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Students' mathematics and real life contexts in solving algebraic word problems

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Abstract

Background: Algebra involves rules of operations, signs of operations, equations, and algebraic structures. Previous studies have indicated that students often struggle with mathematics in both academic and real-life contexts.
Aim: The main objective of this study was to explore how students handle word problems in both mathematics and real-life contexts.
Method: The study utilized a cross-sectional design to examine these issues in the developing world, specifically targeting junior high school students in Ghana. A total of 200 students, comprising 91 males and 109 females from various public Junior High Schools, were randomly sampled. The research categorized problems into mathematics context and real-life context, with analysis further divided into 'attempt statuses' (either 'attempted' or 'not attempted') and 'performance statuses' (either 'correct' or 'wrong'). Follow-up interviews, each lasting 15 minutes, were conducted with three groups of both male and female students.
Results: The results from the independent samples t-test revealed that the mean score for male students (M =15.37, SD =3.435) was not significantly different from that of female students (M = 15.35, SD = 3.619). It was observed that male students attempted all word problems, while some problems were not attempted by female students.
Conclusion: The study concluded that there is no statistically significant difference in the ability of male and female students to solve algebraic word problems. The lack of attempts by female students on some items suggests a potential lack of understanding in context problems. It is recommended that teachers employ multiple representations, technology tools, and metacognitive strategies to help bridge these gaps.

INTRODUCTION

Algebra as a branch of mathematics concerns itself with rules of operations, relations, constructions, terms, variables, constants, operational signs polynomials, equations, and algebraic structures (Julius et al., 2018). In solving algebraic word problems, studies have found a relationship between the contexts in which the word problems have always been presented. There are positive relationships between scores of contextualized mathematics word problems. In this regard, students usually perform much better in plain questions than in contextualized word problems. Studies by Asoma et al. (2022) showed that contexts appeared to influence the solution paths when solving Mathematical word problems. On the contrary, Saleh and Rahman (2016) reported no significant differences in contextualized word problems. However, Arnawa et al. (2019) found differences in gender ability in problem-solving. The reason is that gender, in particular, influences contextualized word problems. In light of this inconsistent literature, it was just prudent to delve into the problem and illuminate the findings in much more detail.

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Algebraic expressions present ideas of expressing numbers using letters or alphabets without specifying their actual values. Mathematical statements can be expressed using variables, coefficients, and constants. The commonest letters are x, y, z, and so on. These letters are known as variables. Any value that is placed before and/or multiplied by a variable is known as a coefficient and any value that stands alone is called the constant (Ali & Abatanie, 2023; Ali & Asemani, 2023; Ralston et al., 2018). In the algebraic problems, (3m – 7) = (6 + 9m)], the variable is 'm', the coefficients are '3' and '9' and the constants are '-7' and '6'. To solve for the variable 'm', one needs to have contextual skills involving identifying and analyzing patterns, examining relationships, making generalizations, and interpreting change. The contextual skills are buttressed with fluency with numbers, operations, and relationships.

Algebraic expressions are also ways of thinking and reasoning that help students prepare for higher mathematical thinking. This calls for the understanding of mathematical symbols and tools to represent mathematical information. These advanced tools include words, diagrams, tables, graphs, equations, value placement, testing proofs, and searching for proofs. Students must develop a contextual appreciation of basic expressions, equations, patterns, and independent and dependent variables. The solutions require both real-life and mathematical context problems (Sibgatullin et al, 2022).

Algebraic word problems are mathematical statements that require the use of algebraic equations or expressions to solve real-world situations. An algebraic word problem is perceived as a task presented in words with a question posed to define a goal the solver is expected to attain in carrying out the task. The skill and technique of solving the word problem is the goodwill to strive hard to resolve the algebraic expression. Another skill is to provide students with explicit instruction on how to identify and interpret keywords and phrases in mathematical problems. This involves teaching students to recognize the problem structure and to translate the words into algebraic expressions or equations. For instance, students may learn to recognize phrases such as 'is twice as many as' or 'the sum of'.

Algebra contributes to solving problems in the natural mathematics world (Parrot & Leong, 2018). In real life, algebra equips the individual to enumerate, calculate, measure, collate, group, analyze, and relate quantities and ideas (Agwagah, 2017). Unfortunately, algebraic learning has been identified as a problematic and challenging subject for most students. Some students encounter difficulties in understanding multiple meanings of letters, variables, and constants while developing algebraic thinking (Parrot & Leong, 2018).

Also, students usually still encounter challenges when solving algebraic expressions and equations (Assadi & Hibi, 2022). Ampadu and Anokye-Poku (2022), and Ampadu and Danso (2018) have reported poor performance in mathematics due to this challenge. In particular, the National Education Assessment in 2013 revealed that mathematics performance was as low as 20% proficiency in mathematics for classes 2, 4, and 6 at the primary level. The average scale scores of 276, 309, and 331 were recorded in 2003, 2007, and 2011 respectively. These scores were significantly below the international average scores of 466 in 2003, and 500 in both 2007 and 2011. Some students were not sure and could not decide on what operation to use to solve an algebraic expression. Other students resort to guessing or using inappropriate strategies. To ameliorate this error, Schoenfeld (2016) proposed multiple representation strategies. These can be in the form of diagrams, tables, or graphs. Students can easily visualize the problem and understand the relationships between the different variables.

Ali and Adu-Poku (2021) opine that some students get stuck when translating algebraic expressions to word problems, transforming word problems into linear equations and inequalities, and appropriating effective skills, techniques, and methods to solve daily life problems (Ministry of Education, 2020). One major contributory factor is late exposure to the teaching and learning of algebraic expressions. The weak foundation of students in algebraic expressions retards teachers' ability to implement problem-solving tasks during mathematics instruction. This may affect the fluency and competency skills in applying algebraic expressions in a real-life context. As recommended, students need to understand concepts beyond the classroom and bridge the gap between school and home mathematics (Adu et al., 2017).

The report of the 2019 Trends in International Mathematics and Science Study (TIMSS) argued that students could not comprehend the mathematics language. Examination reports of a local Municipality district area suggest many students still fall below the national minimum standards in mathematics and algebraic expressions (Mullis et al., 2020) The findings of Asoma et al. (2022) point to the fact that poor expression of language is detrimental to problem-solving. Students often struggle to interpret equations that comprise both letters and numbers. Das (2019) observed that many students simply seek a simple application of arithmetic algorithms needed to produce answers without thinking through the contexts of the word problem. Many studies (Adu et al., 2017; Nashiru, 2018; Asoma et al., 2022) have focused particularly on senior high schools. However, this study has focused on the junior high school level. This would help to assess the inclusion of algebraic word problems in the new mathematics curriculum to make timely and early recommendations impact theory, policy, and practice.

Lastly, Hidayati et al., (2019) found significant differences between genders in problem-solving in mathematics. The findings suggest that the inability of male students to embed social interaction strategies in problem-solving is the cause of their poor performance. Lin et al. (2020) also found out that even single-gender groups had more focused discussions than the mixed-gender groups. The male-male groups tend to develop and test their solutions directly without spending significant time on problem identification. Consequently, the single-gender groups exhibit superior performance compared to the mixed-gender groups in terms of applying their knowledge to problem-solving. Even the findings of Borgonovi et al., (2023) revealed that girls outperform boys in collaborative problem-solving in advanced countries. However, in developing countries, the trend is the reverse. Certainly, there is no doubt about gender differences in problem-solving. Again, literature has made little reference to context and real life in the study of mathematics problem-solving. The literature gap here is whether they have differences in the types of mathematics algebraic problems.

