



Analysis of Problem-Solving Ability of Senior School Students in Mathematics Word Problems

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ABSTRACT

This is a qualitative research which aims to describe and analyze students' ability in word problem solving based on Polya's steps. The problem-solving abilities of the students were analyzed based on gender. To support this research, descriptive analysis is used on 35 senior school students. The instrument for data collection is Mathematics Word Problem Test (MWPT) consisting of four items. The items were selected to evaluate students understanding and ability to inter-relate between mathematical concepts (the use of formula and properties of plane shapes), and formation of equations/equation involving fractions (to find the unknown). The results show that, senior school students have difficulty making connections between mathematical concepts, have difficulty solving mathematical problems involving fractions and difficulty determining the mathematical formula/concepts to use. The findings also revealed difficulty making connections between mathematical concepts, transformation difficulty and reviewing the correctness of answers with questions. The study therefore recommended that a realistic mathematical problem-based approach, and other approaches that provide students with opportunities to solve mathematical problem should be adopted in learning word problems.

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INTRODUCTION

The daily activities of man require the knowledge of mathematics; and mathematics learning is all about problem solving. In another word, problem solving is an integral component of mathematics and the foundation of many mathematical activities (Nurkaeti, 2018; Reys, Lindquist, Lambdin, Smith & Suydam, 2004). That is why Jitendra and Edward (2010) acceded that solving word problems in particular, require the knowledge of mathematics and the language of instruction, which learners need to acquire and apply. Since there is no dividing line between mathematics learning and problems solving; consequently, the understanding of mathematics concepts is better enhanced with students' problem-solving skills well developed (Dayal & Subhas, 2016; Ladele, 2013; Alio & Harbor-Peter, 2000).

Word problems are important components of mathematics education. The concept of word problem is regarded as a vital part in mathematics curriculum as it enhances students' mental skill, develop logical analysis and boost creative thinking (Nurkaeti, 2018; Knapp, 2007; Gray, 2018). It is also used to determine students' ability to depict information and their mathematical analytical skills to solve problems (Dayal & Subhas, 2016). Akinsola (2008) and Karue and Amukowa (2013) in their separate studies reiterate that word problem gives students the chance to solidify and extend their knowledge to stimulate new learning. Furthermore, word problems train students' and test their understanding of the underlying concept within a descriptive problem and their capability to perform algebraic manipulation or other mathematical skill. However, solving word problems in particular, require the knowledge of mathematics which

learners need to acquire and apply (Jitendra & Edward 2010; Omolola, 2013; Percy & Andrew, 2014). According to Polya (in Willson, Fernandez & Hadaway, 1993), mathematical problem solving is a process that involved several dynamic activities such as: understanding the problem, making a plan, carrying out the plan and looking back. Similarly, Mayer (2003) divided mathematical problem solving into four cognitive phases: translating, integrating, planning and execution. However, both of them regarded representing the problem successfully as the basis for understanding the problem and making a plan to solve the problem. Perla-Nesher (1975), examined word problems at three levels based on verbal formulation, underlying mathematical relation and symbolic mathematical expression in which the problem solver needs to understand the problem in term of language usage, variable used (known and unknown), and finally come out with expression using symbols. Therefore, mathematics word problems and problem solving are interwoven with both concepts aimed at developing learner's ability and skill of solving problems

In spite the place of word problem in mathematics learning, student's achievement in mathematics word related problems is not encouraging. For instance, West African Examination Council (WAEC) Chief Examiner's Report (2015-2018) item analysis of candidates' performance who sat for the West African Senior School Certificate Examination (WASSCE) revealed various degrees of problem-solving difficulties especially in mathematics word problems. Some of the difficulties reported include: difficulty in understanding mathematics word problems, poor skill of transforming and computation, and poor comprehension of mathematical concepts; others are challenges in transforming word problem questions into mathematical expressions and equations. The reports showed that difficulty in solving word problem has being a reoccurring problem among and is one of the major causes of poor performance in the Senior School Certificate Examination (SSCE). The dwindling performance in SSCE has been attributed to different factors which include difficulty in solving word problems, poor strategies and method employed by teachers

and learners (WAEC-CER, 2018). Moreover, word problem has wide scope coverage in mathematics curriculum; as a result, problem solving skill is considered as a critical filter for good performance in mathematics. According to Adeize (2011) students' ability to solve mathematics word problem contributes to the overall performance of senior secondary students in standardized examinations. Thus, the need to examine the problem-solving skill of senior secondary school students especially those preparing to for external examinations; previous research focused on students' problem-solving abilities (Kaliky, Nurlaelah & Jupri, 2018; Permata, Kusmayadi and Fitriana, 2018; Willson, Fernandez & Hadaway, 1993; Montague, 2006; Osman, Che Yang, Abu, Ismail, & Jambari, 2018). However, this present study focus on the mathematical word problem-solving skill of senior secondary school II in Borno State Nigeria.

