The Influence of Mathematical Language on Students' Ability to Solve Problems in Junior Schools within Cheptiret Zone in Kenya

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ABSTRACT

In Kenya, performance in mathematics by primary school learners continues to be an issue especially in word problem solving. Though competence may be exhibited in computational tasks, most learners tend to show challenges in mathematical problems that are represented in linguistics form. Mathematical language comprising of vocabulary, syntax, symbolic representation and contextual definition is very important in helping the learners to comprehend and solve these problems. Nonetheless, there is little empirical evidence regarding the predictive power of mathematical language on the problem-solving capabilities among primary school students in the Uasin-Gishu County (Biwott, 2022). This paper has discussed how mathematics language has affected the capability of Class Seven learners in Cheptiret Zone to solve mathematical word problems. The adopted design was a descriptive correlational survey design. A sample of 388 learners and 15 mathematical educators out of a population of 1 292 learners result was selected (Biwott, 2022). Learners gathered the data through their questionnaires, in form of structured word problem-solving exercises and teacher questionnaires in addition to interview schedules. Simple linear regression, Pearson correlation, and descriptive statistics were used to analyze quantitative data, and simple linear regression, Pearson correlation, and simple linear regression on the same, whereas thematic analysis of qualitative data on teacher interviews was performed. The findings showed that the relationship between mathematical language competence and problem-solving capacity is statistically significant (r =.62, p=0.05). Regression analysis also showed that math language was an important predictor of the performance of learners in the word problem solving (=0.58, p <.001), which predicted about 38 percent of variance in the scores of learners. These findings were backed up by the qualitative finding of teacher interviews, which also indicated the problems of learners with the interpretation of mathematical vocabulary or word problems into mathematical expressions.

The paper finds that language proficiency in mathematics is also a central issue in determining the success of learners in mathematical word problems. The research thus prescribes incorporation of systematical vocabulary training and language supportive instruction in math classes so as to promote problem solving skills among the learners.

Keywords: New vocabulary, words problems, mathematical language, problem-solving ability, primary mathematics education.

INTRODUCTION

The common knowledge generally presents mathematics as a fundamental science in respective scientific, technological and the socio-economic growth. It plays the central role during the learning process of logical thinking and problem solving skills and analysis among the learners. However, mathematical correction is not only a mathematical activity but also language and to reality that meaning is brought forth and understood and traded (Pimm, 1987). The language of communication regarding mathematical concepts also follows a technical language of jargons and elements of the form of communication that include technical terms in mathematics, mathematical symbols, graphs, and logical systems. To be successful in mathematical tasks, the learners are

expected to know this language correctly, and they should know how to convert the mathematical language into the solution processes.

Mathematical language does not resemble everyday language, both in form and content. Common words such as difference, product, table, root and mean make no sense in mathematics as they do in normal sense. In addition to the fact that mathematical notation is anchored on the broad use of symbolic notation and skimpy syntax, in which students are required to read and correspond a phrase in language to either algebraic or numeric representation (Morgan, 1998). This makes mathematical language an imperative language towards conceptual understanding and solving of problems. In some cases where the mathematics problems cannot be comprehended in the learners in the language, they would not decode the queries properly and go through the incorrect steps besides arriving at incorrect answers despite having the necessary capabilities to carry out the computations (Schleppegrell, 2007).

Problem solving is one of the objectives of mathematics education in the world that is of the key. It involves having the capability of analyzing a problem, getting the information, selecting the appropriate strategies, and applying processes in acquiring correct solutions. In particular, word problems require the learners to be able to read, digest and translate verbal communications to mathematical expressions following which any calculations are to be performed. This process presupposes in a way language proficiency (O'Halloran, 2005). Therefore, the understanding of mathematical language is closely related with the successes of learners in problem solving.

In Kenya, the performance at social level of mathematics has remained a major concern among the teachers and policy formulation in Kenya. It is revealed that in the past years, many candidates have been reported to score dismally in questions that require interpretation of word problems, as well as in questions that require calculation of mathematical proficiency in uncharted scenarios (KNEC, 2019). The fact that the candidates were not able to analyze the questions, which were set in another language, is the report that it is often given by the examiners to equate this poor performance. It means that the learning challenge in mathematics could not necessarily be explained by the lack of content knowledge only and but by the lack of proficiency in mathematical language.