In this study, the ability of students to translate word problems into linear equations can be described as mathematics context problems and the ability to solve the equations formed correctly can be described as real-life context problems (Das, 2019). Students neither performed well in mathematical nor in real-life contextual problems (Ali, 2021; Pratiwi & Widjajanti, 2020). But contextual problems are the driving forces of Realistic Mathematics Education as they link mathematics knowledge to real-life situations and the versa. Instead of students seeking to understand the mathematics contexts of the problems, they rather seek to obtain the right answers, to the detriment of relating the mathematics problems to everyday life. Solving algebraic word problems demands a blend of conceptual and procedural knowledge.

Moreover, students often do not learn how to solve problems but just memorize solutions that have been explained by teachers. When students are presented with algebraic problems that require the use of variables to represent unknown quantities, they often struggle to interpret equations that comprise both letters and numbers. This study anchor on the power of context in mathematics in real-life situations. This ensures that students solve problems they would like to encounter outside the classroom. This way, applications of problem-solving and its extended consequences on lifelong learning could be a panacea to many problems of the individual and society (Asoma et al., 2022). The purpose of this study was to explore students' mathematics and real-life contexts in solving algebraic word problems.

METHODS

Problem-solving comes in both algebraic expressions and word problems. To solve them, Polya's four-step model is called into play. The model can be used to solve both mathematics contexts and real-life contexts. The design to achieve the process is the cross-sectional descriptive, where both a teacher-made achievement test and a semi-structured interview guide were applied to collect the data. After collecting the data, the analysis was carried out in mathematics contexts, real-life contexts, and students' lived transcripts of the expressions. Empat Langkah polya yang digunakan pada penelitian ini disajikan pada Figure 1.

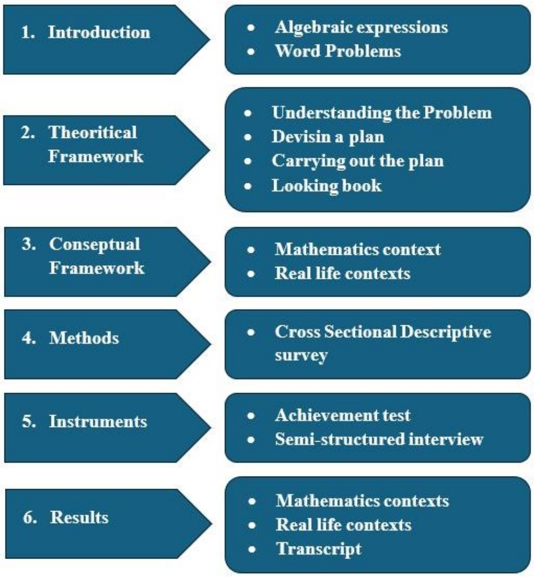

Figure 1. Study flow chart

Design

This study utilized the cross-sectional descriptive survey to examine the difference in knowledge of solving algebraic word problems. In using this design with validated instruments, respondents were not manipulated, but data on their knowledge of solving algebraic word problems was collected and statistical inferences were made. The choice of this design aligns with the views of Ihudiebube-Splendor and Chikeme (2020) that cross-sectional survey designs help to describe a population of interest at a specific point in time. It also allows researchers to record information about a large number of people at one moment in time to define the characteristics of that population without manipulating variables. However, cross-sectional survey designs cannot establish causal correlations among variables because the measurement is performed in a snapshot (Ihudiebube-Splendor & Chikeme, 2020).

Participants

The study involved 200 junior high school students who were randomly selected from across different public junior high schools in Ghana. This consisted of 91 male and 109 female students. The average age of the students was 13 years. In the selection procedure, the students were first given three-digit numbers, ranging between 1 to 200. A table of random numbers was then generated, one after the other. If a student's number came out of the computer, then that particular student was selected. This process continued until all the required sample size was obtained.

Instruments of data collection

Two principal instruments, namely an achievement test and a semi-structured interview guide were used. In the achievement test, the researchers outlined 20-minute teacher-made questions, consisting of 10 items. This was used to assess the ability of the boys and the girls to independently translate expressions into word problems and solve algebraic word problems. The questions were adapted from the 2020 mathematics examination questions, from the Ministry of Education and the Ghana Education Service as contained in Asiedu (2017). The items were grouped into mathematics context problems and real-life context problems. The mathematics context problems were analytically grouped into 'attempted' and 'not attempted'. The real-life context problems were grouped into 'correct' or 'wrong'. These scales were coded into the SPSS statistical software version 25 for the statistical analyses.

Again, following the instruments' administration, three groups each of male and female students were invited for 15-minute follow-up interview sessions. The selection of the students was based on interesting and thought-provoking responses they gave in the questionnaire. These included both excellent and far non-corresponding answers. In each group, each student was called to a conducive secluded place to interact with each of the researchers. The questions bothered on ways of solving algebraic problems, contextual word problems, and applications of word problems. The interview sessions comprised at least three items in each of the three groups. The answers from each of the groups were transcribed, scanned, and pasted in this study. This helped to properly situate the students' conceptions in mathematics and real-life contexts (Das, 2019).

Instruments of data analysis

The sample size and response rate are important considerations in research design and data analysis, as they impact the validity and reliability of the findings (Creswell & Creswell, 2017). Bal and Or (2023) alluded to the significant impact of these relationships and generally recommend large sample sizes. In this study, six outliers were identified and excluded from the analysis. This reduced the sample size to 200 participants, out of the 223 questionnaires distributed, resulting in a return rate of approximately 89.7%. Stedman et al (2019) recommend a minimum response rate of 80% for survey research.

We produced five tables for the analysis. Table 1 was the gender distribution of the students, Table 2 was the summary of descriptive statistics, Table 3 was the students' mathematics knowledge, Table 4 was students' mathematics and real-life contexts and Table 5 was the independent t-test comparison of gender. Apart from Table 5, the researchers used simple frequency counts and percentages to communicate the results of the study. This was to ensure easy reading and interpretation of the ordinary person on the street (Creswell & Creswell, 2017).

An independent sample t-test was conducted to compare the performance of male and female students' knowledge in solving algebraic word problems. All assumptions of the t-test were checked and found tenable. A stem-and-leaf plot together with a box and whisker plot was used to screen the data of any outliers, Shapiro-Wilk was used to test normality, and Levene's test helped in checking the homogeneity of variance. Once the dependent variable was test scores, it was a continuous variable measured on a scale level, hence all assumptions were met, thereby justifying the use of t-test as a parametric test (Bal & Or, 2023).

Validity and Reliability

The test and interview guide were developed based on the Ghanaian Mathematics curriculum for basic seven and suggestions from mathematics experts. These enhanced the content and face validity of the instruments. The experts provided their professional judgment to refine the test items. This helped to ensure that the items' difficulty and discrimination levels were brought down to the barest minimum.

Again, to further enhance the reliability of the test, a pilot study was conducted in one basic school near the study area. The pilot test equally consisted of ten items and lasted for twenty minutes. The school had similar characteristics, social amenities, and teacher qualifications. The feedback obtained from the pilot test was used to refine and improve the quality of the items. The Cronbach alpha coefficient was 0.75, which according to Taber (2018), is an acceptable alpha level for inclusion of the test items in the actual study.