REVIEW OF RELATED LITERATURES

Previous studies revealed that students face different challenges when it comes to solving mathematics word problem questions. For instance, Ramirez, Sales and Tindowen (2019) found that translating worded problems is considered as one of the most difficult tasks of a student, and worse, it becomes a big hindrance in learning mathematics since translation from words into symbols is undeniably is one of the solution processes in solving word problems. Ramirez, et al (2019) aimed at identifying students' difficulties in mathematizing word problems among 2nd year teacher education students. The study administered 20 - item mathematical word problems to determine the difficulties incurred by the students in translating word problems into mathematical expressions. The following difficulties were reported in the study: Lack of Comprehension, Lack of Vocabulary, Incorrect Use of Operation, Interchanging of Values and Carelessness. Moreover, the following are the terms that the respondents misconceived in translating word problems into mathematical expressions: less than, at most, twice of x, together and divides.

Permata, et al (2018) analyzed mathematical problem-solving skills using modified IDEAL (Identify problems, Define the

problem, Explore solution, Act on the strategies, and Look back and Evaluate) problem solving strategy. The research explored, categorized, and analyzed student's problem-solving skills of word problem. The descriptive research includes fifteen senior high school students. The results showed that the indicator identifying the problems are categorized as very poor, indicator defining the problem is categorized as very poor, indicator exploring the solution is categorized as poor, indicator acting on the strategies is categorized as enough and indicator looking back and learning is categorized as very poor.

For Nurkaeti (2018), problem solving is one of the ways to develop higher order thinking skills of learners. As a result, he analyzes the mathematical problem-solving difficulty of elementary school students based on Polya strategy. The research adopts descriptive analysis. The results show that, the difficulty of mathematical problems solving common with elementary school students consist of difficulty in understanding the problem, determining the mathematical formula/concepts to be used, making connections between mathematical concepts, and reviewing the correctness of answers with questions. This was because the problem presented is in a story form, which is rarely studied by the students. Students usually solve mathematical problems in a form of routine questions, which only require answers in a form of algorithmic calculations.

Furthermore, Fahrudin, Mardiyana, and Pramudya (2018) analyze mathematic problem-solving ability using Polya's steps on trigonometric using self-regulated learning. The subject of the research is two students from each self-regulated learning level (high, middle, low). The finding shows that students with high self-regulated learning can apply the Polya's steps while students with middle self-regulated learning can only apply the problem understanding step. In the step of planning, students write the strategy leading to the correct answer but it has not completed yet. In the implementation step, students do the planned strategy but could not complete doing the calculation and they give improper conclusion at the evaluation step. Meanwhile, the students with low self-regulated learning can understand the problem by writing

down what they know and what is asked but fail to plan to implement the appropriate strategy.

Kaliky, Nurlaelah and Jupri (2018) analyses mathematical problem-solving ability students of junior high school to Polya's model. The research aims to analyze the mathematical problem-solving ability of students on the subject of the triangle. The research used descriptive qualitative method with 35 students in grade 8 at a junior high school. The instrument is a written test consisting of three items of problem solving. Analysis was conducted according to Polya model and the result showed that the problem-solving ability of students in the weak category: inability of students to understand the problem, devise a plan to solve a problem, execute plans, and verification solutions.

In addition, a study conducted by Jim and Georg (1997) on the relationship between gender and mathematical problem-solving among high ability students depends on the attributes of the problem-solving questions. This was evident in the study of 12-year-olds. The children were from predominately White families. Eighty-three (83) males and 76 females were tested in both the Fennema-Sherman Mathematics Attitudes Scales and on the Canadian Test of Basic Skills (CTBS). The result found that there is gender difference among the high ability students on the problem-solving scale of the CTBS. The findings suggest that this is origin and gender differences in mathematics and mathematical problem-solving skill.

