Factors Affecting Bhutanese Secondary School Students' Ability in Solving Mathematical Word Problems: A Case Study

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Introduction

The primary mathematics curriculum serves as the foundation for a variety of higher-level mathematics courses, and it is where mathematics education in Bhutan begins. Up until class 10, mathematics is taught as a subject in a mandatory manner. The school mathematics framework [1], which emphasises the need for a balance between the development of conceptual mathematical knowledge, procedures, and attitudes [2], serves as the foundation for the mathematics syllabus. The main goal of mathematics education in Bhutan, as expressed in this curriculum framework, is to equip students with the necessary skills to become productive members of society and to solve mathematical problems [1]. According to Peer [2], the ultimate goal of mathematics education is to inspire pupils to understand and appreciate the subject as a valuable tool for exploring the natural world and acquiring critical thinking and communication skills that will benefit them throughout their lives.

More recently, the Teacher Professional Development Programme (TPDP) [3] described how the Bhutanese government has worked tirelessly to enhance and strengthen the educational process by incorporating transformative pedagogy into the curriculum. These days, teachers have a variety of tools at their disposal to present the lesson to the class. Nonetheless, the National Education Framework (NEF) [4] noted that students' performance in mathematics is generally low. Low maths results are a result of both the teaching approach—particularly the use of the chalk-and-talk method and memorization of material outside of context—and students' dread of mathematics.

Most kids have difficulty with mathematics, especially with "word problems." According to Bhutan's PISA-D national assessment, students outperformed on tasks requiring less cognitive ability, while there was a noticeable performance difference on tasks requiring more cognitive ability [5].

- Issue description

A major part of daily life is mathematics. It is the field that addresses issues requiring analysis, computation, and other mental abilities. There is more to mathematics than computation, measurement, and counting. It improves one's capacity for analytical and critical thought. It's common knowledge that mathematics involves more representations of numbers and symbols. In actuality, though, a significant portion of word problems call on pupils to apply their linguistic knowledge and abilities. Pfannenstiel characterised [6] mathematical word problems as a mix of words and numbers where pupils use what they've learned about mathematics to solve issues. Its goal is to assist learners in applying mathematical ideas to

actual circumstances. However, due of the intricacy of the solution method, a lot of pupils find it challenging to solve mathematical word problems.
Solving word problems is a true assessment of mathematical proficiency. It has to do with comprehending the issue, which in reality necessitates reading comprehension. In order to obtain what is needed, it also needs the correct operation formula. It also needs the involved numbers or phrase to operate correctly. These are a few standard procedures for resolving word issues.

It is important to remember that there is always a solution to an issue. The next task for every problem solver is to come up with some strategies and tactics to tackle the issue. Any student who is not proficient in word problem solving in mathematics (algebra, arithmetic, geometry, etc.) will have trouble coming up with the right answer.

Pupils' aptitude for learning maths varies. While some students are adept at using calculating techniques, others struggle to tackle word problems that call for the same algorithms. As a result, before they try to solve the word problem, they must completely understand it. Word difficulties' descriptive language contributes to their complexity, which is one of the reasons behind this incapacity. Pupils frequently don't grasp the precise question being posed, particularly when it involves abstract ideas [7].

• Literature Review

There are numerous definitions of mathematical word problems in the literature. Any math exercise in which substantial background material is provided as text rather than in mathematical notation is referred to as a word problem [8,9]. Comparably, Pfannenstiel, Bryant, Bryant, and Porterfield [9] described a word problem as a set of words and numbers where students use the knowledge of mathematics to solve problems.

On the other hand, Lai [10] described a word problem as one that aims to assist pupils in applying mathematical ideas to actual circumstances. Word issues can vary in the quantity of English used in the question and are sometimes also referred to as story problems since they feature a narrative of some kind.

The definitions raise the question of whether or not learners should view mathematical word problems as exercises rather than as problems. For some learners, a mathematical problem could be an exercise. According to Stigler and Hiebert [11], a given problem may offer difficulties for different learners based on their background and level of mathematical understanding.

Understanding the elements influencing pupils' word problem-solving ability is necessary to maximise their word problem-solving capacity. The literature reveals that a number of characteristics, including reading comprehension, linguistic competency, and contextual awareness, influence students' word problem-solving abilities.

