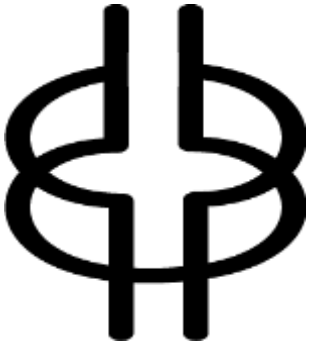
# Ghana Journal of Education: Issues and Practice (*GJE*)



NYANSAPO – "Wisdom Knot"

Symbol of wisdom, ingenuity, intelligence and patience

*Ghana Journal of Education: Issues and Practices (GJE)*
Vol. 5, December 2019, pp. 20 - 48

# Linguistic Influences on Junior High School Students' Mathematics Word Problem Solving

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## Abstract

Mastery of language of instruction is important for the successful teaching and learning of Mathematics since mathematical concepts are communicated through the use of language. The study sought to find Ghanaian Junior High School (JHS) 2 students' performance in Mathematics word problems. It also investigated the linguistic difficulties students face when solving Mathematics word problems and how their English language proficiency affect their problem-solving procedures. A sequential mixed methods design was employed in the study. The target population was made up of all JHS 2 public school students in the Cape Coast Metropolis in the Central Region of Ghana. One hundred and eighty-seven JHS 2 students were selected from six public schools in the Cape Coast Metropolis through stratified random sampling procedures. Achievement test and interview guide were developed and used for the study. The data collected through the test were analysed using descriptive statistics, while that of the interview were analysed using percentages and presented as narrative description with some illustrative examples from what students said in the process of explaining their procedures. The results from the study showed that students had very weak ability in Mathematics word problem solving. Their performance declined as the difficulty level of the questions increased from primary to JHS. The authors recommended amongst others, the need for Mathematics teachers to pay extra attention to the teaching of word problem solving in Mathematics and in-service and pre-service providers to pay attention to Mathematics word problem in professional development programmes.

**Key words**: Linguistic, Mathematics, Word Problem, Junior High School, Ghana.

**Introduction**

Mathematics is one of the subjects which is studied in the school curriculum all over the world. It is important not only as academic subject but also for participation in societal practices such as commerce. It is one of the essentials and basic areas of school curriculum which deals with a wide field of subject matter. Despite the importance of the study of Mathematics to individual students and national development, students' performance in Mathematics both locally and internationally has not been good. Locally, chief examiners' reports in Mathematics at the Basic Education Certificate Examination (B.E.C.E) level, national standardised examinations conducted at the end of grade nine, shows that students perform poorly in Mathematics in general and word problem solving in particular (WAEC 2016; WAEC 2017 & WAEC, 2018). Again, in their study involving an investigation of curriculum delivery in English, Mathematics and Science at the Junior High School level in the Central Region of Ghana, Davis et al. (2019) found that students performed poorly on the Mathematics achievement test. The study revealed a significant effect of school type, that is, above-average, average and below-average achieving school on students' achievement in Mathematics in general. Significant differences in achievement of students from above-average and average achieving schools, above-average and below-average achieving schools, and average and below-average achieving schools, respectively, was also observed by Davis et al. (2019). Internationally, Ghanaian JHS 2 students performed poorly in Mathematics in Trends in International Mathematics and Science Study (TIMSS) (Mullis, Martin, Foy & Arora, 2012).

Several factors could account for Ghanaian students' poor performance in Mathematics. These include factors such as teaching methods used in the teaching and learning of Mathematics, linguistics influences on students' understanding of Mathematics, availability and use of teaching learning materials, home support for students' learning, students' attitudes towards Mathematics and teachers' attitudes towards Mathematics and the teaching of Mathematics (Davis, Bishop & Seah, 2013; Agbenyegah & Davis, 2015; Davis, 2018; Davis, Beccles & Intsiful, 2019).

For the purpose of this study, the authors investigated the linguistic influences on students' understanding of Mathematics, focusing on the processes they follow in solving word problems. This

is because Ghanaian students study Mathematics using the local language up to grade three. From grade four onwards, they study Mathematics in foreign language, which is the English language. In the view of the authors, the sudden switch in the language of instruction from grade four onwards in the Ghanaian school system has the tendency to affect the learning outcomes in Mathematics, especially for the majority of students in public/state schools who hardly use the English language outside the school premises.

Large body of literature, both past and present, suggests that word problem solving remains one of the areas in Mathematics that is difficult for students to learn and teachers to teach. Issues relating to sentence features of Mathematics word problems such as semantic and syntactic have often been reported as being a major source of error for students (Boonen, Koning, Jollies & Schoot, 2016; Spanos, Rhodes, Dale & Crandall, 1998; Verschaffel & Corte, 1993). A study by Boonen, Koning, Jollies and Schoot (2016) among grade six students in the Netherlands revealed that semantically complex word problem solving was difficult for students. Boonen, Koning, Jollies and Schoot (2016) therefore argue about the need for attention to be paid on both reading comprehension skills and mental representation skills in teaching word problems. While a lot of research have been carried out on this important topic in a number of developed countries, the same cannot be said about Ghana. Despite reports of students' poor performance on word problem solving in Mathematics at the Basic Education Certificate Examination (National Examination at grade nine), not many studies have been conducted to deepen our understanding of Ghanaian Junior High School students' performance in word problem solving. This study was therefore carried out to provide some insights about Ghanaian Junior High School students' performance on word problem solving in Mathematics. However, semantic and syntactic sentence features of word problem in Mathematics did not form the main focus of this study.

Researchers have shown that language influences cognition (Perlovsky & Sakai, 2014; Vygotsky, 1987). Many researchers in Mathematics education have also made similar observation (Davis, 2010; Davis, Bishop & Seah, 2013; Davis, 2018; Durkin, 1991). According to Durkin (1991), for example, Mathematics education begins and proceeds in language, it advances and stumbles in language,

and its outcomes are often assessed in language. This suggests that mastery of language of instruction is key to successful study of Mathematics.

