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EFFECTS OF STUDENTS' COMPREHENSION SKILLS ON SOLVING MATHEMATICAL WORD PROBLEMS

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Abstract:
Mathematical word problems are concepts taught at the end of every topic to allow students apply the content that was taught. This paper looks at the effect of students' comprehension skills on solving mathematic word problems in Tindiret Sub County public secondary schools, Kenya. The target population was form three mathematics students and teachers. Stratified random sampling techniques were employed to select nine public secondary schools; one boys' school, one girls' school and eight mixed secondary schools. Questionnaires, achievement test items were used to collect data. The data collected was coded and analyzed using the SPSS. The study revealed that students had difficulties in comprehending mathematical word problems. It was concluded that the poor comprehension of word problems led to student difficulties in solving word problems in mathematics. The paper recommends that the teachers should find ways of ways of improving comprehension skills of the students by having activities like debates and public speaking to improve language mastery and comprehension.

Keywords: comprehension, skills, mathematical, word problems

1. Introduction

Mathematics is a core subject which is studied by all the candidates sitting the Kenya Certificate of Secondary Education (KCSE) examinations. However, performance by candidates in Mathematics has been low compared to other subjects. Since KCSE mathematics is a standardized test, word problems contributes to mathematics overall percentage. It is observed that learners have difficulties in solving mathematical word problems leading to poor mathematics performance. In the past, the ministry of education provided money in order to increase the purchase of textbooks, teaching aids and other teaching resources but learners still record dismal performance. Technology, innovation along with other factors is pillars that the achievement of Kenya's Vision 2030 is anchored on. To achieve the vision 2030, more resources were to be devoted to scientific research. The quality of teaching, mathematics, science and technology in schools, polytechnics and universities was also to be raised (Vision 2030).

Achievement of vision 2030 will require the ability to solve mathematics problems in real life situations through word problems. In mathematics course books, word problems given at the end of every sub-topic enable students to practice the learnt skills in real life situations. Therefore, quality mathematics instruction incorporates techniques that are designed to demonstrate to children the relevancy of mathematics to their daily lives, the world around them and their future careers. Langenes (2011) points out that standardized tests in mathematics consists of word problems that students must interpret before they are able to arrive at answers. However, a considerable number of students in secondary schools have inadequate understanding of mathematical concepts and skills in solving word problems (KNEC, 2007).

The research shows that there has been decline in performance in MAT B from 2011 to 2015 though it is a form of simplified mathematics. Statistics done by KNEC also shows that performance in MAT A has been fluctuating. There were improvement in 2011, 2012 and 2015 but a drop in 2013 and 2015 and also in 2016. The table below shows a summary of KCSE mathematics performance in 2014 and 2015.

Table 1: Overall Percentage in 2014 and 2015 KCSE Examination

Year	**2015**	**2015**	**2015**	**2014**	**2014**	**2014**
Gender	All	Female	Male	All	Female	Male
MAT A	26.88	24.27	29.16	24.02	21.26	26.40
MAT B	8.29	7.84	8.81	12.38	11.85	13.06

Source: (KNEC statistics, 2015).

From Table 1 above, it can be seen that mathematics percentage is still poor countrywide with a mean mark of below 30% for boys and below 25% for girls. It is very unfortunate that the alternative B mathematics introduced has been recording very poor grades as compared to ALT A which is against the expectations of the curriculum planners. This is an indication that still there are challenges in mathematics. Tinderet Sub County has also been performing poorly in mathematics in the same way as reflected in the table above. This state of affairs prompted the researchers to investigate effect of students' comprehension skills on solving mathematical word problems in public secondary schools in Tindiret Sub County, Kenya. This study agrees with what has been observed that a learner may not perform well in mathematics not necessarily because of weak mathematics ability but due to challenges in understanding the language involved in mathematics achievement tests. They are not able to correctly translate word problems into mathematical expressions containing numbers, variables and operations because mathematics KCSE examination questions consists of more word problem questions than the arithmetic questions.

2. Theoretical Framework

This study was guided by constructivist's theory of learning. The theory is based on the idea that humans process the information they receive rather than merely responding to stimuli. Constructivism is a theory of learning that has roots in both philosophy and psychology. The essential core of constructivism is that learners actively construct their own knowledge and meaning from their experiences (Catherine, 1996).Constructivism acknowledges the learner's active role in the personal creation of knowledge, the importance of experience (both individual and social) in this knowledge creation process and the realization that the knowledge created will vary in its degree of validity as an accurate representation of reality. These four fundamental tenets provide the foundation for basic principles of the teaching, learning, and knowing process as described by constructivism.