Research on the relationship between mathematical performance and reading skills has been prompted by the current interest in children's mathematical abilities. A study by Vilenius-Tuohimaa, Aunola, and Nurmi [12] looked into the relationship between reading proficiency and solving mathematical word problems. Their findings demonstrated a high correlation between reading comprehension performance and performance on mathematics word problems. The findings of the study indicated that general reasoning skills were necessary for both reading and math capabilities. Research on the relationship between reading proficiency and mathematical aptitude has also been conducted globally. A study on mathematics and reading comprehension was undertaken by Lerkkanen, Rasku-Puttonen, Aunola, and Nurmi [13]. The findings indicated a strong correlation between the two. According to Nurjanah [14], students have vocabulary-related issues. These issues stem from students' bad reading habits and the boring reading comprehension classes they take in school. On the other hand, Auzar [15] found that in one study looking at the connections between reading comprehension skills and the capacity to comprehend mathematics word problems with 40

When reading comprehension was tested in primary school pupils, the findings showed no significant correlation between reading comprehension and the capacity to comprehend mathematical word problem questions.

The majority of the examined research indicate that students' ability to answer word problems is influenced by their reading comprehension. It is especially important to focus on the semantic-linguistic aspects of word problems in order to assist students in becoming more proficient at solving word problems. There is, however, little data to suggest that a child's real enthusiasm in reading is positively correlated with their ability to solve word problems.

Word problems make up the majority of standardised mathematics exams, which students must first interpret in order to calculate answers [16]. Despite being common, a lot of students struggle with word problems because they don't understand how the problem's semantic structure and linguistic consistency with the necessary procedures work [17].

When it comes to comprehending mathematical word problems, language is crucial. Knowledge—or lack thereof—can make a difference in one's ability to comprehend and solve word problems. Students need to pay close attention to a lot of language in order to comprehend and solve word problems [17]. This makes math word problem solving much more difficult for Bhutanese children for whom English is the exclusive language of instruction. It was demonstrated in the study where students' primary language of instruction was English that they found word problems more difficult than non-verbal computations, most likely because of the language component. When problems were presented in their native tongue, it appeared that they comprehended and remembered them more easily and used the appropriate procedures to solve them [18]. For this reason, it appears difficult to teach mathematical word problems to Bhutanese students in English.

Students' everyday language and the language used in mathematics word problems are not the same [19]. The National Council of Teachers of Mathematics (NCTM) [20] also stated that students require assistance in bridging the gap between their language use within and outside of the mathematics classroom because there is occasionally a mismatch between regular English and mathematical language. Mathematical English uses several vocabulary from common English but in a separate language.

Furthermore, word problems written in complicated language are judged as quantitatively harder to solve than the identical problems written in simpler language, as noted by Barb and Beal [21]. People who struggle with the English language may do worse than their peers in other subjects that don't directly involve the language [22]. This raises the dilemma of language serving as a barrier to maths word problem solution for students learning English as a second language (ESL). Long-term results in mathematics and reading are correlated with children's mathematical achievement [23]. Children's mathematical outcomes have been found to be predicted by their instructors' use of mathematics language [24], yet there aren't many empirical studies that have looked at this relationship.

Pupils must focus on their mathematical proficiency without sacrificing their capacity to interpret and comprehend written material provided in word problems [25]. The goal of mathematics education should be to assist students in drawing connections between mathematical concepts and practical applications [26]. Incorporating students' names, life experiences, and the mathematical concepts being taught into word problems improves focus and reduces language-based issues [27].

The majority of students who did not understand the context of a word problem and instead performed the mathematical operation they thought was suitable were the ones who did not correctly solve word problems [28]. It was found that by making settings more meaningful, word problem solution is improved in familiar circumstances [29]. However, across grades and disciplines, the majority of pupils were unable to comprehend fundamental ideas and apply information to practical circumstances, showing a significant understanding gap [4].

The gap in comprehension of the fundamental concepts mentioned above highlights the need for contextual understanding in word problem solving; however, prior research failed to take into account the fact that students have varied learning experiences that influence how they interpret the material.

setting. For instance, a student who is unfamiliar with American sports could not get the issue with baseball averages or football scores.

• Materials and Methods

A qualitative research methodology was used in the study to identify the variables influencing students' proficiency in answering mathematical word problems. Emerging questions and processes, data acquired in the participant's context, inductive construction of specific to general themes in data analysis, and the researcher's interpretation of the data are all part of the research process [30].