The literature suggests that effective study of school Mathematics by Bilinguals requires mastery of two levels of language proficiency. According to Cummins (1981), these are Cognitive Academic Language Proficiency (CALP) and Basic Interpersonal Communicative Skills (BICS). Basic Interpersonal Communicative Skills is also referred to as Social Language in literature (Haynes, 2007). Other researchers have also observed that linguistic demands for the effective study of Mathematics require more than mastery of BICS or Social Language. Haynes (2007), for example, argues for the need for bilingual learners who are taught Mathematics through the use of English as medium of instruction to acquire good mastery of Academic English Language in order to engage meaningfully in cognitively demanding task in Mathematics. In this research, the authors have used Everyday/Social language to denote BICS and Academic language to denote CALP.

Everyday language includes the basic language the child needs for ordinary everyday conversation such as *go, come and compare*, while Academic language includes the language the child needs in order to understand the school Mathematics curriculum (Cummins,1981). Examples of Academic Language in this study include *dividend, quotient, minuend and subtrahend.* However, it is common to find words in both everyday and academic languages that have different meanings in the everyday and academic sense such as difference and product. Product in Mathematics is the outcome of multiplication of two factors. In everyday language, it means a product of a company. Students' mastery of these levels of language has influence on their ability to understand and solve word problems in Mathematics (Davis, 2010; Agbnyega & Davis, 2015; Mestre, 1988).

Mathematics also has its own system of language (involving the use of symbols) and convention of reading which could be different from the conventional left to right movement of the eyes of texts in other disciplines. In set language, for instance, the use of 'and' denote intersection of sets, whilst the use of 'and' in probability denote the product of probabilities. In series and sequences the convention of

reading is often from bottom to the top. The symbol $\sum_{1}^{10} 2r$ is read as, "from 1, sum 2r up to 10" (Morgan, Craig, Schütte & Wagner, 2014). This suggests that much of children's mathematical education takes place in language and therefore mastery of all levels of language is important for successful learning of school Mathematics. It is against the background of the influence of language on students' learning outcomes in Mathematics that this study was developed to investigate the influence of language on JHS 2 students' performance in Mathematics word problem solving.

Newman's (1977) approach to error analysis in Mathematics word problem solving formed the main theoretical perspective for this study because it afforded the researchers a lens with which students' strategies in solving the word problems were analysed. Newman (1977) outlined five possible sources of error students often encounter when they are solving word problems in Mathematics. First, errors associated with reading of the question (Reading). Second, errors associated with understanding of the question (Comprehension). Third, errors associated with decoding the mathematical problems in the text, that is, translating the statement in English language into mathematical statements. For example, the sum of the first ten counting number can be transformed into mathematical statement as $\sum_{1}^{10} r$ (Transformation). Fourth, errors associated with following the processes involved in solving the problem (Processing Skills). Fifth, errors associated with writing answer to the problem, this may include looking back to ensure that the correct answer is achieved (Encoding). Errors associated with reading constitutes the first step in Newman's approach, as already noted. In order to have further insight into the linguistic challenges students faced, the researchers used Cummins (1981) categorisation of two levels of language proficiencies, namely BICS and CALPS as another theoretical lens. This enabled the researchers to ascertain the sources of students' linguistic challenges.

## Research Questions and Hypothesis

*Research Questions*

The following research questions were posed to guide the study:

1. What is the general mastery level of JHS 2 students in Mathematics word problem?
2. What is the performance of JHS 2 students from above-average, average and below-average achieving schools in the word problem solving?
3. What is the difference, if any, in the performance of students from above-average, average and below-average achieving schools?
4. In what ways do students' English language proficiency affect their word problem solving strategies in Mathematics?

*Null Hypothesis*

To address Research Question 3, the following null hypothesis was formulated:

There is no significant difference in the achievement of JHS 2 students from above-average, average and below-average achieving schools in word problem solving in Mathematics.

## Methods

### Research Design

Both quantitative and qualitative methods were used to address the research questions and hypothesis formulated to guide the study. A sequential explanatory mixed methods design involving collection and analysis of quantitative data followed by collection and analysis of qualitative data was, therefore, employed in this study. Creswell recommends the use of mixed methods design for a thorough and comprehensive treatment of various aspects of issues related to the topic under investigation (Creswell, 2012).

### Population

The target population consisted of all JHS 2 public school students from the 96 public schools in the Cape Coast Metropolitan area of the Central Region of Ghana. This area was targeted because of two reasons, namely public-school students' performance in Mathematics in the area has not been as good as expected and it is the educational hub of Ghana. The area has the Premier Teacher Education University in the country and several top Senior High Schools in the country. JHS 2 students were the target population because JHS1students were still

adjusting to the JHS system whilst the JHS 3 students were busy preparing for their Basic Education Certificate Examinations (BECE), at the time of the research.

**Sample and Sampling Procedure**

One hundred and eighty-seven JHS 2 students comprising 97 boys and 90 girls were selected from six out of the ninety-six public schools in the Cape Coast Metropolitan area, through stratified random sampling procedure. The schools that were sampled for the study constituted 6.25% of the schools in the research locale. Literature suggests that at least 5.0% of the population constitute acceptable sample for research studies (Krejcie & Morgan, 1970). The stratified random sampling procedure was used in order to ensure that above-average, average and below-average achieving schools were all represented. The authors grouped the junior high schools in Cape Coast Metropolis according to their achievement levels in BECE Mathematics, as above-average, average and below-average achieving schools. The simple random sampling procedure was then used to select two schools from each of the three categories of schools (that is, above-average, average and below-average achieving schools). A JHS 2 class was selected from each of the six public schools. For schools that had more than one streams, the simple random sampling procedure was used to select one class. Using the Table of random numbers, one stream was randomly selected. The use of random sampling gave each of the JHS classes in schools that had more than one stream equal opportunity to participate in the study (Creswell, 2012). For each of the classes selected, all the students participated in the first part of the study, which was the administration of an achievement test. The second part of the study involved selection of 36 students, six from each school, using the stratified random sampling procedure. These students were made up of two each of those whose scores were among the highest, median and lowest respectively. The 36 students were each requested to read and explain the import of questions 2, 4 and 6 (see Appendix A), and also explain the processes they followed in solving each of the three questions in interview sessions. Permission was sought from the District Education Office in Cape Coast for the project to be carried out in the schools in the district. Before the administration of the instruments, the project was explained to students and their assent

sought by inviting them to participate. Parents of the students who assented to participate in the study were informed about the study and participation of their child/ward in it.

