivated by the recurring challenges that Bhutanese students face in solving word problems. Classroom observations have consistently shown that many students struggle to connect mathematical concepts with real-life contexts, resulting in low achievement in problem-solving tasks. These challenges highlight the need for instructional methods that strengthen students' conceptual understanding and practical application of mathematics. This study aims to contribute to the body of

knowledge on effective teaching strategies in Bhutanese mathematics education and to provide practical approaches for improving student learning outcomes.

RESEARCH OBJECTIVES

1. To compare grade 4 Bhutanese students' achievements before and after studying through the use of the Bar Model method for addition and subtraction word problem achievement.

2. To examine Grade 4 Bhutanese students' learning satisfaction with the use of the Bar Model method in solving addition and subtraction word problems.

LITERATURE REVIEW

1. Evolution of the Mathematics Curriculum in Bhutan

The mathematics curriculum in Bhutan has evolved significantly, shaped by the Royal Education Council's (REC) efforts to blend modern pedagogical practices with Bhutanese cultural heritage. Initially influenced by India, Bhutan's curriculum relied heavily on imported textbooks and teaching methods. However, as Bhutan developed, the need for a curriculum reflecting Bhutanese values and addressing unique student challenges became evident (REC, 2019). Reforms introduced Bhutanese cultural references and examples to make learning more relevant, promoting a holistic approach to education that focuses on physical, emotional, and intellectual development. Despite these advancements, Wangmo and Tenzin (2019) note that students continue to struggle with Word Problems, which demand not only numerical skills but also language comprehension and the ability to apply mathematical concepts to real-life situations.

2. The Context of Mathematics Education in Bhutan

Mathematics education in Bhutan, like in many developing nations, faces challenges such as a shortage of trained teachers, limited resources, and a curriculum that, while culturally relevant, sometimes lags behind global standards. Bhutanese students often find mathematical concepts abstract and disconnected from their daily experiences, particularly in areas such as word problems (Wangchuk, 2017). To address these issues, recent initiatives by the Ministry of Education and Skills Development (MoESD) and the Royal Education Council (REC) aim to improve mathematics education by introducing new teaching methods and resources (REC, 2019).

3. The Bar Model Method

Originated from Singapore's mathematics curriculum, the Bar Model Method is a powerful visual tool that helps students break down complex problems into manageable parts by representing Word Problem elements as bars (Kho, 2019). In the part-whole model (Figure 1), a set (the whole) is composed of two or more subsets (the parts). In this approach, rectangular bars are utilized to denote the quantities that constitute the 'parts,' with the bars labeled and numbered to effectively represent the word problem, as shown in Figure 1

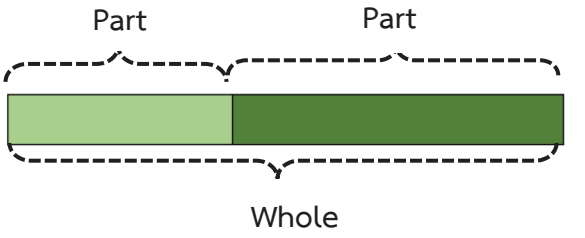

Figure 1 Part - whole model taken from Yeap (2014)

4. Empirical Evidence of Effectiveness

Research consistently supports the effectiveness of the Bar model method in improving students' mathematical problem-solving abilities. Studies across different educational contexts show that students taught using this method outperform those taught through traditional approaches (Gonzalez et al., 2020). For instance, Ng and Phang (2017) found that students using the Bar Model method made significant gains in solving complex word problems, particularly those struggling with mathematics' abstract nature. They also added that the method's adaptability across diverse educational systems further suggests its potential effectiveness which is applicable in Bhutan as well.