• Research design

A case study research design was used for this investigation. Specifically, this research employed Yin's formulation of a single embedded case study [31]. This relates to secondary education. But this case study required more than one analytical unit. The cases of students in classes 7 through 12 as well as the maths teachers at this school were included in these units of analysis. It examined the word problem-solving skills of students at various class levels as well as the perspectives of maths teachers in various classroom settings.

• Research site

In Western Bhutan, at Punakha Central School, this study was carried out. It is an 859-student, whole-day school with 37 teachers. There are 7 maths professors and 19 classes in the school, ranging from 7 to 12. Convenience played a role in the study site selection process as the investigator approached both the suitable site and the subjects.

• Participants

Students from every class level in the school as well as the maths professors who were instructing these classes participated in the study. The researcher recruited four teachers and four students using the purposive sample technique [32]. Purposive sampling, as the name implies, refers to the process of selecting a sample with a specific goal in mind, one that fulfilled the researcher's requirements for conducting that kind of study. Those four pupils were selected from classes 7 and 8, 9 and 10, class 11 arts, class 12 science, and class 11 general education. The teachers who instructed mathematics in grades 7 through 12 made up the participation pool.

• Data collection tools

The main source of information was gathered through one-on-one, semi-structured interviews lasting between 25 and 30 minutes with teachers and students. All of the interviews were recorded on audio and verbatim transcribed to make further data analysis easier. Supporting information was gathered by document analysis of maths textbooks and classroom observations, in which the researcher observed as a non-participant observer [33]. Through the use of previous questions and semi-structured descriptive note-taking, direct classroom observation was conducted. Information

on the application of the word problem's context was obtained through document analysis of mathematics textbooks for grades 7 through 12. Information about whether or not word problem questions in mathematics textbooks have Bhutanese contexts and contextual language was gathered with the aid of document analysis. To verify that word problem questions are used in Bhutanese context, contextual language, and abstract language, a unit-by-unit checklist was created. This was carried out in order to verify the data collected via other methods.

- **Data collection procedure**

Samtse College of Education gave its approval for this project. At the school level, prior authorization was sought from the principal of the concerned school and the Dzongkhag Education Officer (DEO) before visiting a school. The DEO and the administration of the school gave the researcher written permission to gather data. Prior to

the researcher informed participants about the goal of the study and their right to withdraw from the research if they had any issues throughout the conduct of the interviews and the classroom observations. Only those who expressed interest in participating were given an informed and voluntary permission form and participation information sheet by the researcher. In order to avoid interfering with their normal classes, the researcher interviewed student participants after school and instructor participants in their spare time. A researcher watched the teacher participants' class whenever they were teaching word problems at the same time. Confidentiality was maintained for all the information gathered from classroom observations and interviews.

- **Data analysis procedure**

A theme analysis was used to determine the variables influencing students' word problem-solving skills (Fig. 1). One technique for finding, examining, and summarising patterns in data is thematic analysis. Inductive analysis, which includes theme analysis as well, is a type of analysis where "findings emerge out of data, through the analyst's interactions with the data" [34]. Themes in qualitative analysis are notions indicated by the data, not predetermined concepts that come from the data [35].

Creswell's [30] data analysis in qualitative research outlines the several processes that were involved in the procedure. Data were first arranged and ready for analysis. It required typing the observations from the classroom, transcribing the interviews, reviewing math textbooks, and classifying and organising the data into several categories based on the information's original source. Following the collection of data, all of the data was coded by assigning a term to each category found in the transcripts and classroom observations. In order to maximise coherence across codes and provide definitions for codes, the researcher created a codebook. A list of codes along with a brief explanation was provided by the codebooks for classroom observations and interviews. then created a description of the themes for analysis using the coding procedure. The themes were created by grouping codes that were similar. The process of coding produced three themes. These topics emerged as the study's main conclusions. Ultimately, the data was validated using triangulation of the results obtained from the

three techniques.