**Research Instruments**

Two research instruments were developed and used for the study. These were achievement test and interview guide. The achievement test consisted of six items on word problem solving. The items were drawn from the upper primary (grades four to six) and the Junior High School syllabi. Items 1 and 2 were drawn from the upper primary school syllabus, while items 4-6 were drawn from the JHS1 and JHS 2 syllabus. Students had to answer these items in one hour (see Appendix A). The interview guide consisted of items which enabled the authors to collect information on the linguistic difficulties students experienced solving the word problems and how those difficulties affected their interpretation of the questions and the approaches used.

In order to ensure the validity of the achievement test, the items were adopted from some of the Basic School Government approved text books. They were also given to experts in the area of Mathematics education to read through and provide their critical comments. Both the achievement test and the interview guide were pilot tested in a school in another district in the Central Region to ensure that they elicited valid response. According to Robson (2002), reliability is the extent to which a researcher obtains the same results for measuring the same behaviour on different occasions. Robson (Op cit, p.342) indicates that reliability coefficient of .40 to .60 indicates fair reliability, reliability coefficient of .60 to .75 indicates good reliability and reliability coefficient of above .75 indicates excellent reliability. The test items used in the research had reliability coefficient of .662. This reliability coefficient shows that the test was quite reliable, since the reliability was good.

**Data Analysis**

The data collected through the test were analysed using descriptive statistics (the means, the mode and the standard deviation) and inferential statistics (ANOVA and t-test). This was used to provide a vivid picture of trends in students' performance on the test. While the data collected from the interviews were analysed qualitatively and presented as narrative description with some illustrative examples. The

qualitative analysis provided an insight into the linguistic difficulties students faced as they went through the word problem solving. All names used in the presentation of results are pseudonyms.

**Results**

The results of the study have been presented based on the research questions and the hypothesis that were formulated to guide the study.

**Research Question 1:** What is the general mastery level of JHS 2 students in Mathematics word problem?

This research question was posed to ascertain JHS 2 students' performance in Mathematics word problems. For the purpose of analysis, the pass rate for the whole test, and items meant to test students' performance on the primary, JHS 1 and JHS 2 levels word problems were each set at 50% (half of the score allotted). The results of students' performance are presented in Table 1. Results from Table 1 show that students generally performed poorly on the whole test. Less than 5.0% (4.8%) passed the whole test. In order words, less than 5% scored 10 out of 20 or better, (that is, 50.0% or better) on the test. The minimum score on the whole test was 0%, as many as 41.7% of the students scored 0%. The maximum score was 14 out of 20 (that is, 70%). Less than 1% of the candidates scored 70% on the test. The mean score on the whole test was 2.37 out of 20 (11.9%). This implies that the mean score on the whole test was about 12%. The Standard Deviation of 3.07 on the test shows that the scores are highly dispersed.

Pass rate of students in each of the categories of items (primary, JHS 1 and JHS 2) is presented in Table 1. The results show that pass rate of students in each of the three categories was very low. The pass rate on the primary level items was the highest (16.1%), this was followed by JHS1 (7.1%) and JHS 2 (1.6%). This is an indication that 83.9% of the students failed the primary level items, 92.9% failed the JHS 1 level items and 98.4% failed the JHS 2 level items. This shows that almost all the JHS 2 students could not correctly solve the JHS 2 level items in the Mathematics word problems, while the vast majority could not solve the JHS1 and primary levels items in the Mathematics word problems.

**Table 1: Overall Performance of Students on the Test (**N = 187)

| Item | Pass Rate | Minimum | Maximum | Mean | Standard deviation |
|---|---|---|---|---|---|
| Primary (1 and 2) (out of 5marks) | 16.1% | 0.0 (62%) | 5.0 (4.3%) | 0.96 | 1.47 |
| JHS1 (3 and 4) (out of 5marks) | 7.5% | 0.0 (58.3%) | 5.0 (2.7%) | 0.80 | 1.17 |
| JHS 2 ( 5 and 6) (out of 10marks) | 1.6% | 0.0 (68.4%) | 6.0 (1.6%) | 0.64 | 1.20 |
| Overall | 4.8% | 0.0 (41.7%) | 14 (0.5%) | 2.37 | 3.07 |

NB: Values in brackets show the percentage of students who obtained the minimum/maximum score

**Research Question 2:** What is the performance of JHS 2 students from above-average, average and below-average achieving schools in the word problem solving?

In order to ascertain the situation across the various school contexts, that is, above average, average and below average achieving schools, this research question was formulated. The results are presented in this section.

*Performance by Above Average achieving School*

Results of students from the above-average achieving schools are presented in Table 2. The results from Table 2 show that students from the above-average schools generally performed very poorly on the whole test. Less than 10% passed the test. In order words, less than 10% scored 10 out of 20 or better (that is, 50% or better) on the test. The minimum score on the whole test was 0%, as many as 12.9% of the students from the above-average achieving schools scored 0%. The maximum score was 14 out of 20 (that is, 70%). The mean score on the whole test was 4.43 out of 20 (that is, 21.5%). The standard deviation of 3.67 show that the scores are highly dispersed.

Pass rate of students in each of the three categories of items (Primary, JHS 1 and JHS 2) was very low. The pass rate on the primary level items was the highest (30.6%), this was followed by JHS1 (14.5%) and JHS 2 (4.8%). This is an indication that 69.4% of the students failed the primary level items, 85.5% failed the JHS 1 level items and 95.2% failed the JHS 2 level items. This is shows that vast majority of the JHS 2 students could not correctly solve the JHS 2 level items in the

Mathematics word problems, while the majority could not solve the JHS1 and primary levels items in the Mathematics word problems.

**Table 2: Performance of Students in Above-Average achieving School (**Above Average n = 62)

| Item | Pass Rate | Min | Max | Mean | Standard deviation |
|---|---|---|---|---|---|
| Primary | 30.6% | 0 (38.7%) | 5.0 | 1.86 | 1.81 |
| JHS1 | 14.5% | 0(29.0%) | 5.0 | 1.43 | 1.43 |
| JHS2 | 4.8% | 0(46.8%) | 6.0 | 1.18 | 1.54 |
| Overall | 9.6% | 0(12.9%) | 14.0 | 4.43 | 3.67 |

NB: Values in brackets show the percentage of students who obtained the minimum score

Results of students from the average achieving schools are presented in Table 3. The results from Table 3 show that as with the above-average achieving school students, students from the average achieving schools also generally performed very poorly on the whole test. Less than 2.0% passed the test. In order words less than 2.0% scored 10 out of 20 or better (that is, 50% or better) on the test. The minimum score on the whole test was 0%, as many as 51.6% of the students from the average achieving schools scored 0%. The maximum score was 10.6 out of 20 (that is, 53.0%). The mean score on the whole test was 1.49 out of 20, that is, 7.5%. The standard deviation of 2.25 shows that the scores are highly dispersed.