5. Benefits of Using Bar Model Method

The Bar Model method is recognized for enhancing students' understanding of mathematical concepts, especially in solving addition and subtraction word problems. By visually representing mathematical relation-

ships, this method simplifies complex problems, fostering logical reasoning and critical thinking (Suh, 2015). The Bar model method assists students in visualizing problems by translating textual information into clear, recognizable diagrams, which aligns with their learning needs through both visual and practical engagement (Ng & Phang, 2017). By providing a visual framework, the Bar model method enables students to organize and interpret complex information, which is especially useful for tackling difficult mathematical problems (Garelick, 2006). Its adaptability across cultural contexts, makes it a valuable tool, although successful implementation depends on factors such as teacher training, curriculum alignment, and resources. Additionally, the visual framework aids memory retention and problem-solving organization (Choden & Chalermnirundorn, 2021).

CONCEPTUAL FRAMEWORK

The study consisted of an independent variable, the use of Bar model method for addition and subtraction word problem achievement among grade 4 Bhutanese students. The two dependent Variables were students' learning achievement and students' learning satisfaction. Learning achievement was assessed through pretest and posttest. To gain a deeper knowledge of satisfaction, the researcher incorporated a qualitative method that is semi-structured interview, allowing for a thorough study of students' satisfaction and broadening the overall study's insights on the use of the Bar Model method on the learning experience. The positive correlation between the Bar model method and these dependent variables highlighted the method's potential to enhance both academic performance and student engagement in the learning process. The framework is illustrated below:

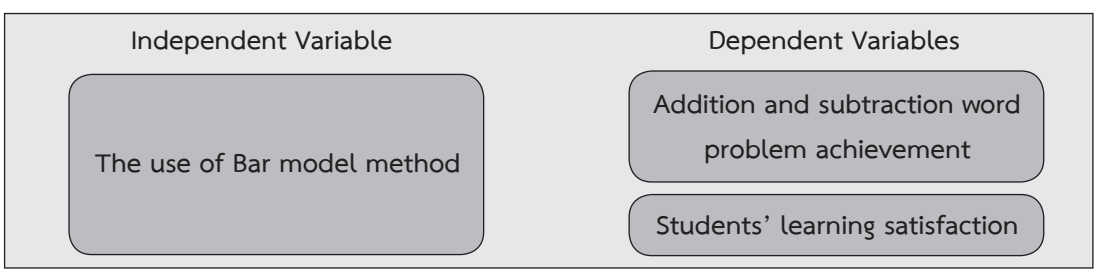

Figure 2 Independent and Dependent Variables for the study

RESEARCH METHODOLOGY

1. Research Design

This study employed a mixed-method design, integrating both qualitative and quantitative methods to investigate the learning achievement and learning

satisfaction of grade 4 Bhutanese students using the Bar Model method for solving addition and subtraction word problems. The researcher employed a mixed-method design to capitalize on the complementary strengths of both qualitative and quantitative approaches. This design was justified by its ability to provide a more comprehensive understanding of the research problem. Quantitative data, gathered through pretest and posttest, allowed for a measurable analysis of students' learning achievements, while qualitative data, obtained through semi-structured interview, offered deeper insights into students' experiences and satisfaction. 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). By combining these methods, the researcher was able to explore both the outcomes and subjective experiences, leading to a more robust and well-rounded interpretation of the study's findings.

2. Population and Sample

The study targeted grade 4 students from a school in Samdrup Jongkhar, Bhutan, encompassing a diverse group of students who are aged 9 to 11 years. A clustered random sampling method was used to select one section consisting of 30 students from five sections, ensuring a representative sample for the study. By maintaining careful oversight throughout the study, the researcher ensured that the sample size remained stable and sufficient for drawing valid conclusions.

By randomly selecting a cluster, such as a specific section of grade 4 students, the researcher minimized bias and ensured that each student within the selected cluster has an equal opportunity to participate. The randomness of cluster selection preserved the integrity of the sampling process, aligned with the study's goal of fair representation. Clustered random sampling was used to efficiently manage time and resources while minimizing disruptions in the school.

It allowed for the random selection of groups, such as classrooms, making it practical given logistical constraints, while still ensuring a representative sample.