Various research works have been employed to examine the factors that revolve around the performance of the students in mathematics in terms of teaching methods, attitude of the students and availability of learning resources or other teaching materials as well as the quality of teachers. However, there is a dearth of empirical studies done regarding the use of mathematical language as a predictor of the problem solving ability of the learners specifically in the Kenyan Junior school environment and further in Cheptiret Zone. The classroom experience, however, has demonstrated that there are so many students who have difficulties with interpreting mathematical vocabulary, learning to utilize symbols as a part of representation, and translation of words in a verbal statement into a mathematical formula.

The awareness on the relationship between the mathematical language and the problem-solving ability of the learners is therefore pertinent to the improvement of mathematics teaching and learning. Just in case, the problematic areas with which learners struggle in mathematics are rather linguistic, then the instruction strategies must imply a clear emphasis on the mathematical language construction and content delivery. This leads to a condition where language sensitive pedagogy is applied in mathematics instruction whereby the teachers teach mathematical terms proactively, demonstrate how to solve word problems and direct students in identifying a connection between verbal/symbolic and graphical constructions.

The belief behind the study was that mathematics learning is a discourse based activity in which language is a means of defining meaning building as well as problem solving ability. The study was an attempt to provide empirical evidence on mathematical language and how students can solve problems with the consideration to how the two variables relate and thus give evidence that can be applied in informing the practice in classrooms, curriculum implementation, as well as in the preparation of teachers.

Specifically, the study aimed to define how mathematical language affects the skills of the students in the problem solving in the Junior schools of Cheptiret Zone, Kenya. The output of this research will contribute not only to the marine of the preexisting body of knowledge about mathematics education, but also to highlight the topicality of using language development in mathematics instruction as well as introducing context-specific evidence that may be implemented to improve the achievements of mathematics learners.

LITERATURE REVIEW

Mathematical Language and Mathematics Learning

Mathematics is commonly termed as a technical language that utilizes symbols, words and methodical phrases to express mathematical concepts. Knowledge of this language is also crucial in enabling the learners to understand mathematical statements and derive solutions to problems. Mathematical language contains words and symbols as well as the structure of a sentence that is used to represent the mathematical relationships and mathematical operations (Riccomini et al., 2015). Students that do not know this language usually have a hard time deciphering mathematical exercises especially word problems.

Studies have indicated that mathematical vocabulary is paramount in the knowledge students have of learning and solving mathematical problems. Blessman and Myszczak (2001) propose that the inability to comprehend mathematical vocabulary may compromise the capacity of learners to interpret languages in their word problems into mathematical language formulations. Likewise, Moschkovich (2012) points out that mathematics learning is not simply the cognitive process of numerical reasoning but also the process of interpretation and the capability of encapsulating mathematical concepts using language.

Current research also emphasizes on the relevance of language in learning mathematics. Vukovic and Lesaux (2018) explain that language proficiency can play a critical role in the development of students in mathematics especially in areas where reading and interpreting are involved in solving mathematical tasks. Likewise, Schleppgrell (2019) says that the mathematical texts are linguistically complicated as a skill that may pose obstacles to learners with low language proficiency. These results care to imply that mathematical language must be taken as a major constituent of mathematical competence as opposed to a facilitating skill.

The phrase and the word problem are language parameters improving children's thinking skills by using mathematical language and solving math problems.

Word problems find wide application in the teaching and learning of mathematics as learners can use mathematics knowledge to solve problems in real life. Yet, word problem solving can be a challenge to many learners despite the fact that such learners may have required computational skills. The language complexity of word problems (Daroczy et al., 2015) is one of the primary causes of these complications.

Word problems also expect the learners to read, understand and translate verbal information into mathematical forms. Hegarty et al. (1995) argue that effective problem solvers first form mental images of problem situations then use mathematical operations. On the contrary, failing learners tend to apply superficial methods, e.g., searching the keywords without complete knowledge about the context of a problem.

Research has uncovered that an individual reading comprehension is closely connected with achievement in solving mathematical word problems. Pape (2004) established that learners with high reading comprehension ability have a higher chance of correctly interpreting statements of the problem and finding the right strategies to solve the problem. On the same note, Powell et al. (2017) noted that learners with superior reading comprehension are much better in tackling mathematical problems that require solving.

The recent studies also emphasize the importance of linguistic characteristics in the determination of difficulty of the word problems. Daroczy et al. (2015) established various linguistic factors that determine the level of difficulty of a problem and they are sentence complexity, vocabulary, and the application of relational terms. The factors may add to cognitive loads imposed on learners especially when they are not familiar with language on which the problem is in.

Mathematical Problem solving Cognitive and Linguistic factors.

Mathematical problem solving is a process which entails cognitive and linguistic processes. In order to solve the problem, Polya (1945) recommends that unraveling the problem, a plan, implementation, and evaluating the solution are to be understood. Language comprehension or the first step, which is understanding the problem, is more or less reliant on language.