RESULTS AND DISCUSSION

Results

Table 1. Gender distribution of the students

Status	Frequency	Percent (%)	Maximum	Minimum	Mean
Male	91	45.5	20	10	15
Female	109	54.5	20	11	14
Total	200	100.0			

Table 1 shows that 91 (45.5%) were male and 109 (54.5%) were female. The maximum age for both genders was 20, while the minimum age for males was 10 and for females was 11. However, the mean age for the sample was 14 years, indicating that the majority of the students in the study were within the expected age range in junior high school. It is worth noting that there may be some variation in age distribution within each level, so it is possible that some students in the sample were older or younger than the typical age ranges.

Table 2. Students' knowledge of solving algebraic word problems

Students' knowledge	Total (N)	Min	Max	Range	Mode	Mean	Standard Deviation
Raw score	200	10	24	14	12	15.36	3.529

The results in Table 2 show that the average student's knowledge of algebraic word problems was 15.36 (SD = 3.529). The minimum score obtained was 10, while the maximum score was 24, giving a range of 14 marks. The mode score was 12, indicating that the most frequently achieved score was 12 out of 30. When expressed as percentages, the mean score of 15.36 out of 30 translates to approximately 51.2%. This suggests that, on average, the junior high school students had only moderate knowledge of solving algebraic word problems. Additionally, the relatively high standard deviation of 3.529 suggests that there was a considerable degree of variability in the student's performance on the test. Overall, these results indicate that junior high school students may require additional support and instruction to improve upon their understanding and ability to solve algebraic word problems.

Furthermore, to determine the level of algebraic knowledge the students possess in solving algebraic word problems based on the context of the word problem, an analysis of performance on the individual items included on the test was done to properly ascertain the scenario. Two different contexts, namely mathematical context and real-life context were used. Items 1 to 8 of the test reflected the mathematical context while items 9 and 10 were based on the real-life context. A correct response was defined as accurately completing all four steps required to solve the problem, resulting in a full mark (4/4) for the item. The analysis was also to allow for a more nuanced understanding of students' strengths and weaknesses in the word problem to highlight areas where further instruction or support may be necessary.

Table 3. Comparison of students' mathematical and real-life contexts

	Context	No attempt	Attempt	Correct	Wrong
1	Mathematical context	45	155	84	116
2	Real-life Context	96	104	15	185

The results in Table 3 show the mean statistics of junior high school students' algebraic performance based on the context of the word problem. In the mathematical context, out of the total attempts made by the students, 45 were attempted, and out of these, only 84 were correct while the rest were wrong. This implies that the students struggled with solving mathematical word problems, and only a little over half of their attempts were correct. The pattern of errors emanated from differentiating between a variable and a constant, grouping operations of addition and subtraction, and getting the right inverse of coefficients. In the real-life context, out of the total attempts made by the students, 104 were attempted, and out of these, only 15 were correct while the rest were wrong. This indicates that the students struggled even more with solving real-life problems than with mathematical ones. Only a very small fraction of their attempts were correct in this context. This difference in performance suggests that the students may be struggling more with applying mathematical concepts to real-world situations. They may be finding it difficult to understand how to use the mathematics they have learned in a practical context. As observed by research (Ali, 2021), students are more prone to understanding mathematics problems in the classroom than in real life because few scenarios have been given by students. In many situations, problem-solving strategies are limited to the mathematics classroom or during instruction. After school, many students see no links between school mathematics problems and real-life ones.

On the whole, the level of knowledge possessed by junior high students in solving problems involving plain mathematical word problems differed significantly from their knowledge of solving real-life based word problems with students having higher mean correct scores in plain mathematics word problems compared to the mean correct score obtained in real life context problems in Mathematics.

Table 4. Male and female students' knowledge

	N	Mean	SD	F	Sig.	t	df	Sig (2 tailed)
Males	91	15.37	3.435	.198	.657	0.50	198	.960
Females	109	15.35	3.619					

The results in Table 4 of the independent samples t-test conducted to compare the performance in solving algebraic world problems between male and female students show that the mean score for male students (M =15.37, SD =3.435) was not significantly different from the mean score of their female counterparts (M = 15.35, SD = 3.619) at 0.05 level of significance, (t(198) = 0.50, n = 200, $p < 0.05$) and 95% confidence interval for the mean difference was -.966 to 1.016. Thus, the critical P-value obtained (.960, 2-tailed) was greater than the alpha level of .05 and the confidence interval included 0, indicating that the difference in mean scores between male and female students was not statistically significant. Therefore, the researchers failed to reject the null hypothesis and concluded that there were no statistically significant differences between males and females in terms of their ability to solve algebraic word problems (Saleh & Rahman, 2016).

Table 5. Students' mathematical knowledge

	Algebraic problem	Attempt Status				Performance			
		No attempt	%	Attempt	%	Correct	%	Wrong	%
1	When 10 is added to a number and the result is multiplied by 2, the result is 40	21	10.5	179	89.5	110	55.0	69	34.5
2	The square of a number plus ten is 91	58	29.0	142	71.0	69	34.5	73	36.5
3	Half of a certain number is 3 more than the number	69	34.5	131	65.5	23	11.5	108	54.0
4	The sum of twice a number and 5 is 21	64	32.0	136	68.0	43	21.5	93	46.5
5	Twice a number decreased by 22 is 48	73	36.5	127	63.5	22	11.0	105	52.5
6	Six times a number is 36	33	16.5	167	83.5	138	69.0	29	14.5
7	A number plus eight is equal to three times the number	13	6.5	187	93.5	137	68.5	50	25.5
8	2 plus half a number is 12	31	15.5	169	84.5	132	66.0	37	18.5
9	Peter is 7 years older than his brother. His brother's age is x and the sum of their ages is 63	85	42.5	115	57.5	22	11.0	93	46.5
10	Baba and Tetteh were given GH¢300.00 to share. Tetteh had GH¢34.00 more than Baba. If Baba's share is x, find Tetteh's share	106	53.5	94	46.5	3	1.5	91	45.5

The results in Table 5 show that some students were not attempting some test items, indicating a lack of confidence or understanding of the concepts involved. The percentage of correct responses ranged from 11.0% to 69.0%, indicating a wide range of proficiency levels among the students. Items 3, 5, 7, and 9 had the highest percentage of wrong responses, indicating that these concepts may have been challenging for some students. Item 2 also had a relatively high percentage of wrong responses, indicating a possible lack of understanding of the concept of squares and square roots. Items 1, 4, 6, 8, 9, and 10 had a relatively high percentage of correct responses, indicating that many students had a good understanding of these concepts.

Also, the results further reveal that the highest number of the students did not attempt the algebraic problems based on real-life contexts. For instance, items 9 and 10 recorded the highest number of non-attempts as compared to items 1 to 8. About 85 (43%) students attempted item 9 while 106 (53%) students attempted item 10, suggesting the students may have lacked real-life contexts in problem solving. This could have been attributed to their low confidence in problem-solving (Akpalu et al., 2018).

