Journal of Mathematics and Science Teacher
2023, 3(1), em036
e-ISSN: 2752-6054
https://www.mathsciteacher.com/

MODESTUM

Research Article **OPEN ACCESS**

Algebra word problem difficulties: A case study in Tema Education Metropolis in Ghana

Daniel Kofi Aforklenu [1], Hamidu Ibrahim Bukari [2,3]*

[1] Akatsi College of Education, Akatsi, GHANA
[2] Bagabaga College of Education, Tamale, GHANA
[3] University of the Western Cape, Cape Town, SOUTH AFRICA
***Corresponding Author:** ibrahimbukari@gmail.com

Citation: Aforklenu, D. K., & Bukari, H. I. (2023). Algebra word problem difficulties: A case study in Tema Education Metropolis in Ghana. *Journal of Mathematics and Science Teacher, 3*(1), em036. https://doi.org/10.29333/mathsciteacher/13133

ARTICLE INFO

Received: 08 Aug. 2022

Accepted: 25 Mar. 2023

ABSTRACT

Modern mathematics education used a different approach when dealing with word problems in algebra because of how people perceive mathematics. The teacher can aid students in honing their problem-solving abilities to assist them build mathematical concepts that can be applied in real-world situations. This research is a case study involving junior high school (JHS) pupils in Ghana's Tema Metropolis. For the study, data collection and analysis used a qualitative methodology. Using a purposive sample technique, data from 12 participants–six JHS mathematics teachers and six students–were gathered. Data were gathered through observation, interviews, and document analysis. The primary finding is that JHS pupils at Tema Education Metropolis are unable to present their own issues as proof of conceptual knowledge of algebra word problems.

Keywords: students' difficulty, mathematics teachers, algebraic word problem-solving

INTRODUCTION

Algebra is the cornerstone of mathematics, which is the foundation for all economic, scientific, and technical growth in any advanced nation. Mathematics education is highly regarded in countries that are concerned about their progress (Ministry of Education [MoE], 2010). A problem-solving mathematics program promotes the use of mathematics in novel or difficult contexts. It also emphasizes using approaches students will utilize in the real world to teach pupils mathematical concepts. Any arithmetic exercise, where important background information is supplied as text rather than in mathematical notation is referred to as a "word problem" in mathematics education (Boonen et al., 2013; Martinez, 2001). Word issues can vary in the quantity of language used and typically incorporate some form of narrative. For this reason, they are sometimes also called story problems.

The current pre-university problem-solving mathematics curriculum in Ghana mandates the application of mathematics to real-world situations (Baah-Duodu et al., 2019). It specifically advised the use of suitable mathematical critical thinking and problem-solving techniques in mathematics teaching and learning (NaCCA, 2020).

The theoretical foundation of this study is based on Shulman's (1986) knowledge domains in instruction including pedagogical content knowledge (PCK), curricular knowledge (CK), and subject matter content knowledge (SMCK). The term "pedagogical content knowledge" was coined by Schulman (1986) in 1986 and was later defined by Kirschner et al. (2022) to refer to the knowledge teachers acquire about how to teach specific subjects to specific students. Coe (2013) posits that, when a teacher has engaged the students in a lesson does not imply that they are learning. Engagement is frequently a subpar substitute for learning, and the idea that one can enter a classroom and magically detect learning is mistaken. Without any requirement for an independent assessment of what, if anything, has been learned, teachers may persist in the fallacy that what they have taught becomes a surrogate for what the students have learned (Coe, 2013).

Teaching entails bringing out the accumulated knowledge and experiences that students bring to class and working on those ideas and experiences with the students by refining, reorganizing, co-constructing, and repairing these ideas and experiences into meaningful and comprehensible forms for students to assimilate (Atteh & Andam, 2019; Shulman, 2000). It follows that to effectively teach mathematics word problem-solving (WPS), teachers must have a thorough understanding of the mathematical knowledge of WPS, problem-solving pedagogy, and the curriculum materials that define the scope and direction of WPS (Baah-Duodu et al., 2019). More critically, teachers need to be well-versed in all of these subject areas. It is only in an interactive learning environment do students reveal to the teacher their ideas, concepts, preconceptions, and experiences (Atteh & Andam, 2019). The knowledge domains proposed by Shulman (1986) provide a clear framework for instructing mathematics problem-solving and are very relevant for teachers today.

Subject Matter Content Knowledge

SMCK is the amount and organization of all knowledge in a teacher's mind (Atteh & Andam, 2019; Shulman, 1986). They contend that a thorough understanding of facts, concepts, and procedures is not sufficient to assess a teacher's subject-matter expertise. Schwab (1978) asserts that a subject's structural components encompass both its substantive and syntactic components. With the use of syntactic and substantive structures, teachers can carefully examine, justify, compare, and contrast students' approaches to solving word problems to identify and correct any flaws or misunderstandings. In addition, teachers' ability to employ instructional resources, assess students' progress and decide on representations, emphasis, and sequencing all depend on their understanding of the mathematical content they are teaching (Atteh & Andam, 2019; Ball et al. , 2005).