The cognitive theory by Piaget also places emphasis on language in cognitive development. According to Piaget (1936), language is very vital in assisting the learners to develop meaning and structures of knowledge. Language aids in learning mathematics because learners are able to make out the statements in problems, mathematical representations, and application of reasoning.

The current studies favor the interaction between language and cognition process in learning math. According to Kintsch and Greeno (2018), solving word problems entails the combination of linguistic and mathematical reasoning by learners. The same researcher discovered that there was a mutual dependence of working memory and language understanding as it affects the capacity of learners to solve mathematical problems (Swanson et al., 2016).

In addition, it is postulated that visual representations and linguistic understanding intermingle to facilitate problem solving. Boonen et al. (2016) discovered that learners with good reading comprehension skills and good visual representations succeed in solving mathematical word problems. These results imply mathematical problem solving needs language comprehension, as well as, cognitive processing ability.

Empirical research on Mathematical Language and Problem solving.

Numerous empirical studies have been done to address the relationship between mathematical language proficiency and problem-solving ability. A study by Vilenius-Tuohimaa et al. (2008) observed that vocabulary knowledge and reading comprehension can greatly be used as the predictor of performance among learners on mathematical word problems. Likewise, complex mathematical language also influenced the problem-solving skills according to Walkington et al. (2019).

It is also noted by other researchers that language proficiency also issues in mathematical achievement. Van Rinsveld et al. (2016) discovered that vocabulary knowledge is closely correlated with performance in arithmetic among primary school students. These results show that students with good language competence can more easily understand mathematical tasks and use relevant strategies of solution.

Besides this, research conducted among learners with mathematics problems reveals that language challenges can have a great influence on mathematical performance. Krawec (2019) identified language comprehension inability as one of the factors that make students with learning difficulties unable to build a proper representation of mathematical problems.

Taken together, these studies show that the proficiency of mathematical language is closely related to the skills of the learners to understand mathematical problems and use the necessary strategies of finding solutions.

Research Gap

Despite the fact that the strength of mathematical language in solving problems has been highlighted in past, an extremely small number of studies have focused on this association within the Kenyan primary schools. Most of the studies in existence have dealt with mathematics achievement in general, but not particularly, exploring how mathematical language affects the capability of learners to resolve word problems.

Moreover, there is scarcity of studies in the Uasin-Gishu County to investigate the implication of the mathematical language in problem-solving capabilities of learners. This paper is thus an attempt at bridging this gap by observing the level at which mathematical language plays the role of determining the capability of Class Seven students in Cheptiret Zone to solve mathematical word problems.

METHODOLOGY

The research adopted a descriptive correlational survey design in this research to test the relationship between the language proficiency in mathematics and the ability to solve mathematical word problems in learners. The independent variable was the mathematical language proficiency and dependant variable was problem solving ability in this design. The correlational method was appropriate to the study as it would enable the researcher to

determine the strength and direction of the relationship between the two variables without affecting them. The design also made it possible to collect quantitative and qualitative data so as to come up with the big picture on the effects of mathematical language on the performance of the learners.

It included 1292 students in Class Seven at Cheptiret Zone, Uasin-Gishu County (Biwott, 2022). The simple random sampling was applied to this population to obtain a sample of 388 learners representing 3 out of the total population as the learners would all have equal chances of being selected. In addition to it, 15 math teachers were selected through purposive sampling because of the direct and close contacts of teaching mathematical word problems and because of having professional views on linguistic problems of the learners.

Data collection was done by using several measures so as to enhance the triangulation and validity. These consisted of a questionnaire among the learners the format of which was a five-point Likert scale to determine the perception and experience with mathematical language, the test task implemented was a structured question on a theme of 20 questions to measure actual performance of^{e} the learner in solving mathematical problems and insights about the instruction of mathematics provided by the teacher came through a questionnaire and a schedule of the interview has been made to find a deeper qualitative data about the problems that are involved in the use of the language in teaching mathematics.

Analysis

Reliability Analysis

Variable	**Number of Items**	**Cronbach's Alpha**
Language Difficulties	3	0.836
Problem-Solving Ability	5	0.787
Teachers' Perspectives	6	0.772

Table 1. Reliable analysis

The values greater than 0.70 imply acceptable reliability.