Similarly, in comparison with items 1-8 (mathematical context), out of the number of students who successfully attempted items 9 and 10 (real-world context), the highest number of wrong responses was recorded for the word problems reflecting the world context. Out of the 115 students who attempted item 9, 22(11%) of the students got it right while the majority 93 (46.5%) had it wrong. Again, item 10 had 94 students attempting it out of which only three had the question solved following the right algorithm, accounting for 45.5% of wrong answers and 1.5% of correct responses (Adu et al., 2017).

Interview Transcript of Male and Female Students

The objective of this study was to examine the ability of male and female students to translate word problems. The word problems have been grouped into mathematics context problems and real-life context problems. Two sets of transcripts were compared. These pairs are 1 and 2, 3 and 4, 5 and 6, 7 and 8, and 9 and 10.

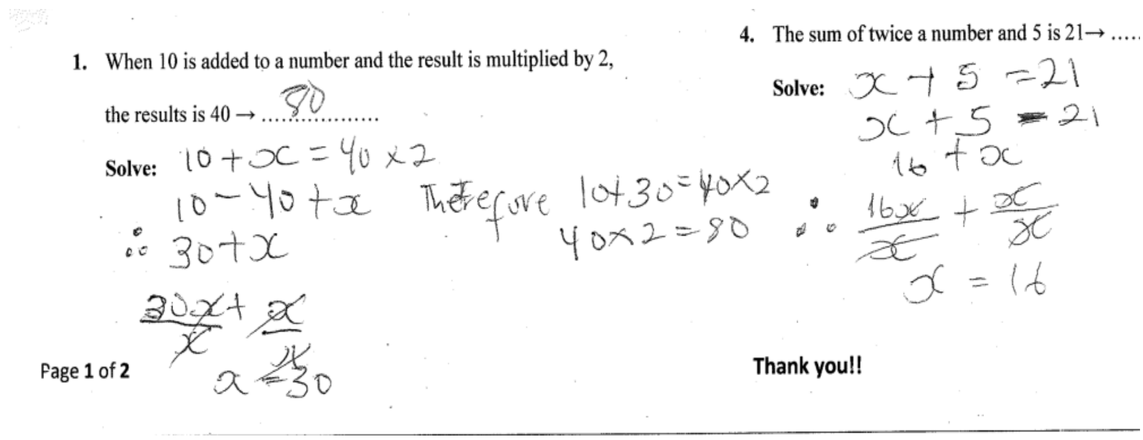

Figure 1. A transcript of male student's knowledge of missing variables

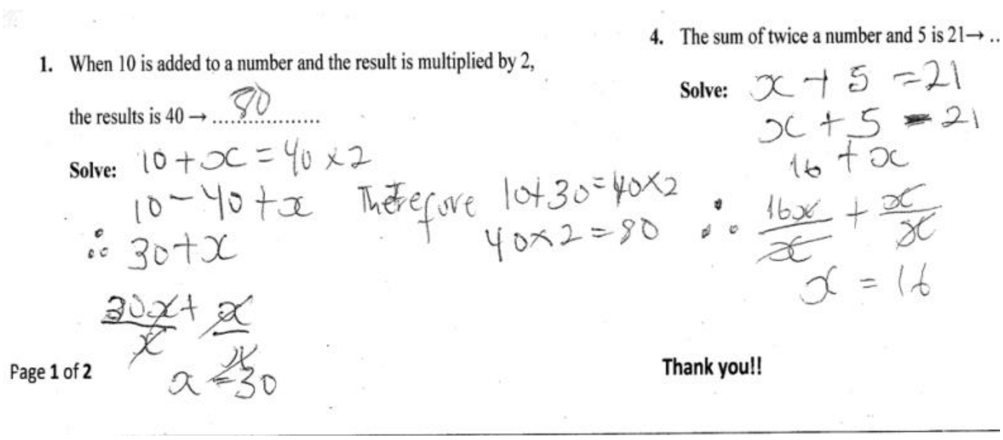

Figure 2. A transcript of female student's knowledge of missing variables

In Figures 1 and 2, the solutions were almost the same. However, the solution in Figure 1 was clearer than that of Figure. So, male students had a little better knowledge of missing variables than female students.

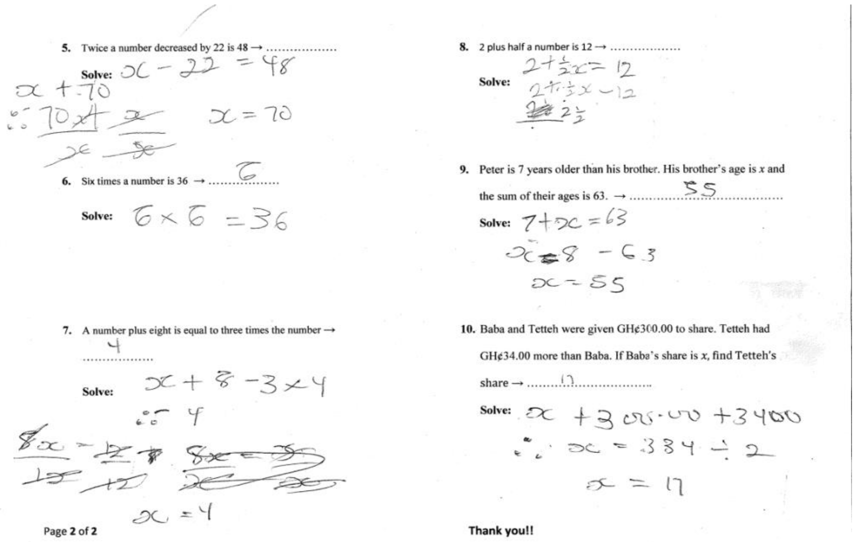

Figure 3. A transcript of male student's knowledge in addition

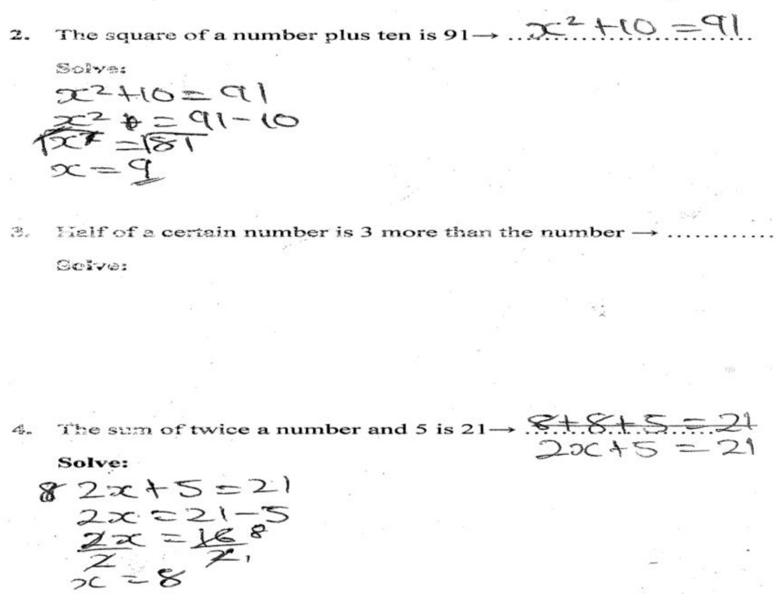

Figure 4. A transcript of female student's knowledge in addition

In Figure 3, the male students answered all questions. However, the female students left out item 3. This can be attributed to female students' low knowledge in addition involving algebraic problems.