Pass rate of students in each of the three categories of items (Primary, JHS 1 and JHS 2) was also very low. The pass rate on the primary level items was the highest (11.0%), this was followed by JHS1 (6.3%) and JHS 2 (0.0%). This is an indication that 89.0% of the students failed the primary level items and 93.7% failed the JHS 1 level items. This is an indication that none of the JHS 2 students could correctly solve the JHS 2 level items in the Mathematics word problems, while the vast majority could not solve the JHS1 and primary levels items in the Mathematics word problems. The majority scored zero on the test for the Primary, JHS 1 and JHS2 items.

**Table 3: Performance of Students in Average School (**Average n = 64)

| Item | Pass Rate | Min | Max | Mean | Standard deviation |
|---|---|---|---|---|---|
| Primary | 11% | 0(62.5%) | 3.5 | 0.68 | 1.09 |
| JHS1 | 6.3% | 0(70.3%) | 3.0 | 0.52 | 0.91 |
| JHS2 | 0% | 0(84.4%) | 4.0 | 0.37 | 1.52 |
| Overall | 1.6% | 0(51.6%) | 10.6 | 1.49 | 2.25 |

Note: Values in brackets show the percentage of students who obtained the minimum score

Results of students from the below-average achieving schools are presented in Table 4. The results from Table 4 show that, as with the students from above-average and average achieving schools, students from the below-average achieving schools generally performed very poorly on the whole test. None of the students from the below-average achieving schools passed the test. In order words, none scored 50% or better on the test. The minimum score on the whole test was 0%, as many as 60.7% of the students from the below-average achieving schools scored 0%. The maximum score was 7 out of 20 (that is, 35.0%). The mean score on the whole test was 1.19 out of 20 (that is, about 6.0%). The standard deviation of 1.89 shows that the scores are highly dispersed.

Pass rate of students in each of the three categories of items (Primary, JHS 1 and JHS 2) was very low. The pass rate on the primary level items was the highest (6.5%), followed by JHS1 (1.6%). This is an indication that 93.5% of the students failed the primary level items, while 98.4% failed the JHS 1 level items. As with the students from average achieving schools, none of the JHS 2 students from the below-average achieving schools could correctly solve the JHS 2 level items in the Mathematics word problems, while the majority could not solve the JHS1 and primary levels items in the Mathematics word problems. The majority of the students from the below-average achieving schools also scored zero on the test for the Primary, JHS 1 and JHS2 items.

**Table 4: Performance of Students in below-average School** (Below Average n = 61)

| Item | Pass Rate | Min | Max | Mean | Standard deviation |
|---|---|---|---|---|---|
| Primary | 6.5% | 0(85.2%) | 4.0 | 0.34 | 0.89 |
| JHS1 | 1.6% | 0(75.4%) | 3.0 | 0.46 | 0.85 |
| JHS2 | 0% | 0(73.8%) | 2.0 | 0.39 | 0.71 |
| Overall | 0% | 0(60.7%) | 7.0 | 1.19 | 1.89 |

NB: Values in brackets show the percentage of students who obtained the minimum score

**Research Question 3**: What is the difference, if any, in the performance of students from above-average, average and below-average achieving schools?

This research question was posed to ascertain the effect of school type, that is, above-average, average and below-average achieving school on students' performance. The null hypothesis: "there is no significant difference in the achievement of JHS 2 students from above-average, average and below-average achieving schools in word problem solving in Mathematics" was formulated to guide the analysis. A one-way Analysis of Variance (ANOVA) was therefore carried out. Table 5 presents the results of the one-way ANOVA. The results in Table 5 shows that there was significant difference in the performance of students among the three school types ($F = 26.904$, $p < 0.05$). This is an indication that school type had effect on students' performance in word problem in Mathematics.

**Table 5: Analysis of variance (ANOVA) of performance by achievement levels (above- average, average and below-average achieving schools)**

| | Sum of squares | Df | Mean squares | F | Sig |
|---|---|---|---|---|---|
| Between Groups | 396.906 | 2 | 198.453 | 26.904 | 0.00 |
| Within Groups | 1357.251 | 184 | 7.376 | | |
| Total | 1754.158 | 186 | | | |

Post Hoc analysis revealed that performance of students from above-average achieving schools was significantly higher than those from average achieving schools ($\mathbf{t_{(124)} = 5.430, p < 0}$). Performance of

students from above-average achieving schools was also significantly higher than those from below-average achieving schools (**$t_{(121)} = 6.13$, $p < 0$**). However, the performance of students from average achieving school was not significantly higher than those from the below-average achieving schools ($t_{(123)} = 0.814$, $p > 0$). This is an indication that the performance of students from average achieving schools was similar to those from below-average achieving schools.

**Research Question 4**: In what ways do students' English language proficiency affect their word problem solving strategies in Mathematics?

This research question was posed to explore students' language proficiency and how their mastery of the language of the test affected their strategies in solving word problem in Mathematics. To address this research question, Newman's error analysis and Cummins categorization of language proficiency based on BICS and CALPS were used to guide the analysis.

*Errors associated with Reading*

Majority (78%) of the students were able to read the questions. The few who were not able to read the questions were mainly from the below-average achieving schools. The words that were challenging to the students are presented under each of the three questions.

*Question 2* "Mr. Obeng had 80 cows, 25% of the cows were black, 3/5 of the cows were white and 3/20 of his cows were a mixture of black and white. Find out how many of each colour of cows Mr. Obeng had"

Students who had difficulty reading this question had challenge pronouncing these words; "Obeng", "were", "3/5" [was read as "three is to five"], "white", "mixture", "out", "many", "each" and "colour".

*Question 4 "Kojo* buys 2kg of apples at GH¢3.60 a kilogram and 3 packets of tea at GH¢2.40 a packet. How much does he pay altogether?

Students who had difficulty reading this question had challenge pronouncing these words; "tea," "kilogram", "apple", "packets", "altogether", "how", 'he", "pay" etc. Those were mainly students from the low achieving schools.