In constructivist guided instruction, the teacher poses a word problem as the last content to be learnt in a given topic. Learners are not shown how to solve the word problem but they are given time to decide on the steps to follow by constructing their own knowledge using past known information. It involves intellectual experience where learners construct knowledge. Word problems are presented to the learners in order to construct mathematical ideas and solve the problems by explaining the steps so as to provide their understanding. Construction of mathematical ideas from real life experiences are also done by applying what they had already been taught. How the words in a mathematics word problems can be converted into the solution were looked at. When a learner understands how to solve word problem, the understanding is not transferable. In order to solve the word problem, the learner must write the required mathematical expression. The process of writing mathematical expression involves intellectual construction of meaning from the word problem.

2. Literature Review

2.1 Comprehension Skills on Solving Mathematical Word Problems

Comprehension skills provide the ability to recognize words and understand their meaning in context. In order to comprehend the text, a learner must be aware of their thoughts as they read. Learners will have difficulty in comprehending the information if they cannot recognize the expressions quickly and understand their meanings.

Knowing definitions of word problems is dependent on understanding the word problem itself, however, people from different cultures or backgrounds will often understand word problems in different ways. Ability to read Mathematical texts does not necessarily lead to successful strategy in solving word problems. Caldwell and Goldin (1979) assert that reading and comprehension difficulties arise when children cannot imagine the context in which a word problem is set or their approach is altered by the context in which the word problem is given. There are various word problems given according to the concepts taught. Every mathematics topic has its own problem in which the learnt concepts in the topic are applied in order to solve them.

Voyer (2011) conducted a study in Canada on performance in mathematical problem solving as a function of comprehension. The study findings revealed that pupils with weaker arithmetic skills construct had different representations based on the information presented in the problem. The study recommended that learners must be taught how to recognize the problem and how to translate word problems into statements that mean something to them. Prathana, Sumiwon, and Siridej (2014), carried out an analysis of Elementary School students difficulties in Mathematical problem solving in Thailand. The study used test items for the learners and interviews for teachers to collect data .From the study, it was established that learners had difficulties in understanding the keywords appearing in problems, thus cannot interpret them in mathematical sentences. The study also revealed that learners were unable to figure out the necessary information required to solve the problem because they were impatient and do not like reading long mathematical problems. MWP differs in how they presented because some are written in one sentence while others are in form of a paragraph depending on the complexity of the problem.

Gokhan, Hayriye and Ahmet (2015) in their study evaluation of students' mathematical problem solving skills in relation to their reading levels. Using a sample of six third grade students with different reading levels, the study carried out a correlation between levels of students' reading and skills in solving Mathematical problems in Turkey. The study employed Ekwall reading inventory (data collection through reading of texts). The results showed that problem solving skills vary according to learners reading levels. Jamal and Carol (2001), in their study investigated the importance of language in student test performance on mathematics word problems. Tests containing original and revised items were administered to 1,174 eighth grade students. It was found that students who were English language learners scored lower on the mathematics test than proficient speakers of English. Scores on the linguistically modified version were slightly higher.

Yushau and Hafidz (2015), in their study on Mathematics Performance and its Relation to English Language Proficiency Level of Bilingual Arab University Students in Saudi Arabia, indicates that many universities in the Arab world are becoming English medium universities. The findings show the students' proficiency level in English are a factor affecting their performance in mathematics. The findings could also be similar in Kenya because their learners are bilingual. Yashau and Omar (2015) investigated the relationship between language proficiency and mathematics performance among bilingual Arab university students. The findings indicated that mathematics performance is significantly related to the English proficiency level of students. The study also showed that percentages of students who are top performers are proficient in English than those who are weak. Participants were native Arabic speaking male students with an average age of 18 years.