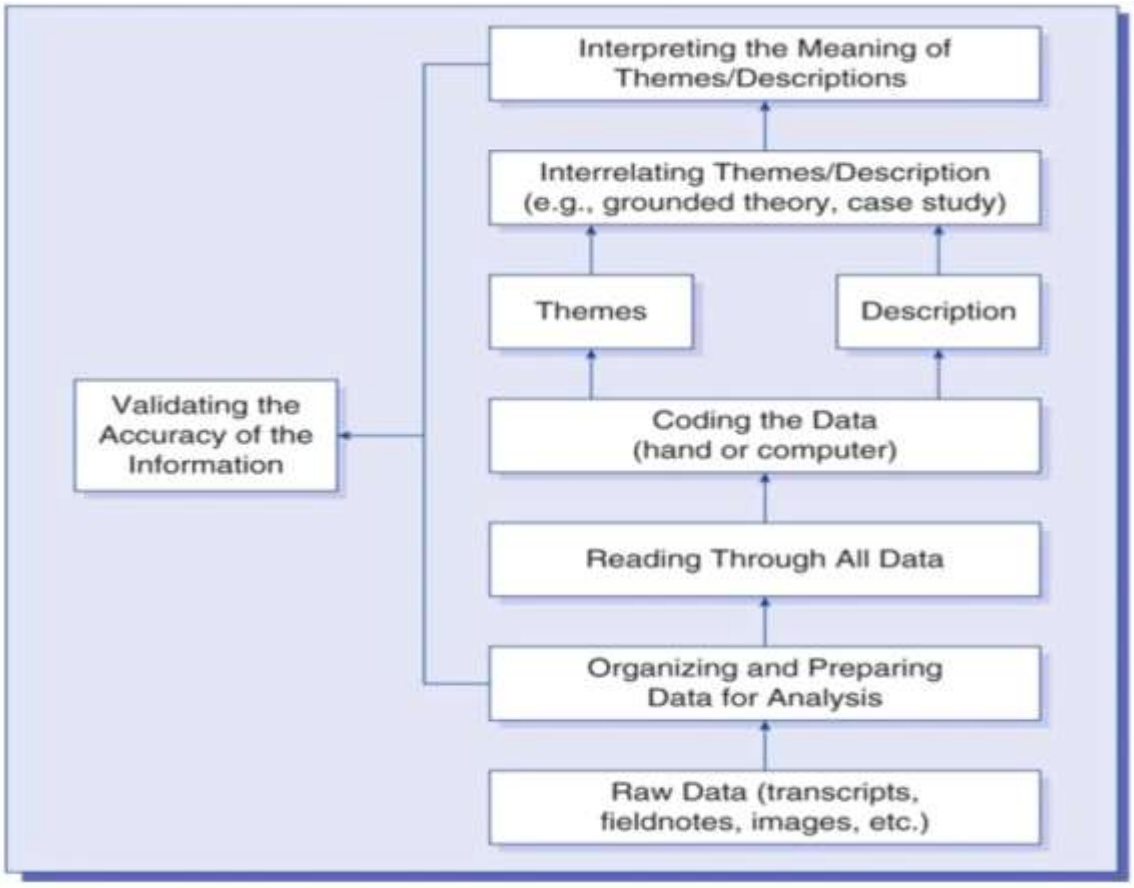


Fig. 1. Data analysis in qualitative research [30]

• Results and Discussion

• Results

The data collected through semi-structured interview, classroom observations and document analysis are analysed and triangulated to validate the findings. In doing so, certain parts of interview transcriptions of teachers and students and classroom observations are directly coded using codes such as Mt_1, Mt_2, Ft_1, Ft_2 to refer to each of the male and female teacher-interviewees, Ms_1, Ms_2, Fs_1, Fs_2 to refer to each of the male and female students and C_1, C_2, C_3, C_4, C_5, $_6$ to refer to each of the classroom observations.

• Language proficiency

One of the most important aspects of word problem solving is understanding the question. In order for pupils to comprehend and solve word problems, they must possess a sufficient level of linguistic proficiency. As a result, both teachers and students must be able to solve word problems with language fluency. However, pupils become perplexed by the problem's purpose due to the lengthy words and plenty of information. They either fail to understand the problem's meaning or interpret it incorrectly. Due to their inadequate language abilities, students frequently misinterpret the issue. "Understanding the problem takes time, as I don't understand the language in the question," FS2 noted. The teacher participants also mentioned that if one is proficient in the language, it becomes easier to understand mathematical terms and terminology and to select the appropriate procedures. FT2 said that in order to overcome word problems, both teachers and pupils must have strong language skills. Because students find it difficult to understand when teachers cannot explain things clearly, and as a result, they are unable to come up with the appropriate operations.