*Question 6: "The sum of the ages of two brothers Kofi and Kweku is 35. Kofi's age is two-thirds Kweku's age. Find their ages."*

Students who had difficulty reading this question had challenge pronouncing these words; "sum" and "two-thirds".

Table 6 presents results on the classification of students' linguistic difficulties based on Cummin's (1981) classification of language proficiency, namely Basic Interpersonal Communication Skills (BICS)/Everyday Language and Cognitive Academic Language Proficiency (CALP). The results in Table 6 show that students who had difficulty reading the questions had challenges with both BICS and CALP. Some of these JHS 2 students, especially from below-average achieving schools had difficulty reading three and four letter words like "out", "tea", "pay", "many", "were" and "each". Reading of words specific to Mathematics such as "sum" and "two-thirds" was also difficult for students.

**Table 6: Classification of Students' Linguistic difficulties based on Cummin's (1981) categorisation of two levels of language Proficiencies**

| Everyday English/BICS | Cognitive Academic Language/CALP |
|---|---|
| "Obeng", "were", "white", "mixture", "out", "many", "each", "colour" "tea," "apple", "packets", "altogether", "how", 'he", "pay" | "3/5" (was read as three is to five), "kilogram", "sum" and "two-thirds" |

*Errors associated with Comprehension*

A number of the students who were able to read the questions were not able to explain the demands of the questions. Those who could not read the questions with understanding read the text several times and used a phrase or two from the word problem to explain how they understood the question. In answering Question 4, for example, Cee, a student from a below-average school, explained the demands of the question as; "the question wants me to add the two amounts of money together because the question wants the money altogether."

In answering Question 6, Dennis, a student from an average school, interpreted the demands of the question after reading it fluently as; "The question says Kofi's is two-thirds and we are to find Kweku's.", which was an inaccurate interpretation of the demands of the question. Others, were frank about their lack of understanding of

the question they had read fluently. Agabus, a student from a below-average school, for example, said "I do not understand the question", when the interviewer asked him to explain the demands of the question.

However, a few who read the questions fluently were also able to interpret the demands of the questions correctly. For example, Kweku, a student from an average-achieving school explained the demands of Question 2 as "Mr. Obeng has 80 cows. He wants us to find out the number of cows, which are white, number of cows which are black and number of cows which are mixture of black and white".

*Errors associated with Transformation and Process*

The majority of the students also had challenge decoding the questions and applying the appropriate mathematical procedures to solve them. The wrong interpretation of the questions, often informed by certain phrases within the questions, resulted in transformational errors and meaningless manipulation of numbers. The students did not only have difficulty in the process of forming mathematical sentence from the problems but they also had difficulty with basic arithmetic. Correct use of basic operations was a big problem for many of the participants.

For example, Dennis, explained how he transformed Question 6 (*The sum of the ages of two brothers Kofi and Kweku is 35. Kofi's age is two-thirds Kweku's age. Find their ages.)* and the processes he followed as "The question did not give Kweku's fraction so Kweku's is 1/3, but I did not use the 1/3 for Kweku. I multiplied 2/3 by 35 and had 23.33 and subtracted it [23.33] from 35 which gives 11.97, and gave 11.97 to Kweku." (see Figure 1)

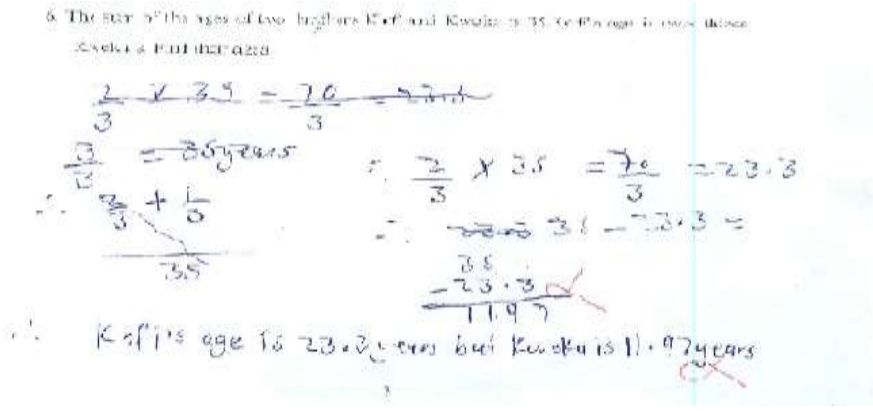


*Figure 1:* Dennis' solution to Question 6

Dennis transformation and process skills were wrong, because writing two-thirds times thirty-five minus thirty-five is not the correct transformation and process to follow to solve the question. Thirty-five is the sum of the ages of the two boys. It is therefore wrong to multiply 35 by two-thirds to obtain Kofi's age. The correct transformation and processes should have been $\frac{2}{3}x + x = 35$, where $\frac{2}{3}x$ = Kofi's age and $x$ = Kweku's age. Simplifying this equation, Kweku's age will be 21years and Kofi's age is 14 years.

Alberta, a student from a below-average school had extreme difficulty reading, transforming and proceeding with the solution to Question 6. She presented her solution as shown in Figure 2.

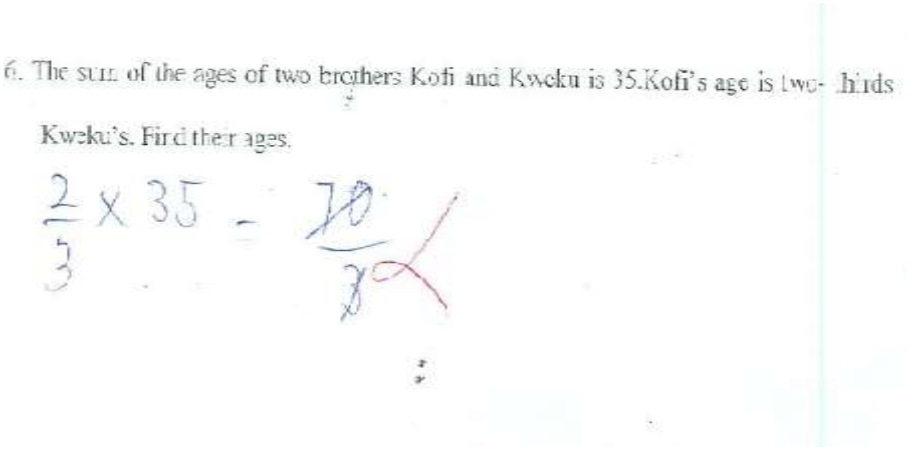


*Figure 2:* Alberta's wrong transformation and process in solving Question 6

Alberta's solution shows clearly that she was just manipulating numbers without understanding what she was doing.