Pedagogical Content Knowledge

In terms of subject knowledge, pedagogical expertise comes in second. Shulman (1986) asserts that PCK transcends the realm of SMCK to encompass the dimension of subject matter knowledge for teaching. It combines the most frequently taught topics, the most helpful ways of representing those ideas, the most potent analogies, and examples, illustrations, explanations, and demonstrations in the art of teaching (Atteh & Andam, 2019).

Additionally, PCK provides strategies for presenting and structuring the subject matter in a way that makes it understandable to students with a range of perspectives and understandings (Nilsson & Lund, 2022) and the teaching of algebra word problems in the curriculum is likely to improve when teachers are ready to harness all available pedagogical strategies of teaching and learning and employ them in the classroom (Atteh & Andam, 2019).

Curricular Knowledge

The whole range of programs created for the teaching of mathematics topics at a specific grade level constitutes the mathematics curriculum. It covers a broad range of educational resources available in connection to the subject matter to be covered as well as the features that direct the utilization of specific curriculum resources under specific conditions (Shulman, 1986). Wardlaw (2008) highlighted the importance of curriculum, pedagogy, and assessment congruence in his presentation at a forum hosted by the National Curriculum Board. It is crucial to emphasize that for effective teaching and learning of WPS in the mathematics classroom, teachers must be fully aware of the alignment for student learning at the fundamental level of education (Foong, 2009) . Teachers should carefully consider students' mathematical concepts, consider textbook explanations, and weigh the relative merits of two different representations when dealing with a specific mathematical problem (Ball & Bass, 2000). The professional teacher is required to be knowledgeable about the curricular elements being studied by their students concurrently in other disciplines.

Conceptions of Problem and Problem-Solving

According to Cooney et al. (1975), a problem is "a question, which provides a difficulty, which cannot be resolved by any conventional technique known to the students" (p. 242). They said that difficulty might also be thought of as a roadblock that stands in the way of a goal. Until the student is driven to get beyond the obstacle and reach the goal, the barrier does not represent a problem. As word problems involve a narrative of some sort, they are occasionally also referred to as story problems and may vary in the amount of language used (Lipton & Zalcstein, 1977). For example, a mathematical problem in mathematics notation, which reads: Solve for J.

J=A-20

J+5=(A+5)/2 might be presented as a text or in a word problem, as follows: John is 20 years younger than Amina. In five years, time, he will be half her age. What is John's age now? (Mathematical Association of Ghana [MAG], 2005).

Three criteria are provided by Krulik and Rudnick (1996) to determine if a situation qualifies as a problem. The first prerequisite is that the person can resolve the problem by achieving a certain goal. Second, there must be barriers in the way of reaching the goal; third, the previous two requirements will push the person to look into ways to get around the barriers. It does not matter if the task at hand is challenging or not, as long as the student views it as such. Here, accepting a challenge entails the student's willingness to identify effective strategies for resolving the issue. However, the process invariably requires a problem solver who is engaged in a mathematical task to organize and deal with domain-specific and domain-general pieces of knowledge (Nortvedt, 2011).

Problem-Solving as Context

Mathematics instruction has been justified by the use of problem-solving. The subject is connected to practical problem-solving situations to convince pupils of the importance of mathematics. Another technique for inspiring students is problem-solving by giving them a contextual (real-world) example of the use of a mathematical concept or procedure. A teacher may use the setting of problem-solving to introduce the idea of fractions, for instance, giving groups of students the task of dividing two pieces of licorice such that each receives an equal share. The teacher aims to accomplish several things by presenting this problem-solving context, including motivating students to learn about fraction concepts through the use of a comfortable and appealing medium, helping to make the concepts more concrete through practice, and providing a justification for learning about algebraic fractions.

Problem-Solving as a Skill

Instead of teaching problem-solving techniques across the curriculum as a way to enhance conceptual knowledge and fundamental abilities, proponents of this viewpoint believe that problem-solving techniques should be taught as a separate topic

(Lester Jr & Cai, 2016). They provide students with practice utilizing these general methods to tackle everyday issues, such as sketching a picture, working backward, or constructing a list. However, when problem-solving is considered as a set of talents, the skills are frequently organized in a hierarchy, with pupils being expected to first acquire the capacity to solve routine problems before attempting non-routine problems. Bukari (2019) claims that the Polya (1945) model of problem-solving skills is still advised for use in today's mathematics classrooms for both teaching and evaluating problem-solving abilities. They are, as follows:

1. Recognizing and unpacking the problem
2. Coming up with a strategy to deal with the problem
3. Carrying out the strategy and
4. Considering the situation critically.

He asserts that although the four steps of problem-solving are presented in a progressive order, it may not be possible to simply follow them to arrive at solving problems.