Foregoing studies show that students' performance is not encouraging when it comes to solving mathematics word problem questions. Some of the difficulties reported includes: lack of comprehension, lack of vocabulary, incorrect use of operation, interchanging of values and carelessness. Others are poor skill of identifying a problem, poor definition of the problem and misconception in translating problems into mathematical expressions. In brief, some reported that vocabulary knowledge and performance in word problems are strongly related hence suggested that knowledge of vocabulary influences students 'success and comprehension in solving mathematics word problems. Therefore, to find mathematical problem-solving patterns of the SS II students and to investigate these

patterns from Polya problem solving strategies, and thus link to educational practice, would have significant impact for stakeholders.

METHODOLOGY

This research is a qualitative descriptive study. The purpose of this study is to describe the students' steps of solving word problems using Polya strategies. Problem-solving difficulties were analyzed according to Polya's problem-solving strategies. The sample of this study is one intact class (35 students) purposively selected from senior secondary school II in Borno State. Data from mathematical word problem solving ability test were collected through a Mathematics Word Problem Test (MWPT) consisting of four items extracted from West African Senior School Certificate Examination past questions. Question one is selected to evaluate students understanding and ability to inter-relate mathematical concepts, the use of formula and Pythagoras theorem. The second question is selected to test students understanding in formation of equations, substitution of values to find the unknown as demanded by the question. Question three is selected to test students understanding in the use of sum and difference, formation of equation from a given statement as well as solving the equation, and making a reasonable conclude as demanded by the question. The fourth question is selected to test students' understanding of fractions with two unknowns, how to form equations and solve simultaneous equations involving fractions.

ANALYSIS OF STUDENTS' PROBLEM-SOLVING SKILLS

In order to attempt to answer the question: "what are the difficulties students faced in solving word problem? The results of the test were arranged based on the stages of problem-solving used and word problem-solving difficulties encountered by many of the students were analyzed according to the different steps in the problem-solving strategies. The results of the analysis show the following difficulties:

1. Students did not understand the problem in the question but have been able to perform some mathematical operations (see figure 7).

2. Computational difficulty: Students understood the problem but could not perform mathematical operations (figure 2, male).
3. Students understood the problem based on interrelationship between fractions but have not been able to perform mathematical operations (see figure 5).
4. Difficulty to understand word problem involving fractions: students were not able to understand the problem based on interrelationship between topics but unable to perform mathematical operations (see figure 3).

Question 1

The sum of two numbers is 14 and their difference is 2. Find the numbers.

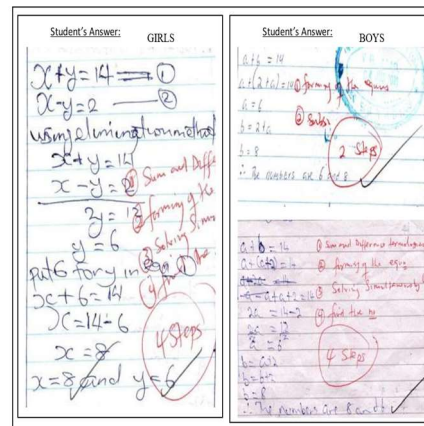


Figure 1: Student plan and perform mathematical operations

An aspect of looking back at results, measured by indicators checking the accuracy of answers with questions: in this aspect, almost all students are precise in determining the accuracy of the answers to the problems presented. This is because students have a good understanding of the problem, good transformation skill into mathematical equations. Incidentally, the student was unable to look back to check answers with questions.

Question 2

If 1 is added to both numerator and denominator of a fraction, the fraction becomes $\frac{1}{2}$. If 8 is added

to both, the fraction becomes $\frac{2}{3}$. What is the fraction?