Additionally, FT1 stated, "I believe that if a teacher can explain it appropriately, I think almost 50% of the students will understand when explained with the single explanation" . It has been noted that teachers explain mathematical word problems to students in languages other than English. During the C2 and C3 classroom observations, it was discovered that although teachers were teaching

word problems to the entire class in English, they were also monitoring and explaining the material to the kids in Dzongkha, the native language. In a same vein, students employed Dzongkha in group discussions and when looking for answers to questions. MT1 revealed, "By analysing the student's facial expression I see that when I explain word issues in Dzongkha, they comprehend it better.

Reading skills

Poor reading habits can impede students' ability in solving word problems. Students face difficulty in solving word problems because they have limited vocabulary as they have read a limited number of books. MS_1 said:

The number of books I read is limited. Due to poor reading habits, I face difficulty in solving word problem questions. I believe if we read more books it will help us in solving word problems more efficiently.

Reading the word problem questions repeatedly can help the students understand better. It was also found that to solve the word problems, students have to read the word problem questions repeatedly to come up with the final solution. To formulate the equation and to choose the right operations, they have to read the word problem questions repeatedly, especially when they are solving multi-step procedures. The students said that they read the word problem questions maximum of three times to get the final solution. FS_1 said, “I usually read word problem questions three times because if we read one or two times we don’t get the right idea”. Correspondingly, the classroom observations showed that the teachers read and explained the word problems several times to make the final solution.

Contextual understanding

The results of the interviews, classroom observations, and textbook study in mathematics demonstrated the significance of context in understanding and resolving mathematical word problems. Each of the four educators

The significance of connecting word problems to actual situations was evaluated by the participants. According to FT1, "Mathematical word problems are important because they help connect classroom instruction with real-world experiences." Moreover, FT2 and MT2 upheld comparable claims: I attempt to connect some subjects to the personal lives of my pupils. For instance, I use a real-world scenario to illustrate commercial mathematics to students in class eight. Use the example of a person taking out a bank loan and repaying it with interest to teach simple interest (FT2).

Completing word problems requires more than just knowing numbers and figures. It is useless to pursue engineering if you are an engineer and are proficient in calculus theory but are unsure on how to apply it (MT2).

Teachers who participated in the discussion noted that pupils are more successful in comprehending and resolving the word problems if they have firsthand experience with the events they are describing. MT2 stated:

My observations lead me to assume that pupils are drawn to word problems that have a personal connection to them. When word problems in mathematics or other areas are abstract, they become less interested. As a result, I believe that making word problem solutions relevant to real-world situations increases students' interest in them.

According to the findings, students prefer word problems that are related to their daily lives. There are multiple word problems in the Bhutanese context found in the mathematics textbooks for grades 7 through 10, which are addressed in context.

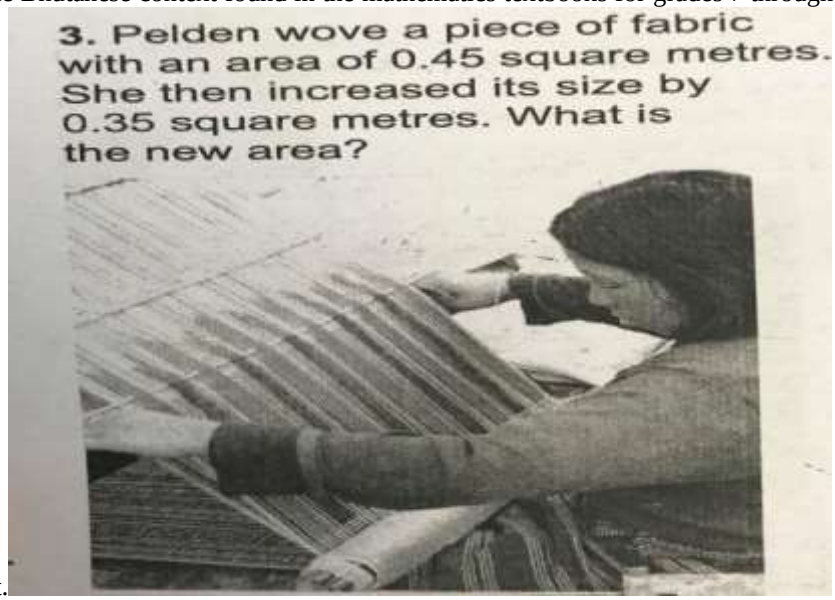


Fig. 2. Class 7 textbook used word problem in Bhutanese context [36]