Rambely, Ahmad and Jaaman (2008) conducted a study on the relationship between English proficiency level and Mathematics achievement in Malaysia. The study used a sample of 118 students. The study found out that good mastery of English was needed to nurture and understand mathematics subject in order to achieve excellent results. On the other hand, low English proficiency resulted in students experiencing a challenge learning mathematics and that led to lower grades in mathematics course. Piia, Kaisa and Jari-Eric (2008) involved 225 respondents aged 9-10 in grade 4, investigated the interplay between mathematical word problem skills and reading comprehension. The results showed that performance on mathematics word problems was strongly related to performance in reading comprehension, indicating that technical reading abilities increases the ability to solve word problems. Clarkson (1992) in his study on Language and Mathematics, a comparison of bilingual and monolingual students of mathematics in the New Papua, New Guinea established that out that students' reading ability as well as carrying out computations are important factors for success in Mathematics. The research showed that performance in solving Mathematics word problems are strongly related to performance in reading comprehension. Students who were competent in both languages scored significantly higher compared to colleagues who had low competence in their languages.

Fluentes (1998) stated that fluent technical reading ability increases solving word problems skills. Even after controlling the level of technical reading, performance in Mathematics word problems still relates to reading comprehension which suggested that these skills require overall reasoning abilities. At the stage of reading a given word problem, difficulties arise when children are not able to decode the words used in a word problem, comprehend a sentence, understand specific vocabularies and lack confidence or the ability to concentrate when reading. Often, real world problems come in the form of word problems. Mathematics outside the classroom learning rarely deals with simple algorithms. Without the ability to read and comprehend Mathematical Word Problems, (MWP) learners will have difficulties in answering word problems.

Research by Monroe and Panchyshyn (2005) shows that the biggest problem in solving MWP is language and the main concern is that many word problems do not use the same language that children use in everyday life; therefore, children are struggling with language, not necessarily real Mathematics computations. With emphasis on learner centered method of instruction, the standards in Mathematics are now more focused on obtaining conceptual skills rather than teaching a general methodology. This will prepare learners for careers because they can explain how to logically arrive at conclusions. Becker and Vanderwood (2009) on their research on evaluation of the relationship between literacy and mathematics skills showed that reading comprehension in fourth and fifth grade students in California was the best predictor of applied mathematics performance. It indicates that comprehension skills when paired with Mathematics computation skills leads to mathematics performance, while another study looked at reading ability and its impact on Mathematics scores of tenth grade students. Larwin (2010) in his research done in U S A on the impact of student reading ability found that the higher the reading ability of the student, the more likely the student will have high Mathematics scores. This indicates that those students scoring low grades in mathematics have a lower reading ability. A similar study performed in Ireland by Ririordain and O'Donoghue (2009) found that students who could speak English but with lower proficiency, scored significantly lower on word based Mathematics tests, than students who are proficient in English. The reading of informational texts can assist in teaching Mathematics concepts. The informational texts create a connection between mathematics and the real world. With real world examples, teachers can build several concepts when compared to the limitations of a simple equation.

Cognitive load theory holds that performance on complex cognitive tasks depend on whether the amount of information presented to the user equals or exceeds the availability of working memory. Kalyuga et al (2003) assert that when working memory is exceeded, the probability of errors increases. This implies that if students must apply cognitive resources to comprehension text, less working memory resources will be available for MWP because the steps in solving them includes: reading and comprehension, which require identification of terms used and their meaning in context, forming a representation of the problem mathematically, identifying the appropriate mathematical operation, performing the computation and checking the answer in cases of English learners. The need to allocate cognitive resources in understanding the problem presented in non-primary language will force the learner to comprehend the problem in the first language, which would reduce the resources available for Mathematics problem solving and thus increase the probability of errors.

In Kenya, the language of communication at a tender age is mother tongue while the language of instruction is acquired in the process of learning. English language is introduced at primary level before the learner is able to master all the vocabularies in the first two languages, thus posing a major challenge to learners. Hegarty, Mayer and Green (1992) observed that many students from Kindergarten through adulthood have difficulties in solving arithmetic word problems that contain relational statements that is; sentences that expresses numerical relations between two variables. From the research done by Hegarty, Mayer and Monk (1995) on word problems containing relational statements, it is evident that the comprehension process plays an important role in solving arithmetic word problems. This is because learners cannot comprehend problems which have the phrases "less than" or "more than" as arithmetic operations. Chi et al (1988) and Smith (1991) pointed out expert-novice differences. It is revealed that novices are more likely to focus on computing a quantitative answer to a story problem for example in Biology whereas experts are likely to initially rely on a qualitative understanding of the problem before seeking a solution in quantitative terms. The direct translation approach makes minimal demands on working memory and it does not depend on extensive knowledge of the types of problems. However this leads to incorrect answers.