3. Research Instruments

The research instruments included lesson plans, pretest and posttest, and semi-structured interview. The lesson plans, developed for four weeks of instruction, incorporated the Bar Model method and various multimedia tools like PowerPoint slides, video clips and worksheets to present the concept of Bar Model to enhance learning. The pretest and posttest, identical in content, were designed to measure learning achievement. The use of identical pretest and posttest assessments is a common practice in educational research, enabling researchers to measure changes in learning outcomes directly (Gall, Gall, & Borg, 2007). However, familiarity with the test can lead to practice effects, where participants may score higher on the posttest simply due to having seen similar questions beforehand (Bridger, 2014). To enhance the validity of the results, future research could employ alternative assessments or create varied test items that assess the same concepts, thereby minimizing the influence of prior exposure. While semi-structured interview provided qualitative insights on students' satisfaction towards the Bar model method.

4. Validity

According to several studies, the acceptable threshold for Item-Objective Congruence (IOC) should be higher than 0.67 (Polit & Beck, 2012). Content validity was ensured through expert reviews, with all instruments receiving ratings above the acceptable threshold (IOC > 0.67). In this study all the instruments (lesson plans, learning achievement test, and semi-structured interview questionnaire form) were validated by three experts and had rated +1 which was above 0.67, it showed that the items were valid for the study.

5. Reliability

The reliability of the achievement test was verified through a pilot test with Grade 5 students, yielding a Kuder-Richardson (KR-20) coefficient of 0.71, indicating reliable test items. A Kuder-Richardson coefficient of 0.70 is generally considered to indicate acceptable reliability in educational assessments (Cohen, 2013). From the pilot test conducted in grade 5, the coefficient obtained was 0.71, which indicated that test items were reliable.

6. Ethical Considerations

Ethical approval was obtained from relevant authorities, including the Research and Development Institute at Rangsit University and the Ministry of Education and Skills Development in Bhutan. Informed consent was secured from parents, and the confidentiality and anonymity of all participants were rigorously maintained.

RESEARCH RESULTS

1. Analysis of achievement test scores

The quantitative results of the study demonstrated a significant improvement on grade 4 Bhutanese students' achievement on addition and subtraction word problems following the implementation of the Bar Model method. The analysis, which involved 30 participants, yielded the following findings:

1.1 Improvement of Mean Scores

Figure 3 below displays the comparison of the mean score between the pretest and the posttest. The mean score of the participants increased from 12.13 in the pretest to 18.53 in the posttest, indicating a notable increase in 6.40 mean difference improvement. This increase suggested that the Bar model method had positive effect on the students' problem-solving achievements.

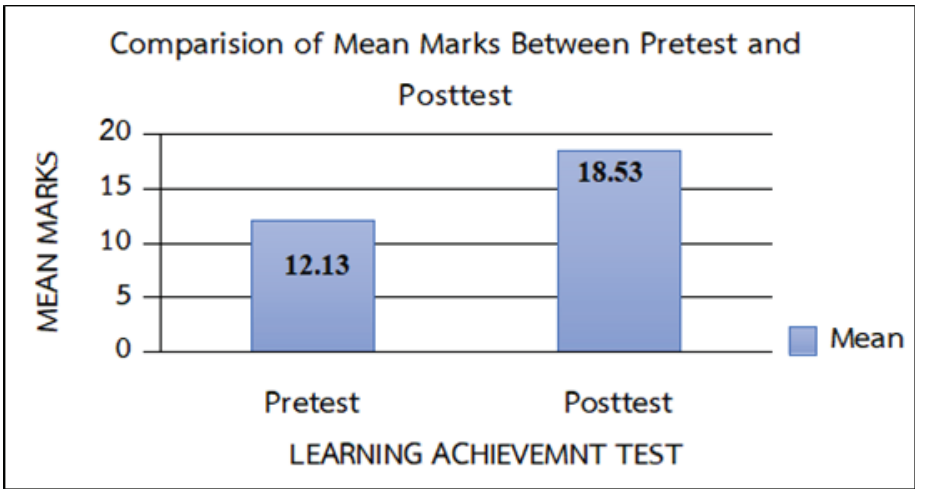

Table 1 Paired Sample T-test

		N	Mean	Std. Deviation	Mean Difference	t	Std. Error Mean	P (value)
Pair 1	Pretest	30	12.13	4.16	18.53-12.13=6.40	-12.01	.76	.000
	Posttest	30	18.53	3.09			.57	