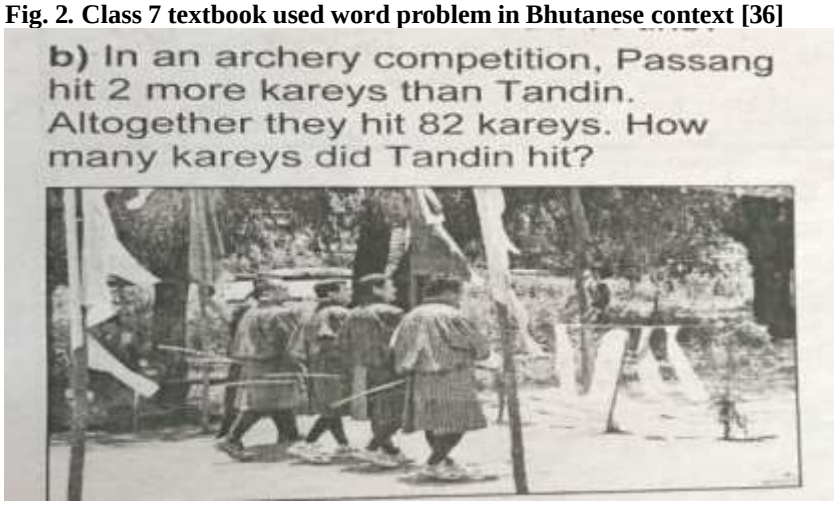


Fig. 3. Class 8 textbook used word problem in Bhutanese context [37]

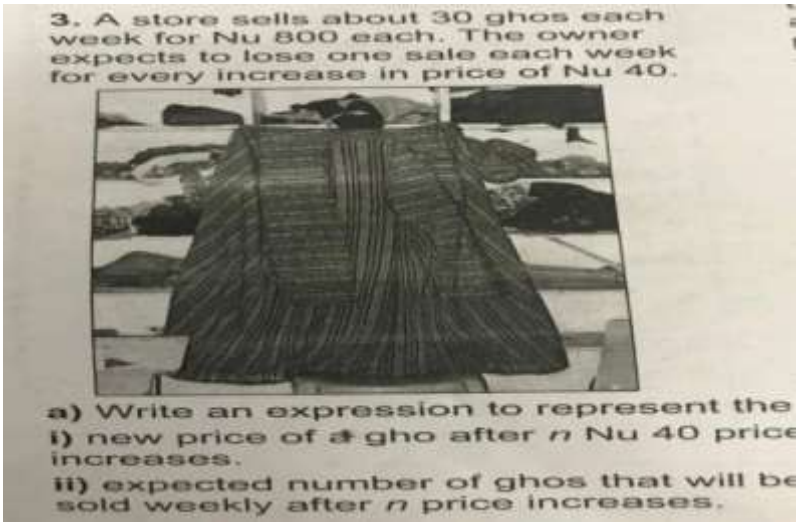
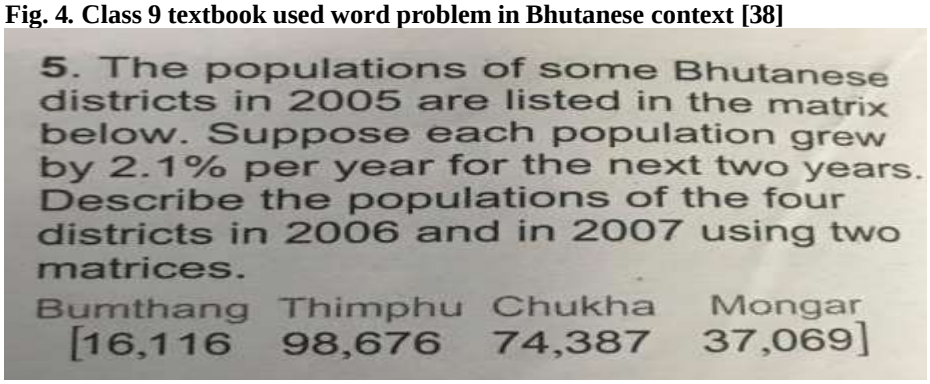


Fig. 4. Class 9 textbook used word problem in Bhutanese context [38]