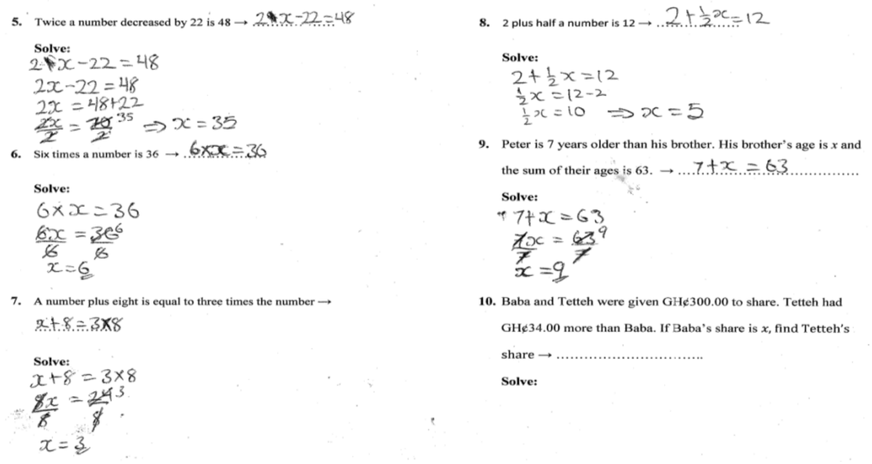

Figure 5. A transcript of male student's knowledge of subtraction

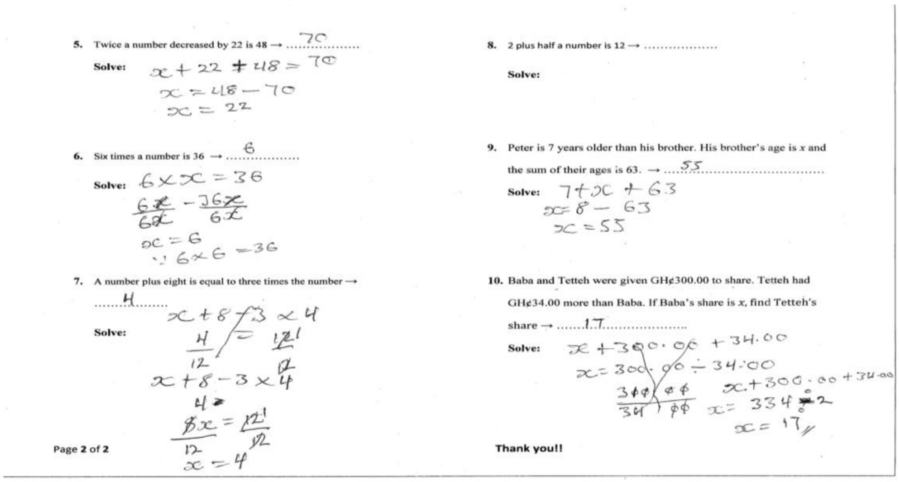

Figure 6. A transcript of female student's knowledge of subtraction

In Figures 5 and 6, both gender groups attempted the questions. However, the female students failed to tackle item 8 in Figure. This is an indication that they did not understand the problem.

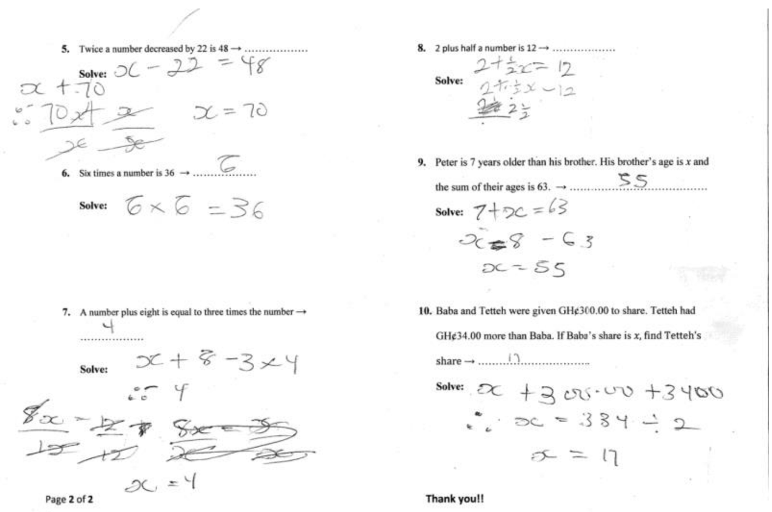

Figure 7. A transcript of male student's knowledge in grouping-like terms

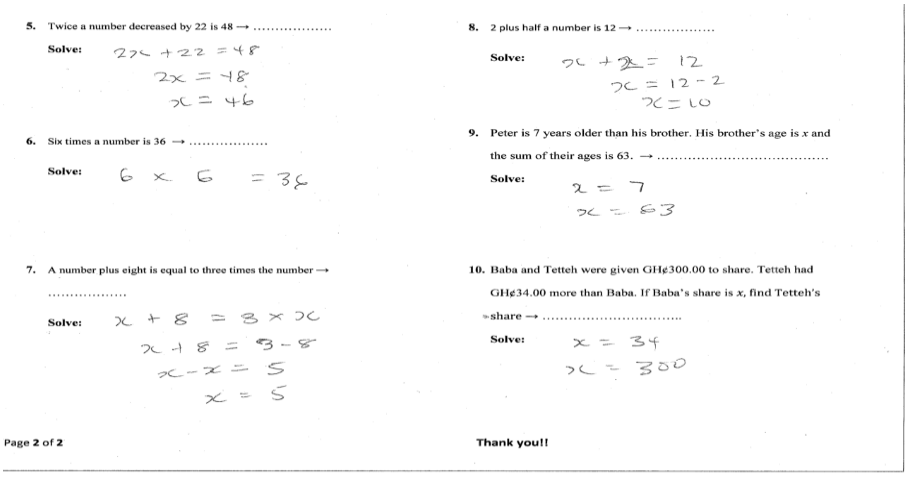
5. Twice a number decreased by 22 is 48 → ………………
Solve: 2x + 22 = 48
2x = 48
x = 46
6. Six times a number is 36 → ………………
Solve: 6 × 6 = 36
7. A number plus eight is equal to three times the number → ………………
Solve: x + 8 = 3 × x
x + 8 = 3 − 8
x − x = 5
x = 5
8. 2 plus half a number is 12 → ………………
Solve: x + 2 = 12
x = 12 − 2
x = 10
9. Peter is 7 years older than his brother. His brother's age is x and the sum of their ages is 63. → ………………
Solve: x = 7
x = 63
10. Baba and Tetteh were given GH¢300.00 to share. Tetteh had GH¢34.00 more than Baba. If Baba's share is x, find Tetteh's share → ………………
Solve: x = 34
x = 300
Page 2 of 2
Thank you!!

Figure 8. A transcript of female student's knowledge in grouping like terms

In Figures 7 and 8, both gender groups solved the problems well. However, a closed examination of Figure 7 suggests that the male students were much more detailed in their solutions as compared to Figure 8. We can infer that the male students understood the items better than the female students.