Figure 3 Comparison of Pretest and Posttest Mean Scores

1.2 Statistical Significance

As represented in Table 1 above, a paired sample t-test was conducted to determine the statistical significance of the observed improvement. The test revealed a statistically significant difference between the pretest and posttest scores ($t = -12.01$, $p < .01$). The significance level ($p < .01$) confirmed that the improvement in scores was not due to random variation but was likely a result of the intervention. The standard deviation of the scores decreased from 4.16 in the pretest to 3.09 in the posttest. This reduction in standard deviation indicated that students' performance became more consistent after the intervention, with less variability in their scores.

1.3 Correlation Between Pretest and Posttest Scores

A strong positive correlation was found between the pretest and posttest scores ($r = .71$, $p < .01$). This suggested that students who initially performed well continued to improve, and those with lower initial scores also made significant progress.

1.4 Visual Representation and Data Presentation

Figures 4 and 5 in the study illustrated sample questions from the pretest and posttest, along with their corresponding answers.

These figures provided a visual representation of the students' problem-solving process before and after the intervention. The results were further detailed in Table 1 above, which presented the paired samples t-test, including the mean difference, standard deviation and standard error of the mean. The P-value was reported as .00, which is less than the

commonly accepted significance level of .05. This indicates that the improvement in test scores was statistically significant.

The quantitative analysis provided strong evidence that the Bar model method effectively enhanced the problem-solving skills of grade 4 students in Bhutan. The significant improvement in mean scores, the reduction in score variability, and the strong positive correlation between pretest and posttest results collectively demonstrated the method's impact on students' academic achievement in solving addition and subtraction word problems.