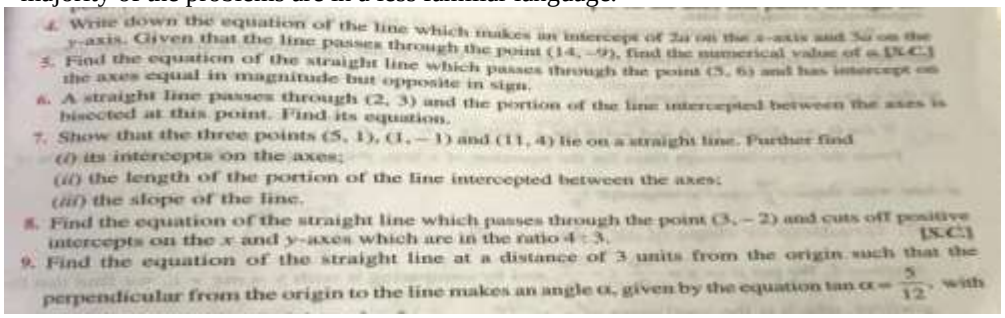

5. The populations of some Bhutanese districts in 2005 are listed in the matrix below. Suppose each population grew by 2.1% per year for the next two years. Describe the populations of the four districts in 2006 and in 2007 using two matrices.

Bumthang Thimphu Chukha Mongar

[16,116 98,676 74,387 37,069]

Fig. 5. Class 10 textbook used word problem in Bhutanese context [39]

However, the word problems of class 11 and 12 textbooks do not have contextual word problems instead the majority of the problems are in a less familiar language.


4. Write down the equation of the line which makes an intercept of 2a on the x-axis and 3a on the y-axis. Given that the line passes through the point (14, −9), find the numerical value of a. [I.S.C.]

5. Find the equation of the straight line which passes through the point (5, 6) and has intercept on the axes equal in magnitude but opposite in sign.

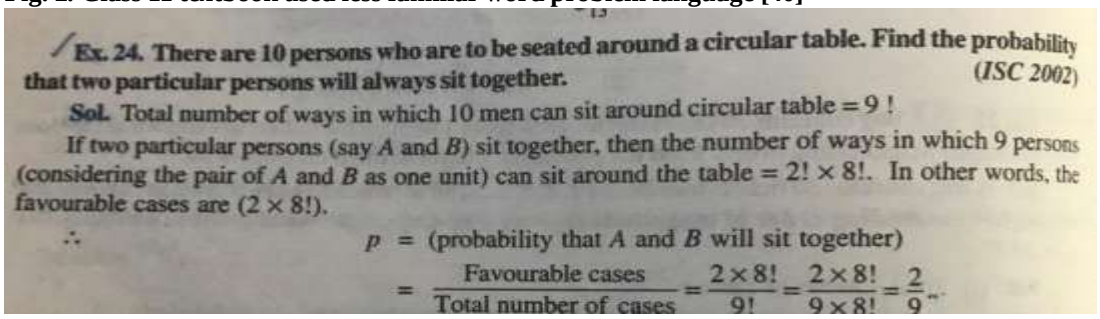
6. A straight line passes through (2, 3) and the portion of the line intercepted between the axes is bisected at this point. Find its equation.

7. Show that the three points (5, 1), (1, −1) and (11, 4) lie on a straight line. Further find
(i) its intercepts on the axes;
(ii) the length of the portion of the line intercepted between the axes;
(iii) the slope of the line.

8. Find the equation of the straight line which passes through the point (3, −2) and cuts off positive intercepts on the x and y-axes which are in the ratio 4 : 3. [I.S.C.]

9. Find the equation of the straight line at a distance of 3 units from the origin such that the perpendicular from the origin to the line makes an angle α, given by the equation $\tan\alpha = \frac{5}{12}$, with

Fig. 2. Class 11 textbook used less familiar word problem language [40]


Ex. 24. There are 10 persons who are to be seated around a circular table. Find the probability that two particular persons will always sit together. *(ISC 2002)*

Sol. Total number of ways in which 10 men can sit around circular table = 9 !