Problems associated with transformation errors and processing skills errors were not limited to only students who could not read and understand the word problem but also those who did not have problems with comprehension. After correctly explaining the demands of Question 4 as; "Kojo buys 2kg of apples at ¢3.60 and three packages of tea is ¢2.40. What is the total cost?", Gohan, a student from an average achieving school had extreme difficulty transforming and proceeding with the solution to the question. Gohan presented his solution as shown in Figure 3.

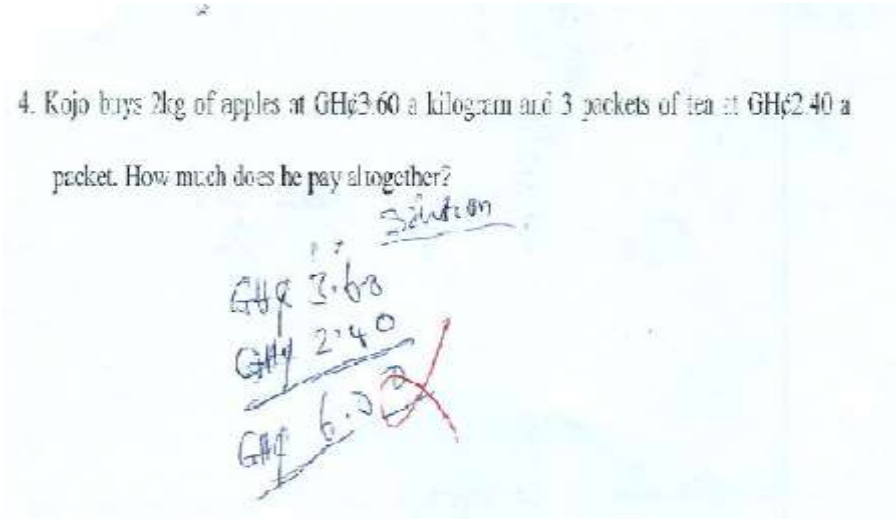


*Figure 3:* Gohan's wrong transformation and process in solving Question 4

Gohan simply added the unit cost of each of the two commodities and obtained Gh₵ 6.00 as the answer. Gohan's transformation and processing skills were wrong. Gohan could have transformed and proceeded to solve Question 4 as Gh₵3.60 x 2 + Gh₵2.40 x 3 = Gh₵7.20 + Gh₵ 7.20 = Gh₵ 14.40 or used another reasonable approach that would have led to the correct solution to the question.

Generally, students who were able to solve the problems correctly were those who were able to read and interpret the demands of the question correctly and also transformed them correctly. Kojo, for example, read Question 2 (*Mr. Obeng has 80 cows, 25% of the cows were black,* $\frac{3}{5}$ *of the cows were white and* $\frac{3}{20}$ *of the cows were mixture of black and white. Find out how many of each colour of cows Mr. Obeng had.*) with understanding and transformed the question correctly. He proceeded with the solution without difficulty, as shown in Figure 4.

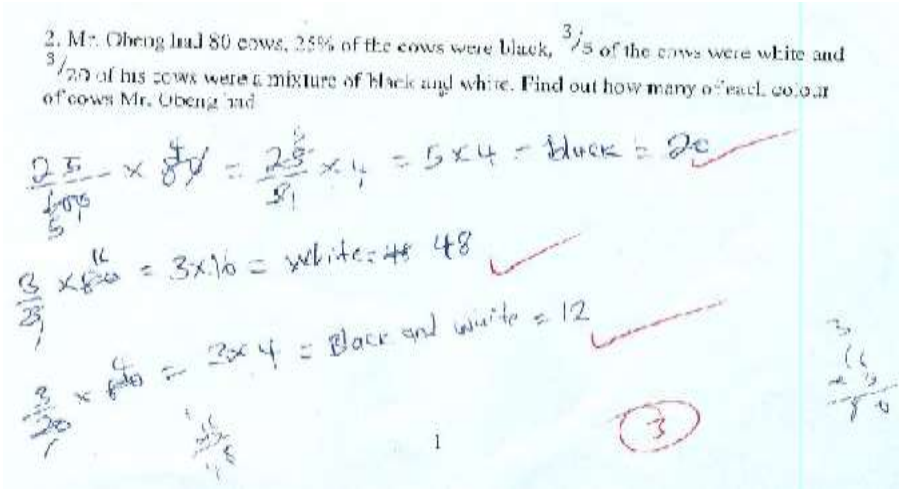


*Figure 4:* Kojo's solution to Question 2

In solving Question 6, Joda explained the demands of the question as "there are two brothers, when their ages are added together it gives 35. Kofi's age is when divided by two will get 2/3 (sic). Find out everyone's age." It is evident that Joda had partial understanding of the question from his explanation but was able to transform the question and solve it to arrive at the correct answer as shown in Figure 5.