Results

Statement	**SA (%)**	**A (%)**	**U (%)**	**D (%)**	**SD (%)**	**Mean**	**SD**
Mathematical vocabulary affects my ability to solve word problems	18.0	19.5	22.0	21.0	19.5	3.05	1.29
I find it difficult to translate words into equations	24.2	26.8	18.3	17.5	13.2	3.31	1.24
Reading comprehension influences my mathematics performance	28.4	21.6	20.1	15.7	14.2	3.34	1.30

Table 2. Performance influence of language.

More than 37.5% accepted that the performance is influenced by the language.

Problem Performance in the word problem test.

Statistic	**Value**
Mean Score (out of 20)	11.4

Standard Deviation	3.82
Minimum Score	3
Maximum Score	19

Table 3. Word Problem Test Results.

Students that had high vocabulary scores scored highly.

Correlation Analysis

Variable	**1.** Mathematical Language Proficiency	**2.** Problem-Solving Ability
1. Mathematical Language Proficiency	1	
2. Problem-Solving Ability	0.62**	1

Table 4: Pearson Correlation Matrix.

The correlation (r =.62) was rave high and positive.

Regression Analysis

R	**R^2**	**Adjusted R^2**	**Std. Error**
.62	0.384	0.381	2.89

Table 5: Regression analysis

Mathematical language explains 38.4% of variance.

Anova

Source	**SS**	**df**	**MS**	**F**	**Sig.**
Regression	1128.45	1	1128.45	135.76	.000
Residual	1810.23	386	4.69		
Total	2938.68	387			

Table 6: ANOVA table

Formula: Problem-solving ability = 4.12 0.73 (Mathematical Language).

Regression Coefficients for the Effect of Mathematical Language on Problem Solving Ability

Model	**Predictor**	**Unstandardized Coefficient (B)**	**Standard Error**	**Standardized Coefficient (β)**	**t-value**	**p-value**
1	Constant	1.214	0.312	—	3.89	0.000
	Mathematical Language	0.642	0.074	0.553	8.68	0.000

Table 7. Regression Coefficients: The findings have shown that mathematical language is a significant predictor of how learners can solve mathematical word problems.

DISCUSSION

This study was done in an attempt to understand the degree, to which mathematical language applies in the ability of learners at the Class Seven levels of Cheptiret Zone where Uasin-Gishu County learners are, to solve mathematical word problems. The results of descriptive statistics, correlation study and the regression modelling all show evidence that mathematical language proficiency is a major determinant in ability to solve problems.

As the descriptive statistics of Table 2 show, a relatively significant percentage of the learners report that mathematical language poses a challenge in solving word problems. Over 37.5 percent of the learners concurred that mathematical vocabulary influences their mathematical problem solving capacity. On the same note, many learners showed that they have a problem in translating words into mathematical equations and reading the problem statements. The average of 3.05 to 3.34 denotes the moderate extent of agreement that language has a bearing on mathematics performance. These results indicate that learners have difficulties in decoding words and sentence patterns in word questions.

This observation is also supported by the outcomes of word problem test. According to Table 3, the mean score of 11.4 out of 20 proves the moderate performance of the learners and there is a significant variation in the total performance that is expressed in form of a standard deviation of 3.82. The big gap between the lowest and the highest score (3 to 19) indicates variation in the capacity of learners to comprehend and translate the statement of mathematical facts. The ones that had better mastery of mathematical language were more likely to exhibit better conceptual knowledge and correct choice of mathematical operation to solve mathematical problems.

According to the correlation analysis in Table 4, the mathematical language proficiency and problem-solving ability are positively correlated strongly ($r = .62, p < .05$). The implication of this finding is that when mathematical language skills are enhanced, it correlates with the enhancement of problem-solving skills. The outcomes substantiate the theoretical points of view of Piaget (1936), who focused on the role that language played in the cognitive development, and Polya (1945), who presented the importance of the meaningful comprehension of the problem as the initial stage of the productive mathematical solving of the problems.

The regression analysis further confirms that mathematical language has a predictive value. The model summary in Table 5 indicates that the mathematical language describes the relationship in nearly 38.4 percent of the variance in the ability of the learners in solving a problem. This is a great proportion of explained variance in the field of educational research indicating that linguistic competence is a major factor in mathematical performance. The standard error is also relatively small (2.89) which implies that the regression model has a rather good fit.

According to the outcomes of the ANOVA (Table 6), the regression model is statistically significant (F = 135.76, p <. 001). This shows that mathematical language proficiency works a long way in providing predictions of the ability to solve problems by the learners as opposed to a model with no predictors.