Problem-Solving as Art

Polya (1945) proposed the notion that problem-solving may be taught as a practical art, similar to playing the piano or swimming, in his classic book *How to solve it*. Polya (1945) defined "modern heuristics" (the art of inquiry and discovery) to refer to the skills required to successfully research new challenges since he considered problem-solving as an act of discovery. He promoted presenting mathematics as an experimental and inductive discipline rather than as a complete body of facts and rules. Teaching children problem-solving as an art is intended to help them become skilled and enthusiastic problem solvers as well as autonomous thinkers who can handle vague, open-ended issues.

Problem-Solving Approaches

Three problem-solving methods are identified in the study literature on problem-solving: teaching *for* problem-solving, teaching *about* problem-solving and teaching *through* problem-solving (Lester Jr, 2013; Li & Lappan, 2014; Siemon & Booker, 1990). Each of these strategies has an impact on the kinds of exercises and teaching methods that might be used with pupils during mathematics lessons. All three methods rely on heuristics and problem-solving techniques. While issue solving is emphasized as an object of inquiry in both teaching for and about it, teaching through problem-solving emphasizes problem-solving as a process of inquiry (Hino, 2007). Though problem-solving-based instruction is thought to be the most effective strategy, it has been claimed that all three approaches have a place in the teaching of mathematics especially in algebra.

Rationale and Research Questions

The rationale of the study is to determine Ghanaian junior high school (JHS) students' and teachers' difficulties in solving algebra word problems and how they practice problem-solving across the content domains described by the mathematics curriculum.

Research Questions

Problem-solving is central to mathematics education in Ghana. Teachers are implementing the problem-solving curriculum and yet many students seem to lack the problem-solving skills to be functional in real-life situations, especially in algebra word problems. The following research questions guided the study:

1. How are teachers' conceptions of algebra WPS in the mathematics curriculum at Tema Education Metropolis in Ghana?
2. How is the teaching of algebra WPS practiced by teachers in the mathematics classroom at Tema Education Metropolis in Ghana?
3. What difficulties do JHS students encounter when solving algebra word problems in the mathematics classroom at Tema Education Metropolis in Ghana?

METHOD

This study is a case study in Tema Education Metropolis of Greater Accra Region of Ghana, this design was utilized to examine WPS strategies employed by JHS mathematics teachers and the challenges that students face while attempting to solve algebra word problems.

The multimethod focus of qualitative research includes an interpretive, naturalistic approach to its subject (Aspers & Corte, 2019). In order to make sense of or interpret occurrences in terms of the meaning's scholars assign to them, qualitative researchers examine phenomena in natural environments.

A case study is an investigation that uses a variety of empirical resources to evaluate a current occurrence or event in its actual context (Silverman, 2013). As a result, the study included both instructors and students from the three sub-metros of Tema Education Metropolis. By including participants in data gathering, this strategy aims to establish trust and rapport with the study's participants (Kornbluh, 2015; Patton, 2014).

Since the study's design mostly relied on a qualitative technique for data collecting and analysis, it was important to poll teachers and students to select for interviews, observations, and workbook analyses that would help us understand the phenomena better.

Research Setting

This study was carried out in Greater Accra Region of Ghana's Tema Education Metropolis, which is made up of the three sub-metros Kpone-Katamanso, Tema East, and Tema West. Schools can be found in both rural and urban areas in these sub-metropolises. A small number of graduate professional and non-professional teachers, as well as three-year post-secondary teaching certificate holders, teach mathematics at JHSs. The majority of the locals in these sub-metros are fishermen and small-scale traders. Most students' parents immigrated to the area as employees of the government or entrepreneurs, students in urban communities come from a variety of socioeconomic backgrounds.

Participants

The participants for the study consisted of JHS mathematics teachers and students in Tema Education Metropolis of Greater Accra Region of Ghana.

Research Tools

A sample is a carefully chosen subset of the population's units. The data collection process employed a purposeful sampling technique. The purposive sampling technique helps the researcher to instantly connect with the participants and employ those participants to gather valuable information for a deeper understanding (Baah-Duodo et al., 2019; Creswell, 2009). There are no guidelines for choosing sample size for a qualitative study, according to Patton (2014). In a qualitative study, sample size "depends on what the researcher wants to know, what is at stake, the research's aim, what would be beneficial, what will have credibility, and what can be done with the resources available" (p. 244). The three sub-metros of Kpone-Katamanso, Tema East, and Tema West were considered for the study after Patton's (2014) remarks. The sub-metros were selected based on three factors:

(1) familiarity with the area's geography,

(2) diversity, as the sub-metros have both underprivileged and wealthy JHS, and

(3) ease of access to the schools.

Due to the use of interview, observation, and document analysis (students' exercise books) as study tools, the researcher purposefully recruited 12 participants from three sub-metros, including six teachers and six students.

Data Sources and Analysis

It is necessary to gather a range of data using three study instruments in order to have a thorough understanding of WPS strategies used by JHS mathematics teachers and the challenges that students face while attempting to solve word problems in algebra. In particular, the study made use of interviews, observations, and document analysis. These instruments were employed to make-up for one instrument's shortcomings.