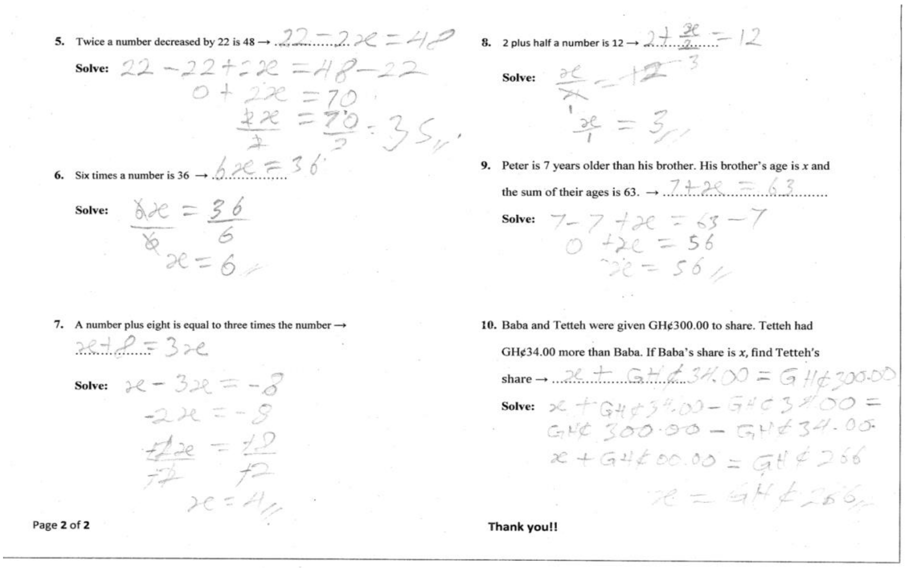
5. Twice a number decreased by 22 is 48 → 22 − 2x = 48
Solve: 22 − 22 + 2x = 48 − 22
0 + 2x = 70
2x/2 = 70/2 = 35
6. Six times a number is 36 → 6x = 36
Solve: 6x/6 = 36/6
x = 6
7. A number plus eight is equal to three times the number → x + 8 = 3x
Solve: x − 3x = −8
−2x = −8
−2x/−2 = −8/−2
x = 4
8. 2 plus half a number is 12 → 2 + x/2 = 12
Solve: x/2 = 3
x/1 = 3
9. Peter is 7 years older than his brother. His brother's age is x and the sum of their ages is 63. → 7 + x = 63
Solve: 7 − 7 + x = 63 − 7
0 + x = 56
x = 56
10. Baba and Tetteh were given GH¢300.00 to share. Tetteh had GH¢34.00 more than Baba. If Baba's share is x, find Tetteh's share → x + GH¢34.00 = GH¢300.00
Solve: x + GH¢34.00 − GH¢34.00 = GH¢300.00 − GH¢34.00
x + GH¢00.00 = GH¢266
x = GH¢266
Page 2 of 2
Thank you!!

Figure 9. A Transcript on male student's knowledge in Contexts

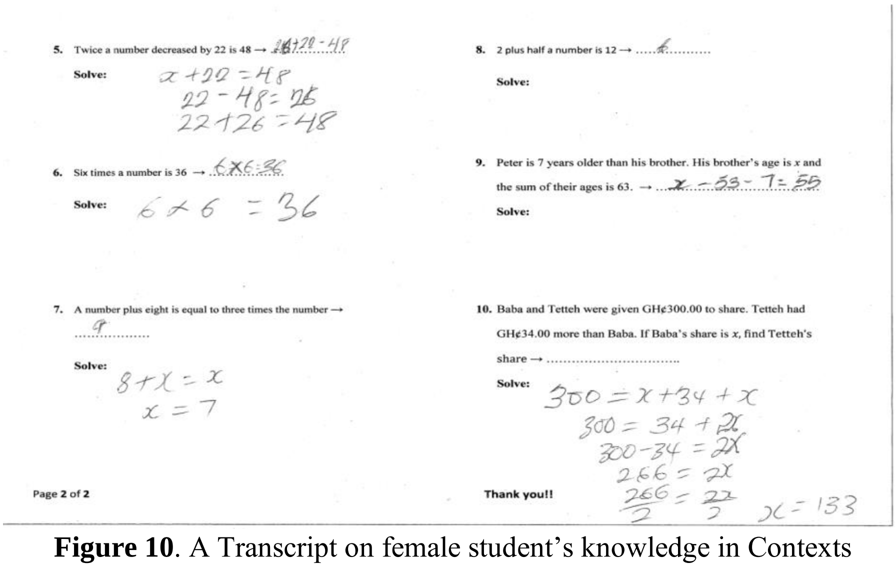
5. Twice a number decreased by 22 is 48 → 26+22 = 48
Solve: x + 22 = 48
22 − 48 = 26
22 + 26 = 48
6. Six times a number is 36 → 6×6 = 36
Solve: 6 × 6 = 36
7. A number plus eight is equal to three times the number → 9
Solve: 8 + x = x
x = 7
8. 2 plus half a number is 12 → 6
Solve:
9. Peter is 7 years older than his brother. His brother's age is x and the sum of their ages is 63. → x − 63 − 7 = 55
Solve:
10. Baba and Tetteh were given GH¢300.00 to share. Tetteh had GH¢34.00 more than Baba. If Baba's share is x, find Tetteh's share → ………………
Solve: 300 = x + 34 + x
300 = 34 + 2x
300 − 34 = 2x
266 = 2x
266/2 = 2x/2 x = 133
Page 2 of 2
Thank you!!

Figure 10. A Transcript on female student's knowledge in Contexts

In Figures 9 and 10, the male students attempted all problems as seen in Figure 9. However, the female students failed to attempt item 9. One cannot suggest anything other than saying that the female students did not understand context problems.

Discussion

In this section, the discussion centred on students' knowledge of algebraic problem-solving, conceptions of algebraic problems, contexts of problem-solving and gender differences in problem-solving.

Students' Knowledge of Algebraic Problem-Solving

The findings of the students' knowledge in algebraic problem solving were consistent with those of Assadi and Hibi (2022), who equally discovered that solving algebraic word problems was found very difficult for most junior and senior high school students. The importance of algebra in school mathematics and everyday life, the government and educators in Ghana have implemented policies to make teaching and learning mathematics with algebra as a key aspect more enjoyable and practical, with a focus on literacy, numeracy, and technology through its major reforms in the educational curriculum (Ministry of Education, 2020). Despite these efforts, algebraic learning in Ghana, and specifically in the Effutu Municipality, has not been the best.

Again, several studies have been conducted into the problem, with a primary focus on students' reasoning and difficulties in solving algebraic tasks (Das, 2019), common errors (Marpa, 2019) and misconceptions (Khanal, 2018), attitudes towards solving problems in algebra (Julius et al., 2018), and the use of various interventions, such as digital games (Susriyati et al., 2020) and algebra tiles (Amidu et al., 2020; Akpalu et al., 2018). Teacher knowledge for teaching algebraic concepts has also been explored (Asoma et al., 2022). Linear equations, a key aspect of algebra, have also been investigated.

Other similar studies have primarily focused on influential factors in algebraic word problems (Das, 2019), difficulties in solving word problems in algebra (Khanal, 2018), and factors accounting for poor performance in algebraic word problems. The qualitative case study design of Khanal (2018) was an icebreaker in this study. We detected and devised effective strategies for combating algebraic word problems and analysed the results thereafter. The ultimate goal confirmed that students' algebraic knowledge had been improved.