If two particular persons (say A and B) sit together, then the number of ways in which 9 persons (considering the pair of A and B as one unit) can sit around the table = 2! × 8!. In other words, the favourable cases are (2 × 8!).

$$\therefore \quad p = \text{(probability that } A \text{ and } B \text{ will sit together)} = \frac{\text{Favourable cases}}{\text{Total number of cases}} = \frac{2\times 8!}{9!} = \frac{2\times 8!}{9\times 8!} = \frac{2}{9}.$$

Fig. 3. Class 12 textbook used less familiar word problem language [41]

Classroom observations revealed that teachers teaching classes 7 to 10 relate the word problems with the real-world experiences and personal life experiences of the students. For instance, the concepts like volume, capacity, probability, and speed were related to the real-world experiences of the students. However, class 11 and 12 teachers were seen using abstract language without relating with the real-world experiences. They taught derivative, ellipse, and homogenous equation concepts without relating with the real-world experiences.

• Discussion

Research revealed that non-native English speakers could underperform compared to their classmates in courses unrelated to language [22]. Similar to this, the results of this study showed that students' competency in solving word problems is significantly influenced by their comprehension of the language used in mathematical word problems. A mismatch between mathematical and English language could be one cause of not understanding the mathematical language. For instance, the word "function" in everyday English refers to an action that is inherent to or serves the purpose of a thing or person. In mathematics, however, a function is a relationship or expression that involves one or more variables; this is known as the function (x + y).

Furthermore, this study demonstrated that successful word problem solving is influenced by teachers' language use as much as by students'

language proficiency. The results of Klibanoff et al.'s [24] study, which discovered that instructors' mathematical language might predict children's word problem-solving outcomes, corroborate the findings of this study. The literature has very few empirical research that looked at instructors' use of mathematics language. Nonetheless, this study found that students' ability to solve mathematical word problems can be influenced by both teachers' and students' linguistic competency. It was evident that students could not successfully solve word problems on their own without the teachers' proficient use of the English language.

Additionally, there is a relationship between reading comprehension and mathematics word problem solving abilities. It is discovered that reading the word problem questions aloud to the pupils can improve their comprehension. Overall, this study's findings concur with those of other research [12, 13, 16]. Researchers discovered that pupils' word problem-solving abilities are influenced by their reading proficiency. Additionally, they advised students to go back and review the assignment to make sure they understood the question and answered it correctly.

The significance of connecting word problems to the students' everyday environments was also considered in the study. Research has shown that by making situations more relevant, word problems can be solved more effectively in familiar circumstances [29]. According to the study's findings, students are more engaged with word problems that are tailored to them and presented in a setting they are comfortable with than with problems that are taken straight out of a maths textbook. There is a significant understanding gap, as evidenced by the research, which shows that most students in all grades and courses struggle to comprehend fundamental ideas and apply their knowledge to practical circumstances [4]. The word difficulties may not be in the Bhutanese context with contextual language, which could be the reason for the frequency of such gaps.

• Conclusion

The increased usage of word problems in the mathematics curriculum in Bhutan served as the catalyst for this study, which looked into the reasons behind the challenges secondary instructors and students encountered when attempting to solve mathematical word problems. These difficulties stem from three areas: reading comprehension, contextual awareness, and language ability. The ability to communicate in language is crucial for resolving mathematical word problems. In actuality, word problem-solving abilities can be accessed by comprehending the mathematical language. The proficiency of students in speaking the national language (Dzongkha) is given a lot of importance. But the key to assisting kids in solving mathematical word problems in the classroom was the teacher's language. When it comes to word problem solving, the way teachers use language in the classroom is a key illustration of good communication. According to this study, students may struggle in any subject to solve word problems including mathematics. In actuality, deficiencies in any of the abilities, either singly or collectively, may be the root problem. As a result, this study demonstrated the important impact that reading plays in the perceptions of both teachers and students regarding the challenges that students face when completing mathematical word problems. Given the significance of reading abilities in resolving mathematical word problems, the researcher suggests the Ministry of Education (MoE) prioritise reading programmes in schools. Students could then develop better reading habits as a result.

with a larger vocabulary to increase their language skills, which is necessary for both students and teachers when working through word problems in mathematics. The study has certain limitations, thus its conclusions might not apply to other situations. It would have been simpler to generalise the findings of this study to a larger population if there had been more individuals from more diverse secondary education backgrounds. Because the study was limited to a single school, its conclusions might not apply to other educational institutions across the nation.

Consent and Ethical Approval

The researcher considers the ethical dilemma in this investigation. The relevant authority's written consent was acquired prior to data collection. Prior to the interview and classroom observations, all participants duly signed consent letters.

Competing Interests

The author has stated that there are no conflicting interests.

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