Stanovich (2001) and Naglietric (2001) showed that students with low reading ability are generally low academic achievers. Due to the skills needed in reading comprehension and success in real life Mathematics problems, it is possible that reading comprehension will be a factor in conceptual Mathematics. Engaging learners in mathematics through reading and discussing mathematical ideas is an important means of developing these practices and skills needed to succeed in these tasks. Research done by Carole, Niall and Paul (2010) focused on the relationship of English proficiency and mathematics performance in a sample of high school students, 47% included English language learners. Results indicated that mathematics performance for the ELLs increased with English-reading proficiency in a nonlinear manner. In 2009, 87% of children of immigrants were born in the United States and 11% of those children enrolled in U.S. public schools and needed to acquire English proficiency to succeed academically. Low levels of English proficiency were probably linked to the fact that these children usually resided in homes where adults spoke no English. The increasing number of English ELLS led to low Mathematics performance.

Brown et al (2011) and Henry, Baltes and Nistor (2015) asserted that Mathematics assessments in the United States required English proficiency for all test takers, implying that students with low Mathematics achievement are weak in English. There are many subjects who are included in the school curriculum yet there is greater pressure for children to succeed in Mathematics than for example in History and Geography even though these other subjects also form part of the curriculum. Mathematics is allocated the highest number of lessons per week, second to English and in a way, given special consideration. For much mathematics is seen in terms of the arithmetic skills which are used at home or in offices, workshops and some regard Mathematics as the basis of scientific development and modern technology. It can also be used to present information in many ways not only by means of figures, but also by using diagrams, tables, graphs and geometrical drawings so that it cannot only explain the outcome of an event which has already occurred but also used to predict the outcome of one which is yet to take place.

Dawe (1983) carried out a study on bilingualism and mathematical reasoning in English as a Second Language of Italians and Jamaicans; a case study of children aged 11-13 growing up in England. The study established that first language competence is an important factor in a child's ability to reason in Mathematics than in English as a second language. The study further showed that bilingual students who performed poorly in Mathematics tended to have low levels of competence in their native languages. He explained that, this occurred because students had learned their second language (i.e. English) without proper foundation of the first language competence. They had not acquired proficiency which is a necessary foundation for academic learning.

A study by Njagi (2015) on language issues in Mathematics achievement in Tharaka-Nithi county-Kenya, found out that solving mathematical problems modified into mathematical expressions had a positive effect on improving students' achievement in Mathematics. Achievement tests were administered to provide the needed data. It was therefore concluded that a learner may not perform well in mathematics not because of weak mathematical ability but due to challenges in understanding the language involved. The language of communication in Kenya is English, although at a child's early stage of life their native language is used. In pre-school the child is introduced to Kiswahili Language and later English which becomes the medium of communication throughout the education system. Instruction of Mathematics is done in English; a third language which learners acquire last, therefore, Kenyan children are bilingual. Teachers and learners experience some problems in teaching and learning Mathematics due to these changes from their native languages to Kiswahili and English.

According to Abedi and Herman (2010), the problem of teaching science and mathematics in English language was faced by most countries around the world due to globalization and migration from underdeveloped states whose mother tongue was not English language, to developed countries whose medium of instruction is English. The trends in International Mathematics and Science study (TIM) (2008); administering assessments written in English to students currently learning English complicates the learning experience for those students because of their weak English proficiency skills. According to the curriculum, Mathematics is studied in order to develop the power of logical thinking accuracy (Opton, 1987). Bernardo (2002) conducted a study to determine whether Filipino-English bilingual students understanding and solving word problems claimed students were able to understand and solve problems in their first language whether the first was English or Filipino. The language used in thinking is always likely to be the first language. Thus, knowledge communicated in the second or third language for that matter English in Kenya, might need to be translated into another language to allow thinking and then will be translated back to enable feedback. This implies that errors and misunderstandings might arise at any stage of translation. This argument is supported by Algarni, Biresi & Porter (2012) by explaining that cognitive load is much higher when using the second language because the brain must work to translate the language while simultaneously trying to understand the new information. From this information, it is well indicated that bilingual students are much affected by MWP.