Trustworthiness of Instruments

In qualitative research, credibility is used to demonstrate that the findings are "worth paying attention to" (Guba & Lincoln, 1994). Any qualitative research endeavor must address four challenges of reliability. Credibility, transferability, dependability, and confirmability are some of these problems. Transcripts of the interviews were handed back to the interviewees so they could confirm that what was written down accurately reflected their answers, establishing the legitimacy of the research findings. They might remark on whether they thought the data were used in a way that was consistent with their own experiences. Getting participant comment on results improves credibility. To prove transferability and support claims made by specific participants, researchers employed detailed explanations to shed light on the circumstances. We went into great detail on the protocols we followed before, during, and after data collecting for our research. Researchers in mathematics education with competence in qualitative research examined the study's data analysis and research procedures documentation (Guba & Lincoln, 1994). Guba and Lincoln (1994), who are quoted in Shenton (2004), emphasize the connections between dependability and credibility, contending that in practice, proving the former helps to guarantee the latter.

Official letters were written by the researchers to get in touch with the headmasters and mistresses of the schools taking part in the study and request their consent. Prior to completing the interviews, observations, and document analysis, participant consent was obtained. we were quite open about the study's objectives and made it apparent that it was simply academic research. Also, we provided participants with guarantees of anonymity and confidentiality regarding the data we obtained.

RESULTS AND DISCUSSIONS

Interview Results

Six JHS mathematics teachers from Tema Education Metropolis' three sub-metros were interviewed. In each sub-metro, two teachers were interviewed from each of two schools. Each of the two schools had one teacher who was interviewed. The purpose of the interview was to provide the researcher with a thorough grasp of the study. The six teachers were chosen based on their attendance records at the school and their expressed concern when the researcher approached them about the inclusion of algebra word problems or word problem solutions in the mathematics curriculum. The abbreviation T followed by a number in the presentation is the code for the teacher interviewee; for example, T1 and T3 mean first and third teacher interviewees, respectively, as labelled in the transcription report. The abbreviation S is the code for the student interviewee; for example, S1 and S2 mean first and second student interviewees, respectively.

How are teachers' conceptions of algebra word problem-solving in the mathematics curriculum at Tema Education Metropolis in Ghana?

Mathematics curriculum is implemented by teachers. Teacher's understanding of algebra WPS will determine if it is practiced or included in the mathematics curriculum. Six JHS mathematics teachers were questioned about word problems and WPS to have a deeper knowledge of the research. A sample of the response is shown below:

Q: In your own opinion what do you think algebra WPS is all about?

In responding to the question T3 said:

> "Mathematics WPS has to do with the effort that one makes to solve or find a solution to a problem that has been posed in a sentence form or case study form that might not have one way of solving."

How is the teaching of algebra word problem-solving practiced by teachers in the mathematics classroom at Tema Education Metropolis in Ghana?

The researchers questioned the mathematics teachers about the instructional methods they frequently employed when teaching word problem solutions in the classroom.

Q: Mention some of the strategies you often use in teaching your algebra WPS lessons? A sample of the response common to them was what T1 said.

In responding to the question, T1 states:

> "Teaching starts from known to unknown, so I normally start my WPS lessons from the child's environment. I sometimes use a story or puzzle telling and make a table or chart, draw a diagram to simplify the problem, make a model, look for a pattern, and backwards. Sometimes, I use equation or a formula, use guess and check."

Researchers asked to understand how T1 uses the strategies in teaching and the response T1 gave was:

> "I lead students through the strategies, work examples with them using the strategies in real life context and then give them problems that need the application of the strategies."

T2 in responding to the question, states:

> "Strategies vary based on topics. Sometimes I lead students to draw diagrams to bring out the concept in the problem. I also make tables to simplify problems and use trial and improvement to solve problems."

Teachers adopt different strategies to achieve curriculum objectives as captured in the responses they gave to the interview question. The excerpts of the responses of TI, T2, T3, and T5 indicate that JHS mathematics teachers use problem-solving strategies such as recognising and unpacking the problem, coming up with a strategy to deal with the problem, carrying out the strategy, and considering the situation critically. Based on the teachers' responses, one can conclude that there is no definite WPS strategies that teachers ought to use to achieve mathematics curriculum objectives (Rosales et al., 2012).

What difficulties do junior high school students encounter when solving algebra word problems in the mathematics classroom at Tema Education Metropolis in Ghana?

The researcher in trying to understand the difficulties JHS students' encounter when solving mathematics algebra word problems in the classroom, asked the following question:

Q: What are the difficulties students' encounter when solving algebra word problems?

In responding to the question, T1, T2 and T5 said:

> T1: "The main source of students' difficulties in solving mathematical word problems is an inability to understand the problem. Students have difficulties in comprehending what a question required, do not pay much attention to strategies involved in answering questions and do not read the terms used in problems very closely."

> T2: "Students' weakness in solving word problems is that they make avoidable preliminary mistakes. Students' carelessness, as well as inabilities to understand what they read, to plan and choose suitable mathematical operations, is among the factors that prevent them from solving word problems correctly."