Students' Conception of Algebraic Word Problems

The performance in Table 3 and the transcripts of a female student suggest that their conception was not good enough. The act of solving a word problem is a process of accepting a challenge and striving hard to resolve it. However, students were not sure and could not decide on what operation to use, and many students resorted to guessing or using inappropriate strategies to solve word problems. To help students solve algebraic word problems, Schoenfeld (2016) proposed multiple representation strategies. These include diagrams, tables, or graphs to help students visualize the problem and understand the relationships between the different variables.

Another strategy proposed by Huang et al. (2020) is to provide students with explicit instruction on how to identify and interpret keywords and phrases in mathematical problems. This involves teaching students to recognize the problem structure and to translate the words into algebraic expressions or equations. For instance, students may learn to recognize phrases such as 'is twice as many as' or 'the sum of'. Technology can also be used to support students in solving algebraic word problems (Huang et al., 2020). Various digital tools and software can provide students with practice problems and feedback, help students visualize problems, and assist with the translation of word problems into algebraic equations.

Students' Mathematical and Real-Life Contexts

The transcript in Figure 5 shows that contexts matter a lot in problem-solving. While female students failed to understand the context problems, the male students had a slim edge. The findings support Asoma et al. (2022) whose findings showed that contexts influence the comprehension of learners when solving Mathematical word problems. There are equally found students performing much better in plain questions than in contextualized word problems.

On the contrary, Saleh and Rahman (2016) reported no significant increase in student achievement when mathematical word problems were contextualized. This argument notwithstanding, Pratiwi and Widjajanti (2020) showed many students neither master the mathematical context nor the real-life context of the problem. Instead of seeking to understand the mathematics contexts of the problem, some students seek to achieve the right answers to the questions. Such attitudes fail to promote and serve the best intention of using contexts in algebraic problem-solving.

In the transcripts, some students could not relate the problem to their everyday life. Solving algebraic word problems demands a blend of conceptual and procedural knowledge. Procedural knowledge is the ability to apply and use steps or strategies for different problems, also known as mathematics context. Conceptual knowledge is the knowledge of abstract ideas, also known as real-life context. The challenges with word problems are particularly pervasive in understanding multiple meanings of letters, the underlying logic, and making transitions from arithmetic to algebra and vice versa while learning algebra and developing algebraic thinking. Many students also face problems and difficulties when solving algebraic expressions and equations, especially when a particular component is missing (Assadi & Hibi, 2022). These studies affirm that problem-solving in algebra is the chief cause of students' failure in mathematics.

Moreover, students often do not learn how to solve problems but just memorize solutions that have been explained by teachers (Asoma et al., 2022). In solving algebraic word problems, students have difficulty setting up the equations while some students could write equations to represent problems but do not use these equations to find the solution, preferring instead to use more informal methods. When students are presented with algebraic problems that require the use of variables to represent unknown quantities, they often struggle to interpret equations that comprise both letters and numbers. These difficulties, particularly with algebraic word problems, have been attributed to students' poor conception (Schoenfeld, 2016). Poor knowledge of solving an algebraic word problem is a result of students' abstract reasoning and use of different approaches to problem-solving, difficulty in understanding algebra language, letters, and meanings given to symbols, difficulty in changing from arithmetic to algebraic conventions, the nature of algebra concepts; abstract, algebraic structure and process-object duality as well as the use of formal representation as teaching methods.

Gender and Problem-Solving

In the hypothesis, the researchers failed to reject the null hypothesis and concluded that there were no statistically significant differences between male and female students' ability to solve algebraic word problems. These findings were consistent with previous studies of Saleh and Rahman (2016), who all found no significant effect of gender and algebraic thinking. However, it disconfirmed a study by Arnawa et al. (2019). Having realised the geographical effect, it was prudent to infer that gender had no statistically significant difference. Algebraic word problems are an essential part of mathematics education that requires the use of algebraic equations or expressions to solve real-world situations. Mathematical problems are perceived as tasks presented in words with questions posed to define the goals of the solver (Asoma et al., 2022). All students require both mathematics and real-life contexts to solve algebraic problems.

There were two major limitations in the outcomes of the findings. First, some still struggled to cope with context-based problem-solving strategies. They are always used to the mathematics problem-solving. So, in many situations, some students still translated the tasks into mathematics context before redirecting their understanding to real-life scenarios. Again, Polya's four-step problem-solving strategies seem to be too linear and assume that a student who understands step 3 has understood step 2. However, some students exhibited contrary learning behaviours as observed from the transcripts. It was suggested that future researchers could explore more on differential methods of solving algebraic word problems with regards to gender.

CONCLUSIONS

The findings several key points emerge for mathematics teachers to consider when teaching algebraic expressions. First, students often lack a deep conceptual understanding of algebraic expressions, making it crucial for teachers to thoroughly explain the concepts behind algebraic word problems, rather than just teaching the procedures for simplifying expressions. Second, no significant difference exists between the abilities of male and female students in solving algebraic word problems. Therefore, efforts should be made to address the gender barriers in utilizing and applying algebraic word problems. This includes incorporating more real-life context word problems into Ghanaian mathematics textbooks and exams. Third, students face challenges in relating mathematics to real-life contexts. Instructional strategies such as using diverse representations, explicit instruction, technology, and teaching metacognition can help students overcome these challenges. Teachers are recommended to use more real-life situations and contexts in their teaching to increase student interest across both genders. Additionally, teachers need to provide more guidance on approaching and solving real-world problems. Finally, stakeholders should focus on enhancing resources for effective pre-service and in-service training programs, creating teacher collectives for idea sharing and pedagogical discussion, and ensuring adequate teaching resources are available.

AUTHOR CONTRIBUTIONS STATEMENT

JB conceived the research problem, wrote the background and statement of the problem, and analysed the data. CAA helped to review the literature, conceived the methods, and made the conclusions

REFERENCES

Adu, E., Mereku, D., Assuah, C., & Okpoti, C. (2017). Effect of multimedia courseware with cooperative learning on senior high school students' proficiency in solving linear equation word problems. *African Journal of Educational Studies in Mathematics and Sciences*, *13*, 1-11.

Agwagah, U. N. V. (2017). Improving the teaching of mathematics language on errors committed by senior secondary school students in bearing problems in Omuo-Ekiti, Nigeria. Abacus. *The Journal of the Mathematical Association of Nigeria*, *38*(1), 50-56.

Akpalu, R., Adaboh, S., & Boateng, S. S. (2018). Towards improving senior high school students' conceptual understanding of system of two linear equations. *International Journal of Educational Research Review,* *3*(1), 28-40. https://doi.org/10.24331/ijere.373336

Ali, C. A. & Abatanie, E. P. (2023). *teaching and assessing upper primary mathematics (Intermediate) (JBM351)*. Winneba: College of Distance and e-Learning (in-press).

Ali, C. A. & Asemani, E. (2023). *Teaching and assessing junior high school mathematics (Advanced) (JBM361)*. Winneba: College of Distance and e-Learning (in-press).

Ali, C. A. (2021). Ghanaian indigenous conception of real mathematics education in teaching and learning of mathematics. *Indonesia Journal of Science, Technology, Engineering and Mathematics (IJSTEM),* *4*(1), 82-93, https://doi.org/10.24042/ijsme.v4i1.7382

Amidu, B., Salifu, A. S., & Nyarko, S. (2020). The effect of algebra tiles manipulative on preservice teacher's mathematics knowledge in teaching basic algebra. *International Journal of Mathematics and Statistics Studies*, *8*(2),26-39.