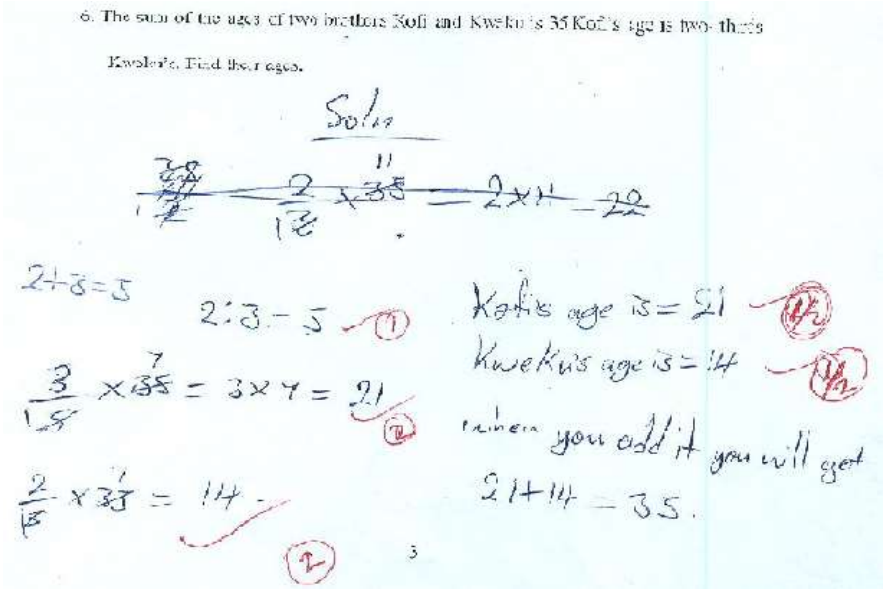


*Figure 5:* Joda's Solution to Question 6

*Errors associated with Encoding*

Throughout this research, the researchers observed that students, both those who had the correct and the wrong answers did not spare a moment to look back to check the reasonableness of their answers. For example, after Dennis had obtained 23.3years as Kofi's age and 11.97years as Kweku's age, he did not find it necessary to check whether 23.3years, which was Kofi's age was indeed two-thirds of 11.97years, which was Kweku's age (see Figure 1). Encoding would have drawn Dennis' attention to the fact that 11.97years is smaller than 23.3years, so Kofi age cannot therefore not be 23.3years because 23.3years is not two-thirds of 11.97years. In Figure 3, Gohan also obtained Gh₵ 6.00 as his answer without looking back to ascertain the reasonableness of the answer.

**Discussion**

The results from the study showed that very few of the JHS 2 students exhibited some level of proficiency in solving word problem in Mathematics. This was reflected in the overall pass rate of less than 5% on the whole test, the mean score of 11.9% (2.37 out of 20 marks) and Standard Deviation of 3.07. The vast majority (95.2%) of the students failed the test with almost two-thirds (41.7%) scoring zero on the whole test. Granted that the test comprised two items each from Primary, JHS 1 and JHS2 (see Appendix A), one would have expected the research participants to score high on the primary and JHS 1 levels items, which were below their level but that was not the case. The general performance of students on the items at each of the levels tested was very low, that is, Primary (16.1%), JHS1(7.5%) and JHS2(1.6%). The pass rate decreased from Primary through JHS 1 to JHS 2. Majority of these JHS 2 students' proficiency in word problem solving did not even measure up to primary school level. It is therefore not surprising that very few (1.6%) of them passed the JHS 2 level items and the pass rate decreased with increase in the grade level. The results provide a clear evidence that the students did not have enough knowledge and experience to tackle the word problems, even at the primary school level.

Analysis of the results across the various school contexts, that is, above-average, average and below-average achieving schools showed that the phenomenon of students' poor performance in word

problem was common to all the three categories of schools. None of the students from the below-average achieving schools passed the whole test, 1.6% of the students from the average achieving schools pass the test, while 9.6% of the students from the above-average achieving school passed the test. It is evident that less than 10.0% of the students passed in each of the school types (see Tables 2, 3 and 4). None of the students from the below-average and average achieving school was able to pass the JHS 2 level items (see Tables 3 and 4). This is an indication that none of them was proficient in word problem solving at the JHS 2 level. The results show that as compared to the above-average achieving schools, the situation was more serious in the below-average and average achieving schools. It was evident from the study that the few students who were able to pass the test were mainly from the above-average achieving schools. The one-way ANOVA confirmed a significant difference in performance in word problem in Mathematics among the students from each of the three categories of schools ($F = 26.\ 904$, $p<0.05$). However, while the performance of the students from above-average achieving schools was significantly higher than the average ($t_{(124)} = 5.430$, $p < 0$) and below-average ($t_{(121)} = 6.13$, $p < 0$) achieving schools, the performance of the students from the average achieving schools was not significantly higher than those from below-average achieving schools ($t_{(123)} = 0.814$, $p > 0$). This implies that the performance of students from the average achieving schools in word problem in Mathematics was similar to those from the below-average achieving schools.

While the finding between the above-average achieving schools and other school contexts is not surprising, the one between the average and below-average achieving schools appears to challenge the observation of Davis et al. (2019) about significant difference in achievement of students from average and below-average achieving schools in Mathematics. The finding of similar achievement between the below-average achieving schools and average achieving schools in word problem in Mathematics reported in this study and those from Davis et al. (2019) suggests that while school type has effect on students achievement in the average and below-average achieving schools in Mathematics in general, the effect of school type does not seem to affect achievement in word problem solving in Mathematics in the two context of schools. This finding appears to show that the proficiency

level in word problem in Mathematics in the below-average achieving schools is similar to the average achieving schools.

The majority of students were able to read the questions. The few who were not able to read the questions, mainly from the below-average achieving schools, had very low English language proficiency. This was evident in their inability to read two letter words like "he" and three letter word like "pay". Their challenge was not limited to only Everyday Language but also Cognitive Academic Language. Words such as "sum", "Kilometers" and "two-thirds" were difficult to read (see Table 6). Although the majority of the students read the questions with understanding, a number of those who read the question without difficulty had challenge understanding the demands of the questions. Such students often looked at the key words or phrases in the question to guess the demands of the questions. Students' inability to read simple two and three letter words in English language at JHS 2 and their inability to read the relatively simple word problems with understanding could be attributed to the bilingual education being carried out in Ghana, where local language is used as medium of instruction from primary 1 to primary 3 and English language is used as medium of instruction from primary four onwards.

The students' linguistic difficulties could also be a problem that might have been carried from the primary school level. A study carried out in the research locale on linguistic influences on primary school pupils' word problem solving revealed that a number of them had difficulty reading the relatively simple word problems given to them with understanding. The study revealed that a number of the primary school pupils had difficulty pronouncing simple words in English language (Davis, 2010). The system of whole sale promotion in the Ghanaian school system where students who do not measure up to the grade level in which they are, are promoted to the next grade level without providing them with any remedial teaching support targeted at bringing such students up could contribute to this situation. It is evident that even though the student participants in the present study were in JHS2, they were operating far below that level.