T5 in responding to the question said:

> T5: "Learners' difficulties in solving algebra word problems are due to their inability to read and comprehend the language of text."

The excerpts of the responses of T1, T2, and T5 indicated that reading and understanding/comprehension of the language of the problems posed are the main challenges that students encounter when solving algebraic word problems.

Table 1. Instructional practices used by junior high school mathematics teachers in the classroom

Instructional practices	T1	T2	T3	T4	T5	T6
Explain in detail what students have to do to solve problems	√	√	√	√	√	√
Set application problems that allow students to practice the skills they have just learned	√	√	√	√	√	√
Provide concrete materials for students	×	×	√	×	√	×
Discuss useful problem-solving strategies	√	√	√	√	√	√
Encourage students to use variety approaches to solve problems	√	×	×	√	√	×
Pose open-ended problems that require open investigations	×	×	×	×	×	×
Give opportunities for students to explore solutions by their ways before being shown by teacher	√	√	√	√	√	√
Serve as a facilitator, a guide by allowing students to construct their own knowledge during problem-solving lesson	×	×	×	×	×	×
Help students to model word problems into equations or diagrams	√	√	√	√	×	√
Encourage students-centered instruction	√	√	√	√	√	√
Use problems that arise from school context, or which relate to students' past experiences	×	√	×	×	√	×
Allow students to work in cooperative groups	√	×	×	√	√	×
Ask students to present their solutions to the whole class on chalkboard	√	×	×	√	√	×
Explain the key elements in a problem to students	√	√	√	√	√	√
Encourage students to pose their own problems	×	×	×	×	×	×

Note. √: Practice performed; ×: Practice not performed during teaching; T1: First teacher observed; T2: Second teacher observed; etc.

Results of Observations

This study required observation since it was important to see and comprehend how math teachers instruct algebra WPS in a genuine classroom setting. The six JHS mathematics teachers who were interviewed also had their algebra lessons monitored. Two teachers had post-observation interviews conducted as well. The goal of the observation was to observe how JHS teachers used algebra word problems in their lessons on mathematics. The purpose of the post-observation interview was to ascertain why teachers did not put specific instructional strategies into effect during their WPS lessons. Every teacher had 70 minutes of observation time.

An observation checklist with 15 classroom teaching methods served as the basis for the observation. The researchers watched and checked off any problem-solving techniques used by the teacher during the delivery of the lesson. **Table 1** displays the matrix of instructional strategies that teachers employ. In WPS lessons, all six teachers provided detailed explanations of what students must do to solve issues, as seen in (**Table 1**). They talk about techniques for solving issues like comprehending them, formulating a plan of action, putting it into action, and assessing the results. It was noted that all six teachers (**Table 1**) provide opportunities for students to explore solutions in their own ways prior to being shown by the teacher. Problem-solving heuristics that were frequently observed include making a table, drawing diagrams, guessing and checking, trial and improvement, etc. Additionally, they emphasized student-centered instruction and clarified crucial components of difficulties for students (**Table 1**). Only two teachers were seen employing issues that come from the school setting or that relate to students' prior experiences, while all six teachers presented application problems that allowed students to apply skills and concepts they had just learned (**Table 1**).

During lesson observation, three crucial instructional strategies were completely overlooked. Posing open-ended questions that demand in-depth research, letting students build their own knowledge during WPS courses while teachers act as facilitators and mentors, and encouraging students to come up with their own challenges were some of these techniques (**Table 1**). The researchers then asked two of the teachers they had witnessed why these instructional strategies were not being used, and they responded, as follows:

> T5: "It is a fact, yes that open-ended problems lead to open investigations and multiple solutions, which are not that easy to find the right answers to. This makes it takes a lot of time and difficult to prepare lessons since you have to make provisions for most of the possible solutions that students may produce consistent with (Baah-Duodo et al., 2019)."

> T3: "Majority of students lack vocabulary to enable them to construct their own problems. Now on the issue of allowing students to explore problems, I will say the syllabus is too loaded and this practice will waste time leading to the incompletion of the syllabus in consonance (Baah-Duodo et al., 2019)."

According to the answers given, some of the reasons why the teachers observed did not engage in those techniques included teachers' weak pedagogical subject knowledge of algebra WPS, students' poor aptitude, and a lack of curricular materials.

Table 1 shows that five of the teachers were helping their pupils model algebra word problems into equations or diagrams, particularly challenges like the "choose a number" game in algebraic expressions and word problems involving ages in linear equations. Four of the teachers were observed using concrete materials that students could manipulate during sessions, so this practice was not neglected (**Table 1**). Three teachers were observed urging students to share their methods for answering with their peers in small groups and to write their responses or solutions on the chalkboard for a discussion with the class as a whole. The six teachers observed in this study practiced such problem-solving approaches as teaching *for* problem-solving and teaching *about* problem-solving (Siemon & Booker, 1990; Xenofontos & Andrews, 2012). However, the approach of teaching *through* problem-solving was less practiced by the teachers. Meanwhile, teaching through problem-solving starts with a problem, by teachers posing problems to challenge students' knowledge thus providing a need for the students to organize their understanding in order to resolve the problem. In this approach too, the teacher's role is transformed from knowledge transmitter to a guide and a facilitator.