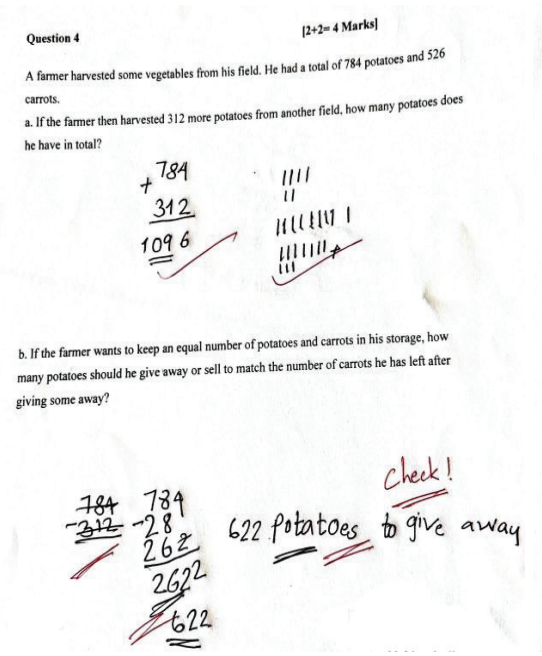

Figure 4 Pretest problem-solving sample question and its answers

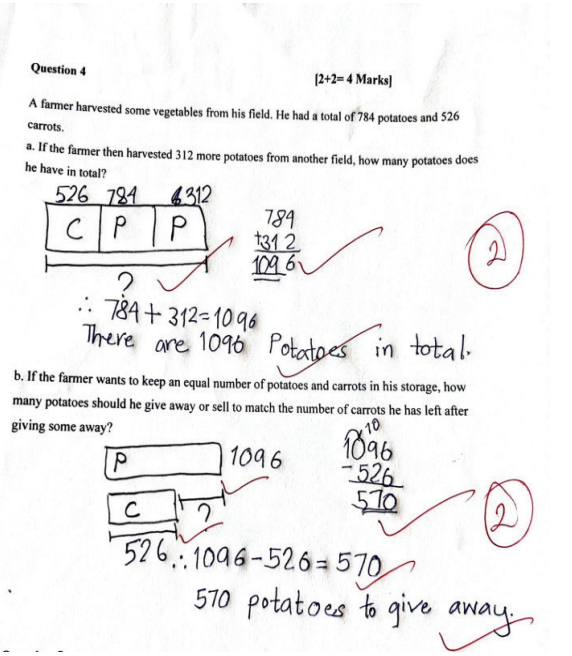

Figure 5 Posttest problem-solving sample question and its answers

2. Qualitative Analysis: Students' Learning Satisfaction

The qualitative data, derived from semi-structured interviews with 20 students, provided in-depth insights into their learning satisfaction towards the Bar Model method. Due to the time constraint and the convenience of the research participants, 20 students randomly selected out of 30 students. The interviews in this study were conducted individually, in pairs, and in groups to accommodate the convenience and comfort of the participants. This flexible approach is

justified by the need to foster an environment where participants feel at ease, allowing for richer, more natural responses. Research shows that adapting interview formats based on participant preferences can enhance the quality of data collected, as it encourages more open and honest dialogue (Creswell, 2014). By providing different settings, the study ensured that participants were able to engage in a way that best suited their individual needs, thus improving the depth and reliability of the data collected. The analysis was organized under the following themes:

2.1 Experience gathered from the use of the Bar Model Method

Students' experiences with the Bar model method evolved over time, initially presenting challenges that later transformed into greater ease and understanding. Student 001 stated, "I found it really helpful because it made the problems easier to understand." Similarly, Student 002 reflected, "At first, it was a bit confusing, but once I got used to it, I liked using it for solving problems." These reflections indicated that, while the method required an initial adjustment period, its benefits in simplifying complex word problems became apparent with continued use.

2.2 Preferences for Visual Learning

A preference for visual learning emerged as a consistent theme, with students appreciating the Bar Model method's ability to break down word problems into manageable parts. Student 018 remarked, "I liked that I could see the parts of the problem clearly," while Student 007 noted, "It helped me understand where to start and what steps to take." These comments underscored the method's effectiveness in providing a structured and visually guided approach to problem-solving.

2.3 Understanding and Clarity

Despite the initial confusion, students reported a clearer understanding of mathematical concepts after becoming accustomed to the Bar Model method. Student 030 mentioned, "It was confusing at the start, but then it got easier." Student 004, who initially struggled with breaking down problems into bars, emphasized the importance of guided practice, stating, "I had trouble understanding how to break down the problems into bars." Over time, the clarity and utility of the method

became more apparent as students adapted to its structured approach.

2.4 Attitude towards Collaborative Learning

The interview responses revealed varied experiences with collaborative learning. Some students enjoyed working together, with Student 008 stating, "We could help each other when someone didn't understand." However, there were few students who were less enthusiastic, as expressed by Student 026: "I don't like working in a team as some friends don't cooperate." These differing experiences highlighted the importance of managing group dynamics to optimize the benefits of collaborative learning alongside the Bar model method.

2.5 Desire to Continue Using the Bar Model Method

Students expressed a strong desire to continue using the Bar Model method, reflecting its positive impact on their learning experiences. Student 014 articulated this sentiment, stating, "I would like to use it again because it makes mathematics word problems easier to understand and solve." This enthusiasm suggested that the method not only enhanced their current performance but also fostered confidence and a willingness to apply it in future mathematical challenges.

RESULTS CONCLUSION AND DISCUSSION

1. Results Conclusion

The study demonstrated that the Bar model method significantly improved grade 4 Bhutanese students 'achievement in solving addition and subtraction word problems. Quantitative analysis revealed a substantial increase in mean scores from 12.13 in the pretest to 18.53 in the posttest, indicating a 6.40 of mean difference of improvement. The paired sample t-test confirmed this improvement was statistically significant ($p < .01$). Additionally, the decrease in standard deviation from 4.16 to 3.09 suggested more consistent performance among students. This consistency, along with a strong positive correlation between pretest and posttest scores ($r = .71, p < .01$), underscored the method's effectiveness in enhancing students' problem-solving skills.