3. Materials and Methods

The study area was Tinderet Sub County in Nandi County. The study adopted quantitative research design to assess the student's difficulties when solving mathematical word problems because of the methods of data collection employed. The target population was all form three students in Tinderet sub-county. Stratified random sampling was used to take care of categories of schools in terms of gender; boys', girls' and mixed schools. Students were selected from the sampled schools using simple random sampling by writing yes/no papers which were folded and students were allowed to pick. Form three teachers of mathematics were purposively sampled but in cases where the teachers were unavailable, any other mathematics teacher was picked. The study employed two sets of questionnaire: a set for form three students and another for mathematics teachers. Achievement test was also administered to the students. Learners' details were coded and analyzed using descriptive statistics in form of percentages in order to generate a general opinion. The structured Likert scale questionnaires from the sampled schools were analyzed using percentages and presented inform of tables, pie charts and bar graphs.

4. Results and Discussions

4.1 Effects of Comprehension Skills on Learners in Solving Mathematical Word Problems

The first research objective sought to determine the effects of students' comprehension in solving mathematical word problems. In order to find out student attitude towards comprehension of word problems, seven questions were asked. The first question was asking whether the learners read through a word problem to the end. Below is Tables 3 and 4 showing the findings obtained.

Table 3: Comprehension Skills and Solving Mathematics Word Problem

Statements on comprehension skills	**SD**		**D**		**NS**		**A**		**SA**	
	F	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
I read through the word problem to the end before interpreting	9	7.4	10	8.3	7	5.8	48	39.7	47	38.8
We often do word problems in class	16	13.2	15	12.4	9	7.4	56	46.3	25	20.7
Mathematics teacher gives us time to read through the word problems in class	12	9.9	20	16.5	8	6.6	48	39.7	33	27.3
I have difficulties in comprehending word problems	21	17.4	9	7.4	4	3.3	57	47.1	30	24.8
I dislike word problems	42	34.7	40	33.1	9	7.4	13	10.7	17	14.0
I do not read word problems in an examination	61	50.4	36	29.8	8	6.6	9	7.4	7	5.8

Key: SD-Strongly Disagree, D-Disagree, NS-Not Sure, A-Agree & SA-Strongly Agree.

Table 3 shows that there was a fair distribution of responses on whether students read through mathematical word problems. However, those who agreed and strongly agreed took a fairly larger percentage by 75.8%, showing that most of the learners read mathematical word problems to the end.

Table 4: Teachers View on Students Comprehension Skills and Solving Mathematics Word Problem

Statements on comprehension skills	**SD**		**D**		**NS**		**A**		**SA**	
	F	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
Learners have difficulties in reading and comprehending word problems	0	0	0	0	2	22.2	3	33.3	4	44.4
Learners find solutions to a word problem before identifying the problem in question	0	0	2	22.2	1	11.1	3	33.3	3	33.33
Learners interpret words in the problem wrongly	0	0	2	22.2	0	0	4	44.4	3	33.3

Key: SD-Strongly Disagree, D-Disagree, NS-Not Sure, A-Agree & SA-Strongly Agree.

Caldwell and Goldin (1979) explain that comprehension difficulties arise when children cannot imagine the context in which a word problem is set or their approach is altered by the context in which the word problem is given. This was seen from test item one, where learners were not able to comprehend and solve a given word problem. All the learners in the study were not able to solve the problem due to poor comprehension skills, they misunderstood the terms. This was supported by the teachers' responses on how learners interpret word problems in Table 4 above.

From the table above a majority of the teachers agreed that learner understood word problems wrongly which makes them unable to solve the problems correctly. Students would solve the problem if they had translated the problem into personal and meaningful vocabulary. This was pointed out by Hollunder (1990) that solving word problems can be enhanced when the reader attempts to increase his/her comprehension through translating the language of the text into personal and meaningful vocabulary at their comprehension level. The study also attempted to find out whether the learners were given time to solve problems in class and the results were as shown in Table 3. The findings also showed that learners who often did word problems in class represented by 57.9%. Apart from working out the problems, the learners were also allowed to read the word problems. There was a fair distribution on learner involvement in reading through word problems in class. However, a larger percentage agreed that their mathematics teachers gave them time in class. This was represented by 61.1%, indicating that there is enough student involvement. Results obtained showed that learners have difficulties in comprehending word problems as seen from the table above. The information is supported by the teachers' views as shown in the Table 4. A majority of the teachers indicated that learners have difficulties in comprehending word problems. This shows that students' difficulty in comprehending word problems affects their ability to solve such problems. The findings agrees with (Clarkson, 1992) that students reading ability is an important factor to success in mathematics. The research also showed that performance in mathematics word problems are strongly related to performance in comprehension. This is also supported by Fluentes (1998), that fluent technical reading ability increases solving word problems skills.