Table 2. Summary of class works/exercises on WPS

Serial number	Number of class work/exercises	Number of class work/exercises on WPS	Number of corrections on class work/exercises	Number of corrections on WPS class exercises
TKE×Bk I	21	0	4	0
TKE×Bk II	43	1	11	1
TEE×Bk III	33	1	6	0
TEE×Bk IV	44	3	6	2
TWE×Bk V	63	4	30	2
TWE×Bk VI	62	3	11	1
Total	266	12	68	6

Results of Junior High School Students' Class Works/Exercises on Algebra Word Problem-Solving

The analysis of the students' class notes and exercise books was done to help the researchers determine whether or not JHS students practice algebra WPS in the mathematics classroom and how frequently they do so in the schools, as recommended by the mathematics curriculum. We looked at the classwork and activity books of six students, two from each of the two Tema Education Metropolis sub-metros (including the three interviewed students). Students will be able to accomplish the curriculum's intended goals with the help of WPS practice. They will acquire the abilities, principles, and knowledge required to deal with problems, issues, and circumstances encountered in daily life. Thus, information was gathered based on pre-established criteria to classify class projects and exercises on WPS for the three terms in each of the six schools under investigation. **Table 2** displays the outcomes from the textbooks used for classwork and exercises.

Table 2 shows that no class work or exercises were completed on WPS out of the 21 class activities that were examined. In a similar vein, one class work/exercise out of 43 that were reviewed was completed using WPS. This further suggests from **Table 2** that just one class work/exercise was completed on WPS out of a total of 64 class work/exercises checked in the TK sub-metro (TKE×BkI & TKE×BkII). **Table 2** showed once more that one of the 33 class assignments/exercises verified was on the done WPS list. In a similar vein, three of the 44 class assignments and exercises that were reviewed were completed using WPS. This indicates that just four of the 77 class assignments and exercises checked in TE sub-metro (TEE×BkIII & TEE×BkIV) were completed using WPS (**Table 2**). **Table 2** further revealed that out of 63 class works/exercises that were analyzed, four were done on WPS, and out of 62 class works that were analyzed, three were done on WPS. **Table 2** showed that only seven of the 125 class assignments and exercises checked in TW sub-metro (TWE×BkV & TWE×BkVI) were completed using WPS (**Table 2**).

Table 2's findings show that just 12 of the 266 class assignments/exercises that were checked or 4.5% were on WPS. **Table 2** further showed that just one of the 15 corrections made on exercises and classwork in TK sub-metro were on WPS. Similar to this, only two of the 12 changes made on exercises or classwork in TE sub-metro were on WPS. **Table 2** further shows that only three modifications were made to WPS out of the 41 corrections made to assignments and exercises in TW sub-metro. **Table 2**'s findings show that just six of 68 corrections made to exercises and classwork or 8.8% of all corrections were made to WPS. A lot of emphasis should be placed on WPS in public exams and standardized assessments in order to motivate teachers to teach WPS and its principles. This will assist in avoiding circumstance shown in **Table 2** so that pupils will meet the anticipated mathematics levels.

DISCUSSIONS

The findings revealed that teachers' conceptions of WPS especially in algebra were seen from three different perspectives, including embracing a challenging mathematical problem and putting much effort into solving it; solving challenging mathematics story problems that involve real-world scenarios and coming up with solutions for any mathematics problem, where significant background information is presented as text rather than in mathematical notation and does not have an immediate method of solving it. In the classroom, teachers' choices are implicitly influenced by their conceptions. How teachers conceptualize a subject in the curriculum has a significant impact on what they teach in class, how they teach it using specific teaching resource materials, and why they use a particular technique, and this finding is in consonance with (Atteh & Andam, 2019). In this study, teachers responded that on WPS one has to figure out a solution to any mathematics activity when significant background material is supplied as text rather than in mathematical notation and there is not an obvious way to solve it. This result agrees with (Boonen et al., 2013; Martinez, 2001) theory of word problem solution. Also, teachers use various problem-solving heuristics such as drawing a diagram, producing a model and looking for a pattern, which was in consonance (Li & Lapan, 2014). With this idea in mind, teachers hold the opinion that there is no direct algorithm for solving algebra word problems that may be used also consistent with (Rosale et al., 2012).

For the purposes of this discussion, pupils' difficulties were divided into three main categories. They include the teachers' poor subject-matter expertise in problem-solving, their poor pedagogical expertise in teaching mathematics WPS, and their poor understanding of the course contents. These results were consistent with the knowledge domains for effective instruction proposed by Shulman (1986). Insufficient problem-solving exercises in mathematics textbooks have been mentioned by (Ali et al., 2010; Anderson et al., 2004) as obstacles to teaching mathematics WPS.