Qualitative analysis provided further insights into students' learning satisfaction with the Bar model method. The majority of students expressed

positive experiences, noting that the visual and structured nature of the method made word problems more understandable and less intimidating. Students appreciated how the Bar Model Method helped them break down problems into manageable parts, leading to increased confidence and a more positive learning experience. However, initial challenges were reported, with some students requiring time to adjust to the method. Collaborative learning was also noted as beneficial, although some students faced challenges due to varying levels of cooperation among peers.

2. Discussion

2.1 Students' Learning Achievement

The findings of this study were consistent with previous research highlighting the advantages of visual learning tools in mathematics education. The significant improvement in test scores supported the effectiveness of the Bar model method, which aligned with theories such as Bruner's Theory of Instruction, emphasizing the use of visual aids to support cognitive development and aid in the retention of new information (Bruner, 1966). This result corroborated the work of Boaler (2016) and Van Garderen (2006), who identified visual aids as crucial for enhancing students' understanding and retention of mathematical concepts.

The study's result also aligned with Mayer's Multimedia Learning Theory, suggesting that structured visual representations can reduce cognitive load and improve learning outcomes (Mayer, 2009). The paired sample t-test confirmed that the improvement in test scores was statistically significant ($p < .01$), validating the Bar Model Method's effectiveness in supporting students as they transitioned from basic arithmetic to more complex problem-solving tasks. Despite the initial confusion experienced by some students, the Bar model method proved effective as they became more familiar with it. This outcome supported Sweller, Ayres, and Kalyuga's (2011) emphasis on comprehensive instructional support when introducing new teaching methods. The improvement in problem-solving skills over time demonstrated the method's potential for long-term integration into the curriculum.

To maximize the effectiveness of the Bar model method in improving students' problem-solving skills, it is recommended to embed it into the grade

4 mathematics curriculum. This integration would allow students to better manage complex problems by breaking them into simpler, more comprehensible parts. Additionally, targeted professional development for teachers is essential, focusing on both the theory and practical application of the method, along with strategies to address potential challenges. Gradual implementation alongside traditional techniques is also suggested to ease student adaptation, minimizing confusion and anxiety while fostering greater proficiency over time.

2.2 Students' Learning Satisfaction

Students' qualitative feedback regarding their satisfaction with the Bar model method provided valuable insights into its practical application and acceptance in the classroom. Most students reported a positive experience, expressing that the visual and structured nature of the Bar model made word problems more approachable and less intimidating. The impact of collaborative learning was notable, with many students reporting positive experiences when working with peers. However, the mixed feedback regarding teamwork highlighted the need for careful management of group dynamics to ensure effective collaborative learning (Johnson et al., 2000). 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, Ayres, & Kalyuga, 2011).

To improve students' learning satisfaction, promoting a collaborative learning environment alongside the Bar Model method is advised. Teamwork and peer learning can play a significant role in fostering positive learning experiences. Structured group activities and peer tutoring can create opportunities for students to assist each other in solving complex word problems, leading to greater engagement and satisfaction in the learning process.

For future research, it would be valuable to explore how the Bar Model method could be adapted to support other areas of mathematics, such as multiplication, division, and fractions. Investigating the method's applicability across various mathematical domains could provide a more comprehensive understanding of its effectiveness. Additionally, comparative studies could evaluate the Bar Model method against traditional problem-solving strategies to determine the most effective approaches for improving students' learning satisfaction and overall mathematical understanding.

The study had several limitations. The study was conducted with a single section of grade 4 students from one primary school in Bhutan, which restricts the ability to generalize the findings to all grade 4 students in Bhutan. Secondly, the data may have differed if the research had been conducted over a longer period. Lastly, the study focused solely on the Bar Model method for teaching addition and subtraction word problems, so it does not provide insights into student performance across the broader mathematics curriculum.

In conclusion, this study demonstrated that the Bar model method was an effective instructional tool for improving grade 4 students' achievement in to solving addition and subtraction word problems and enhancing their learning satisfaction. The visual and structured approach of the method, combined with its capacity to foster collaborative learning, supported its integration into the Bhutanese mathematics curriculum. The recommendations provided aim to maximize the benefits of the method and guide future research to further explore its potential in mathematics education.

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