The study also sought to find whether students interpret the statements given correctly before writing mathematics expressions. The table above shows those who agreed and strongly agreed took a slightly higher percentage than those who disagreed. The results above are supported by Figure 1 on page 60.

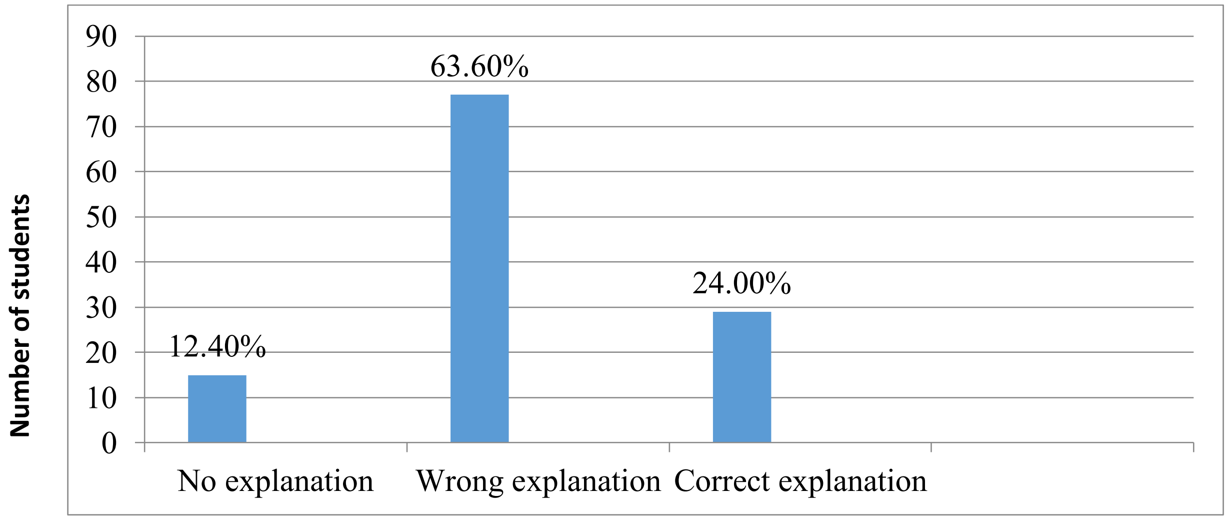

Figure 1: Students' Word Problem Explanation

From the bar graph above, a majority of the learners explained the word problem given although most of them gave wrong explanations. This indicates that students attempted to solve word problems but there were difficulties in finding solutions arising from comprehension of mathematical words employed. Parantham et al (2013) supports the above information that students have difficulties in understanding keywords appearing in problems, thus cannot interpret them in a mathematical sentence. Making a wrong or failing to give an explanation on the understanding of the word problem leads to wrong interpretations and finally wrong solutions.

The attitude towards the word problems was also tested and this was summarized in table as shown. Those who disagreed that they disliked word problems were eighty two students representing 67.8%. This showed that most of the students have a positive view towards word problems indicating inexistence of attitudinal challenge that could have led to poor comprehension. The research determined further whether the students read word problems in examinations and their responses also indicated that learners have a positive attitude towards word problems. Ninety seven students disagreed that they don't read word problems in an examination representing 80.2%. This confirms the positive view of the learners towards MWPs. The findings indicated that majority of the learners read through word problems in an exam and therefore reading is not an issue but comprehension is a challenge in the application of mathematics solving skills in word problems.

5. Conclusions and Recommendations

The findings indicate that students read through the word problems before they could attempt to solve them. A majority of the students were not able to comprehend word problems, while those who comprehended were unable to express themselves in the language of instruction. As a result, teachers opted to make lengthy explanations aimed at improving students understanding. The findings from the study indicated that learners have poor comprehension skills which affect their understanding of the word problems. It was also realized that due to poor comprehension skills learners did not have the capability to write correct mathematical expressions and therefore unable to solve mathematical word problems. It can be concluded that students' poor comprehension skills leads to inability to solve mathematical word problems. The study recommends that the school managements to look for ways of improving English language comprehension, by having activities like debates and public speaking to improve language mastery and comprehension.

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