In this study, it was shown that one difficulty in teaching mathematics algebra word problems to students was their language incapacity. This was consistent with earlier research (Adesoji, 2008; Fletcher & Santoli, 2003). For students to learn how to solve algebra word problems, they must be able to read and comprehend language. Students are less able to investigate the process of solving a problem when they lack the terminology to interpret a mathematical problem.

CONCLUSIONS

Teachers' conceptions either direct or impact the way they teach in the classroom. Teachers approached algebra WPS differently because of how they conceptualize the task. The ability to accept a challenging mathematical problem and putting much effort into solving it; solving difficult mathematics story problems that involve real-world scenarios and coming up with solutions for any mathematics problem that contains enough background information but no clear pathway of tackling the problem are the ideal stages outlined in this study. The major finding is the inability of students at JHSs at Tema Education Metropolis to pose their own problems as evidence of conceptual understanding algebra word problems.

Recommendations

The study identified in a broader perspective the challenges of teaching mathematics WPS including teachers' inadequate SMCK, inadequate PCK, and inadequate knowledge of curricular materials. Based on the findings, we recommend:

1. The pupils at JHSs should be given opportunities to practice more investigative problems in mathematics using appropriate models to solve them.
2. Colleges of education now train mathematics majors to teach in JHSs instead of generalist teachers who sometimes may lack content and PCK for teaching mathematics.
3. Ghana Education Service through heads of JHSs in Tema Metropolis should enforce this policy of using trained mathematics professionals and avoid the use of non-specialist professionals to teach mathematics at JHSs.

Suggestions for Further Research

Future studies, according to the researchers, should look at how JHS mathematics teachers' attitudes and beliefs on algebra WPS and their instructional strategies relate to one another.

Author contributions: All authors have sufficiently contributed to the study and agreed with the results and conclusions.

Funding: No funding source is reported for this study.

Ethical statement: Metropolitan Director of Education was consulted for approval before using junior high schools mathematics teachers and students as research subjects.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

Adesoji, F. A. (2008). Students' ability levels and effectiveness of problem-solving instructional strategy. *Journal of Social Sciences, 17*(1), 5-8. https://doi.org/10.1080/09718923.2008.11892628

Ali, R., Hukamdad, D., Akhter, A., & Khan, A. (2010). Effect of using problem solving method in teaching mathematics on the achievement of mathematics students. *Asian Social Science, 6*(2), 67-72. https://doi.org/10.5539/ass.v6n2p67

Anderson, J., Sullivan, P., & White, P. (2004). The influence of perceived constraints on teachers' problem-solving beliefs and practices. In *Proceedings of the 27th Annual Conference of the Mathematics Education Research Group of Australasia* (pp. 39-46).

Aspers, P., & Corte, U. (2019). What is qualitative in qualitative research. *Qualitative Sociology, 42*(2), 139-160. https://doi.org/10.1007/s11133-019-9413-7

Atteh, E., & Andam, E. A. (2019). Model for mathematics teachers development. *Journal of Scientific Research and Reports, 22*(4), 1-8. https://doi.org/10.9734/jsrr/2019/v22i430096

Baah-Duodu, S. , Ennin, F. C., Borbye, S., & Amoaddai, S. (2019). Pre-service primary school teachers' mathematical knowledge for teaching fractions through problem solving. *International Journal of Advances in Scientific Research and Engineering, 5*(3), 08-17. https://doi.org/10.31695/ijasre.2019.33085

Ball, D. L, Hill, H. C., & Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade, and how can we decide? *American Educator, 29*(1), 14-17, 20-22, 43-46.

Ball, D. L., & Bass, H. (2000). Interweaving content and pedagogy in teaching and learning to teach: Knowing and using mathematics. In J. Boaler (Ed.), *Multiple perspectives on mathematics teaching and learning* (pp. 83-104). Ablex Publishing.

Boonen, A. J. H., van der Schoot, M., van Wesel, F., de Vries, M. H., & Jolles, J. (2013). What underlies successful word problem solving? A path analysis in sixth grade students. *Contemporary Educational Psychology, 38*(3), 271-279. https://doi.org/10.1016/j.cedpsych.2013.05.001

Bukari, H. I. (2019). Using problem-based learning to enhance junior high school students' understanding and attitude towards linear equations word problems. *Journal of Education and Practice, 10*(3), 126-135. https://doi.org/10.7176/jep/10-3-14

Coe, R. (2013). *Improving education: A triumph of hope over experience*. Center for Evaluation and Monitoring.

Cooney, T. J., Davis, E. J., & Henderson, K. B. (1975). *Dynamics of teaching secondary mathematics*. Houghton Milfflin Company.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative and mixed method approaches* (2nd edn.) Sage Publication Inc.

Fletcher, M., & Santoli, S. (2003). *Reading to learn concepts in mathematics: An action research project*. https://files.eric.ed.gov/fulltext/ED482001.pdf

Foong, P. Y. (2009). *Review of research on mathematical problem solving in Singapore*. *Mathematics Education*, 263-300. https://doi.org/10.1142/9789812833761_0012

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. Denzin, & Y. S. Lincoln (Eds.), Handbook of qualitative research (pp. 105-117). SAGE.