Ampadu, E., & Anokye-Poku, D. (2022). Influence of personal, motivational and learning environment factors on students' attitudes toward mathematics. *International Journal of Research in Education and Science*, *8*(2), 378-392. https://doi.org/10.46328/ijres.2666

Ampadu, E., & Danso, A. (2018). Constructivism in mathematics classrooms: Listening to ghanaian teachers' and students' views. *Africa Education Review,* *15*(2), https://doi.org/10.1080/18146627.2017.1340808

Arnawa, I., Yerizon, Y., & Sri, N. (2019). Improvement students' level of proof ability in abstract algebra through the APOS theory approach. *International Journal of Scientific and Technology Research*, *8*(7), 128-131.

Assadi, N., & Hibi, W. (2022). The impact of using real life situations in solving linear equations by seventh graders. *Journal of Educational and Social Research*, *12*(1), 51. https://doi.org/10.36941/jesr-2022-0006

Asiedu, P. (2017). *Mathematics for junior high schools (Form 1, 2, and 3)*. Accra: AKI-OLA Publications.

Asoma, C., Ali, C. A., Adzifome, N. S., & Appiah-Kubi, E. (2022). Mathematics teachers' problem-solving knowledge, practices and engagement among public junior high schools in Berekum West, Ghana. *East African Journal of Education and Social Sciences (EAJESS)*, *3*(1), 29-37. https://doi.org/10.46606/eajess2022v03i01.0143

Bal, A. P., & Or, M. B. (2023). Investigation of the relationship between problem-solving achievement and perceptions of students. *Pedagogical Research*, *8*(1), em0151. https://doi.org/10.29333/pr/12745.

Borgonovi, F., Han, S. W., & Greiff, S. (2023). Gender differences in collaborative problem-solving skills in a cross-country perspective. *Journal of Educational Psychology*, *115*(5), 747-766. https://doi.org/10.1037/edu0000788

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approache*. Sage publications.

Das, P. N. (2019). *Students' difficulties in solving algebraic word problems at secondary Level*, Doctoral of Philosophy Dissertation, Department of Mathematics Education.

Hidayati, Y., Rosidi, I., & Hadi, W. P. (2019). The identification problem-solving abilities based on gender: implementation teaching science through guided discovery model's in Bangkalan District. IOP Conf. Series: *Journal of Physics Conference Series1227 (2019)*, 012039. https://doi.org/10.1088/1742-6596/1227/1/012039

Huang, M. C. L., Chou, C. Y., Wu, Y. T., Shih, J. L., Yeh, C. Y., Lao, A. C., ... & Chan, T. W. (2020). Interest-driven video creation for learning mathematics. *Journal of Computers in Education*, *7*, 395-433. https://doi.org/10.1007/s40692-020-00161-w

Ihudiebube-Splendor, C. N., & Chikeme, P. C. (2020). *A descriptive cross-sectional study: Practical and feasible design in investigating health care–seeking behaviors of undergraduates*. SAGE. https://doi.org/10.4135/9781529742862

Julius, E., Abdullah, A. H., & Suhairom, N. (2018). Attitude of students towards solving problems in algebra: A review of Nigeria secondary schools. *IOSR Journal of Research & Method in Education*, *8*(1), 26-31.

Khanal, N. (2018). *Difficulties in solving word problems in algebra.* An Unpublished Master's Degree Thesis, T.U. Kathmandu.

Kusumaningsih, W., Darhim, Herman, T., & Turmudi. (2018). Gender differences in algebraic thinking ability to solve mathematics problems. *Journal of Physics: Conference Series, 1013(1), 01214.. IOP Publishing*. https://doi.org/10.1088/1742-6596/1013/1/012143

Lin, Y.-T., Wu, C.-C., Chen, Z.-H., & Ku, P.-Y. (2020). How gender pairings affect collaborative problem-solving in social-learning context: The effects on performance, behaviors, and attitudes. *Educational Technology & Society*, *23* (4), 30–44.

Marpa, E. P. (2019). Common errors in algebraic expressions: A quantitative-qualitative analysis. *International Journal on Social and Education Sciences*, *1*(2), 63-72. https://doi.org/10.46328/ijonses.11

Ministry of Education (2020). *New curriculum for basic schools in Ghana.* Accra: National Council for Curriculum and Assessment (NaCCA).

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 international results in mathematics and science*. Retrieved from Boston College, TIMSS & PIRLS International Study Center.

Nashiru, A., Alhassan, I. N., & Sadiq, Z. A. (2018). Translate word problems into algebraic expressions: the case study of George Polya's problem-solving model. *ADRRI Journal of Physical and Natural Sciences*, *2*(2), 1-25.

Parrot, M. A. S., & Leong, K. E. (2018). Impact of using graphing calculator in problem-solving. *International Electronic Journal of Mathematics Education*, *13*(3), 139-148. https://doi.org/10.12973/iejme/2704

Pratiwi, S. A. & Widjajanti, D. B. (2020). Contextual problem in mathematical problem solving: core ability in Realistic Mathematics Education. *Journal of Physics Conference Series 1613*, 01201. https://doi.org/10.1088/1742-6596/1613/1/012018

Polya, G. (1945). *How to solve it.* USA: Princeton University Press. https://doi.org/10.1515/9781400828678

Ralston, N. C., Li, M., & Taylor, C. (2018). The development and initial validation of an assessment of algebraic thinking for students in the elementary grades. *Educational Assessment*, *23*(3), 1–17. https://doi.org/10.1080/10627197.2018.1483191

Saleh, S., & Rahman, M. A. A. (2016). A study of students' achievement in algebra: Considering the effect of gender and types of schools. *European Journal of STEM Education*, *1*(1), 19-26. https://doi.org/10.20897/lectito.201603

Schoenfeld, A. H. (2016). Why are word problems so darned hard? *University of California Berkeley, CA, USA.*

Sibgatullin, I. R., Korzhuev, A. V., Khairullina, E. R., Sadykova, A. R., Baturina, R. V., & Chauzova, V. (2022). A systematic review on algebraic thinking in education. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(1), 123-134. https://doi.org/10.29333/ejmste/11486

Son, A.L., Darhim, & Fatimah, S. (2020). Students' mathematical problem-solving ability based on teaching models intervention and cognitive style. *Journal on Mathematics Education, 11*(2), 209-222. https://doi.org/10.22342/jme.11.2.10744.209-222

Susriyati, M., Siti, Z., Deny, S,. Hidayati, M., & Fahrul, G. M. (2022). Empowering college students' problem-solving skills through RICOSRE. *Educational Sciences*, *12*(3), 196. https://doi.org/10.3390/educsci12030196

Stedman, R. C., Connelly, N. A., Heberlein, T. A., Decker, D. J., & Allred, S. B. (2019). The end of the (research) world as we know it? Understanding and coping with declining response rates to mail surveys. *Society & Natural Resources*, *32*(10),1139-1154. https://doi.org/10.1080/08941920.2019.1587127

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in science education*, *48*, 1273-1296. https://doi.org/10.1007/s11165-016-9602-2

West Africa Examination Council (2019). *Basic education certificate examination, chief examiners report*. Accra: West Africa Examination Council Press.