Lastly, the regression coefficients in Table 7 give additional knowledge about the effect of mathematical language as a predictor. The unstandardized coefficient (B = 0.642) shows that a one-unit change in the level of mathematical language proficiency has an average effect of about 0.64 unit on the performance in problem-solving. Moreover, the standardized coefficient (= 0.553) indicates a mediocre positive effect of the mathematical language on the capacity of learners to resolve word problems. These findings indicate that proficiency of mathematical language is not only linked with performance but also making it a major predictor of the ability of learners in solving problems.

On the whole, Table 1 to 7 results demonstrate the same evidence that the mathematical language is vital in assessing the capabilities of the learners to help them resolve mathematical word problems. Such findings are in line with earlier reports (Hegarty et al., 1995; Verschaffel et al., 2000) proposing the fact that the successfulness of problem solving not only depends on the computational skills, but also the capability to interpret and comprehend the linguistic form of the mathematical problems.

These results thus indicate that calculation procedures alone should not be used in teaching mathematics at any level and that the other areas such as development of mathematical vocabulary, reading and translating mathematical statements into symbolic statements should also be included in the teaching as well. Enhancing these aspects of language can considerably enhance problem-solving skills of learners.

Teacher Interview Themes

The results of the teacher interviews gave some themes on the difficulties that learners go through when solving mathematical word problems. Among the key themes that were identified was the problem of language comprehension. According to the teachers, a significant number of learners find it difficult to extract the language employed in mathematical questions especially when questions are written in a textual form. On the one hand learners usually do well in calculations involving numbers, but they usually find it difficult when asked to read and comprehend word problems. The teachers indicated that learners often fail to understand major terms or simply do not understand the problem statement, which can influence them in terms of the identification of the appropriate solution strategy.

The other significant theme that arose during the interviews was the challenge that learners face in conversion of word problems into mathematical problems. Teachers also said that learners usually have difficulties trying to convert verbal statements into mathematical equations. In most instances, learners would read the problem and only fail to identify the right mathematical operation that should be used in solving the problem. It was described that at times, the learners are guided by guessing or surface evidence as opposed to grasping the context of the problem. Consequently, even those learners who have sufficient computational skills can give the wrong answers due to their inability to translate the problem into a mathematical form.

Another key aspect of mathematical vocabulary was clarification that was noted in the interviews. Teachers pointed out that a significant number of learners are not conversant with mathematical terms and symbols in formulating problems. The teachers indicated that mathematical vocabulary can be understood better by making the meaning of the vocabulary clear to the learners, in addition to allowing them a chance to use the same vocabulary as additional practice. The teachers recommended it, and the introduction of vocabulary teaching and language-centered teaching techniques to the mathematics lesson would contribute to the easier interpretation of the problem statement by learners and their general problem-solving capacity.

CONCLUSION

This investigation looked into the level of mathematical language effects on the Class Seven learners in the Cheptiret Zone, Uasin-Gishu County to solve mathematical word problems. The results show that mathematical language proficiency is an important variable in the performance of learners in solving problems. Descriptive and inferential analyses revealed that those learners who have a stronger level of mathematical vocabulary, reading comprehension, and translation skills are in a better position to interpret word problems and use appropriate strategy of solving them.

The finding showed that there was a significant positive correlation between mathematical language proficiency and the ability to solve problems, and the mathematical language accounted of a significant percentage in the performance of the learners. These results indicate that the challenges connected with grasping mathematical vocabulary and defining the statements of mathematical problems may impede the correct idea of mathematical operations and effective word problem solving.

In general, the research proves that mathematical language is an important aspect of mathematics education that should be paid more attention during classroom teaching. To develop better problem-solving competence among learners, teaching them mathematical language and improving their skills in interpreting mathematical statements can play a major role. Thus, language-centered instructional techniques need to be incorporated into mathematics learning to enhance the performance of mathematical word problem solving among the learners.

RECOMMENDATIONS

The study suggests that mathematics teaching is supposed to focus more on the advancement of mathematical language and vocabulary to enhance the problem-solving capacity of learners. The teachers are expected to explicitly teach mathematical words and get the learners to read, interpret and translate mathematical word problems into mathematical statements. Application of reading comprehension strategies in mathematics lessons may assist the learners to understand problem statements better, and be able to determine relevant solution procedures. Curriculum developers should also make sure that the mathematics text books and learning resources contain good explanations of mathematical vocabulary and have tasks to test the comprehension of mathematical words by the learners. Moreover, the training programs ought to teach the educators effective methods of teaching mathematical language to learners and helping them to be able to interpret word problems. Future studies ought to continue with investigating the effect of mathematical language on mathematics performance by balancing out other aspects of research including mathematical learners' previous academic performance, reading comprehension skill, and the quality of their instruction.

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