Hino, K. (2007). Toward the problem-centered classroom: Trends in mathematical problem solving in Japan. *ZDM-International Journal on Mathematics Education, 39*(5-6), 503-514. https://doi.org/10.1007/s11858-007-0052-1

Kirschner, P. A., Hendrick, C., & Jim, H. (2022). *How teaching happens: Seminal works in teaching and teacher effectiveness and what they mean in practice*. Routledge. https://doi.org/10.4324/9781003228165

Kornbluh, M. (2015). Combatting challenges to establishing trustworthiness in qualitative research. *Qualitative Research in Psychology, 12*(4), 397-414. https://doi.org/10.1080/14780887.2015.1021941

Krulik, S., & Rudnick, J. A. (1996). *Teaching reasoning and problem solving in junior and senior high school.* Allyn and Bacon.

Lester Jr, F. K. (2013). Thoughts about research on mathematical problem-solving instruction. *The Mathematics Enthusiast, 10*(1), 12. https://doi.org/10.54870/1551-3440.1267

Lester Jr, F. K., & Cai, J. (2016). Posing and solving mathematical problems. In P. Felmer, E. Pehkonen, & J. Kilpatrick (Eds.), *Posing and solving mathematical problems: Advances and new perspectives* (pp. 117-135). Springer. https://doi.org/10.1007/978-3-319-28023-3_8

Li, Y., & Lappan, G. (2014). *Mathematics curriculum in school education: Advancing research and practice from an international perspective*. Springer. https://doi.org/10.1007/978-94-007-7560-2_1

Lipton, R. J., & Zalcstein, Y. (1977). Word problems solvable in logspace. *Journal of the ACM, 24*(3), 522-526. https://doi.org/10.1145/322017.322031

MAG. (2005). *Mathematics for junior secondary schools (MJSS) books 1 & 2*. Pearson.

Martinez, J. G. R. (2001). Thinking and writing mathematically: Achilles and the tortoise as an algebraic word problem. *The Mathematics Teacher, 94*(4), 248-252. https://doi.org/10.5951/mt.94.4.0248

MoE. (2010). Junior high school mathematics syllabus. *Curriculum Research and Development Division, Ministry of Education, Ghana*.

NaCCA. (2020). Republic of Ghana mathematics curriculum for basic 7-10 (common core program). *NaCCA*. https://curriculum.nacca.gov.gh/wp-content/uploads/2020/02/MATHEMATICS-CCP-CURRICULUM-B7-B10-DRAFT-ZERO.pdf

Nilsson, P., & Lund, J. (2022). Design for learning-involving teachers in digital didactic design (D3). *Interactive Technology and Smart Education, 20*(1), 142-159. https://doi.org/10.1108/ITSE-08-2021-0143

Nortvedt, G. A. (2011). Coping strategies applied to comprehend multistep arithmetic word problems by students with above-average numeracy skills and below-average reading skills. *Journal of Mathematical Behavior, 30*(3), 255-269. https://doi.org/10.1016/j.jmathb.2011.04.003

Patton, M. Q. (2014). *Qualitative research & evaluation methods: Integrating theory and practice*. SAGE.

Polya, G. (1945). *How to solve it: A new aspect of mathematical method*. Princeton University Press. https://doi.org/10.1515/9781400828678

Rosales, J., Vicente, S., Chamoso, J. M., Muñez, D., & Orrantia, J. (2012). Teacher-student interaction in joint word problem solving. The role of situational and mathematical knowledge in mainstream classrooms. *Teaching and Teacher Education, 28*(8), 1185-1195. https://doi.org/10.1016/j.tate.2012.07.007

Schwab, J. J. (1978). *Science, curriculum and liberal education*. University of Chicago Press.

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information, 22*(2), 63-75. https://doi.org/10.3233/EFI-2004-22201

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14. https://doi.org/10.3102/0013189X015002004

Shulman, L. S. (2000). Teacher development: Roles of domain expertise and pedagogical knowledge. *Journal of Applied Developmental Psychology, 21*(1), 129-135. https://doi.org/10.1016/S0193-3973(99)00057-X

Siemon, D., & Brooker, G. (1990). Teaching and learning *for, about* and *through* problem solving. *Vinculum, 27*(2), 4-12.

Silverman, D. (2013). What counts as qualitative research? Some cautionary comments. *Qualitative Sociology Review, 9*(2), 48-55. https://doi.org/10.18778/1733-8077.09.2.05

Wardlaw, C. (2008). *Presentation to the National Curriculum.* Forum held in Melbourne.

Xenofontos, C., & Andrews, P. (2012). Prospective teachers' beliefs about problem-solving: Cypriot and English cultural constructions. *Research in Mathematics Education, 14*(1), 69-85. https://doi.org/10.1080/14794802.2012.657439