Transformation of word problem constituted a major challenge that affected the processes students followed to solve the word problems. All students who could not read the questions such as Alberta and some of the students who were able to explain the demands of the

questions correctly such as Gohan had challenges transforming the word problem into the correct mathematical equation (see Figures 2 and 3). They were therefore unable able to follow the correct processes to solve the word problem. This suggests that apart from linguistic difficulties which affected the ability of students who could not read the question at all and those who read the question without understanding its import, some of the students who read the question with understanding also lacked the skill of decoding the Mathematics from the word problem and proceeding with the solution. This suggests that such students were not able to solve the word problems not because of linguistic challenges but because of lack of knowledge and skills involved in decoding the mathematical equations/expressions from the word problems and proceeding with their solution. This finding appears to strengthen existing literature. Barton (2008), for example, observed that sources of difficulty bilinguals encounter in the study of Mathematics in their second language may not only be linguistic but may also be related to the understanding of the mathematical content itself. Again, encoding was not observed throughout the research. None of the students who were interviewed questioned the reasonableness of their answers and looked back to check whether their answers adequately addressed the word problems they set out to solve.

The challenges the students faced in solving the word problems could also be pedagogical. The literature suggests that prospective Ghanaian primary and Junior high School teachers struggle with non-routine word problem solving even before they enter the teaching profession. Wilmot, Davis and Ampofo (2015), found that the performance of Ghanaian pre-service teachers at the Colleges of Education in Ghana in word problem declined from primary school level through junior high school level to senior high school level. The study found that they had difficulty transforming and processing non-routine word problems in Mathematics. Again, Wilmot et al. (2015) also made similar observation about encoding. Their study found that the pre-service teachers hardly looked back to ascertain the reasonableness of their answers. One could therefore infer that since the challenges related to transformation, processing skills, encoding and trends in performance of the students in the present study reflected those faced by the research participants in Wilmot et al. (2015), some of the teachers who are teaching these children themselves might have

similar problems as the children. This might therefore affect students' opportunities to learn word problem in Mathematics.

**Conclusion and Implications**

The JHS 2 students from all the three categories of schools, namely above-average, average and below-average achieving schools exhibited extremely low proficiency in word problem in Mathematics. They exhibited low proficiency in word problem solving at each of the levels tested, that is, primary, JHS1 and JHS 2. Very few of them were able to tackle JHS 2 level word problems in Mathematics. However, the study found a significant effect of school type on students' ability to solve word problem in Mathematics. The performance of the students from above-average achieving schools was significantly higher than those of the average and below-average achieving schools. However, the performance of students from Average achieving school was not significantly higher than those of the below-average achieving schools. In other words, their performance was similar. None of the students from the average and below-average achieving schools passed the JHS 2 level items in the word problems in Mathematics. This implies that none of the students from these two school types measured up to JHS 2 level in solving word problem in Mathematics even though they were in JHS 2.

Linguistic challenges associated with both Everyday English language (BICS) and Academic Language (CALP) affected understanding, transformation and solution processes of a number of students in solving the word problems. Students who either had difficulty reading the questions or read the questions without understanding them had extreme difficulty with transformation of the questions into the Mathematics expressions or equations and proceeding with their solution process. Such students often ended up with wrong transformation of the word problem based on their interpretation of the problem. However, it can be concluded from the results of the study that, apart from linguistic difficulties that affected students' solution processes, there was also evidence of difficulties associated with decoding the Mathematics from the word problems. Some of the students who read the word problem with understanding still had difficulty transforming the problem and proceeding with their solution. The study also found that encoding was a major problem. Both

students who had the correct and wrong answers to the problems they solved during interviews were not observed looking back to check the reasonableness of their solution. Encoding was simply absent.

The findings from the study have implications for teacher education, especially in-service teacher education, curriculum delivery in Mathematics in the research locale and future research. Teacher education programmes, especially in-service programmes should pay particular attention to the teaching of word problem since application of Mathematics in real life situations is often presented as word problems. For example, business Mathematics involving profit and loss, taxation and discounts are often presented as word problems. Curriculum delivery should pay attention to differentiated teaching. This study has shown that the situation in which teachers progress from one topic to another based on the absorption rate of the average students does not provide the opportunity for students who are operating below the grade level to catch up. It rather exacerbates the cognitive deficit. Teaching and assessment should therefore target the ability levels of students in word problem in Mathematics. For example, JHS 2 students who are struggling with primary level word problem in Mathematics should be given the opportunity to learn word problem at that level and be tested with primary school level word problem. Such students should not be made to study the same content and take the same examination as their counterparts who can solve JHS 2 level word problem.

This study also calls for the need for a debate on mass promotion of students from one level to another which is currently done in public schools in Ghana since the findings from this study has shown that it appears to have adverse effect on quality of students' learning outcomes. As suggested in Davis et al. (2013), the language of instruction policy being currently practiced in public/state schools in Ghana where the language of instruction is switched from a local language to English language from primary four onwards should be looked at again. A gradual shift from the use of the local language as a medium of instruction based on the linguistic needs of students may help improve the performance of students in word problem solving in Mathematics specifically and application problems in Mathematics in general. The researchers will agree with the suggestion of Boonen, Koning, Jollies and Schoot (2016) on the need for attention to be paid on both reading comprehension skills and mental representation skills

in teaching of word problem solving to students. Attention should therefore not be paid only on transformation, process skills and encoding but also on reading comprehension skills.

Although the findings from this study cannot be generalised across the whole of Ghana because of its scope, it may point to what could be happening in schools in the country. Further studies are therefore needed to be carried out in the various regions of the country to ascertain the national picture and inform policy on curriculum development and implementation at the national level and in other sub-Saharan African countries that share similar situation as Ghana.

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**Appendix A**

Department of Basic Education
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Cape Coast

Word Problem Solving Test for Junior High School 2 Students

Time Allowed: 1 Hour

1. Kwesi's father's foot is 280mm in length. Kwesi's foot is 120mm in length. Write down the ratio of the length of Kwesi's foot to that of his father's.
2. Mr. Obeng has 80 cows, 25% of the cows were black, $\frac{3}{5}$ of the cows were white and $\frac{3}{20}$ of the cows were mixture of black and white. Find out how many of each colour of cows Mr. Obeng had.
3. The mass of each book of an encyclopaedia is $1\frac{3}{4}kg$. There are 20 books in the encyclopaedia. Find the total mass of the encyclopaedia.
4. Kojo buys 2kg of apples at Gh₵ 3.60 a kilogram and 3 packets of tea at Gh₵ 2.00 a packet. How much does he pay altogether?
5. In a dining hall, 25m by 12m, an area $8m^2$ is kept clear for cooking. What area is there for dinning?
6. The sum of the ages of two brothers Kofi and Kweku is 35. Kofi's age is two-thirds Kweku's age. Find their ages.