MALE CANDIDATES' ANSWER

$$\frac{1+x}{1+y} = \frac{1}{2} \quad \text{--- (1)}$$

$$\frac{2+x}{8+y} = \frac{2}{3} \quad \text{--- (2)}$$

From equation 1

$$1+y = 2+x \quad \text{--- (3)}$$

From (2)

$$16+3y = 24+2x \quad \text{--- (4)}$$

$$14y = 24+2x \quad \text{--- (5)}$$

$$16+3y = 24+2x \quad \text{--- (6)}$$

$$-2x + 4y - 1 = 24 + 4y - 1$$

$$-3x + 24 + 24 - 16 = 0 \rightarrow -3x + 31 = 0$$

FEMALE CANDIDATES' ANSWER

5) let the fraction be $\frac{x}{y}$

$$\frac{x+1}{2x+1} = \frac{1}{2} \quad \text{--- (1)}$$

$$\frac{2x+x+1}{2x+1} = \frac{1}{2} \quad \text{--- (2)}$$

$$2x+x+1 = 2x+1 \quad \text{--- (3)}$$

$$2x+x+1 = 2x+1 \quad \text{--- (4)}$$

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$$2x+x+1 = 2x+1 \quad \text{--- (100)}$$

Figure 2: Skill of understanding word problem involving fractions

Figure 2 show that the student (both male and female) had a good understanding of the problem which includes translational skill, the use of fraction, simultaneous equation, and simplification of equations. Hence, they were able to interpret the word problem into simultaneous equation, simplify equations and perform mathematical operation correctly. However, the male student had a good understanding of the problem but could not go further to solve the problem (computational difficulty).

MALE CANDIDATES' ANSWER

$$\frac{4x}{1+y} = \frac{1}{2} \quad (1)$$

$$\frac{1+x}{1+y} = \frac{8}{1} \quad (2)$$

$$\frac{x+8}{y+8} = \frac{2}{3}$$

$$2y+16 = 3x+24$$

$$2x-3y = 24-16$$

$$\frac{1x}{1} = \frac{8}{1}$$

$$1-x = 8$$

MALE CANDIDATES' ANSWER

$$a+1=1 \quad a+8=2$$

$$b+1=2 \quad b+8=3$$

numerator =

$$a+1=1 \quad b+1=2$$

$$a+8=2 \quad b+8=3$$

$$a=0 \quad b=1$$

$$a=-6 \quad b=-5$$

$$2a=-6 \quad 2b=-4$$

$$a=-3 \quad b=-2$$

Figure 3: Difficulty to understand word problem involving fractions

In Figure 3, the students had difficulties in interpreting the mathematical terms (denominator and numerator) in the word problem. The student could not mathematically transform *“the addition of 2 to both parts of the fraction”* and also express the *“subtraction of 3 from the denominator and numerator”* mathematically. Therefore, the value of the fraction could not be determined because the candidate had poor understanding of the problem, which is traceable to inability to translate problem into mathematical expressions/equations.

Question 3

Four knives and six forks cost N700. Six knives and five forks cost N800. Find the cost the knives and the fork.

FEMALE CANDIDATES' ANSWER

1 let knives be K and forks be F

$$11K + 4F = 100 \quad (1) \times 5$$
$$5K + 2F = 50 \quad (2) \times 6$$
$$20K + 12F = 300 \quad (3)$$
$$5K + 2F = 50 \quad (4)$$

sub (4) from (3)

$$15K + 10F = 480$$
$$- 5K + 2F = 50$$
$$10K + 8F = 380$$
$$10K = 1300 - 8F$$
$$K = 130 - 0.8F$$
$$= 130 - 0.8(25)$$
$$= 110$$
$$20(11) + 12F = 300$$
$$220 + 12F = 300$$
$$12F = 80$$
$$F = 6.67$$

MALE CANDIDATES' ANSWER

$$4K + 6F = 700 \quad (1)$$
$$6K + 5F = 800 \quad (2)$$

multiply equation (1) by 3

$$12K + 18F = 2100$$
$$12K + 15F = 2400$$
$$3F = 300$$
$$F = 100$$
$$4K + 6(100) = 700$$
$$4K + 600 = 700$$
$$4K = 100$$
$$K = 25$$

Subst. eqn (2) in eqn (1)

$$4K + 6(100) = 700$$
$$4K + 600 = 700$$
$$4K = 100$$
$$K = 25$$

Subst. eqn (2) in eqn (2)

$$6K + 5(100) = 800$$
$$6K + 500 = 800$$
$$6K = 300$$
$$K = 50$$

Subst. eqn (2) in eqn (2)

$$6K + 5(100) = 800$$
$$6K + 500 = 800$$
$$6K = 300$$
$$K = 50$$

Subst. eqn (2) in eqn (2)

$$6K + 5(100) = 800$$
$$6K + 500 = 800$$
$$6K = 300$$
$$K = 50$$

Figure 4: Sample of word problem showing good understanding of the problem

In Figure 4, the students had good understanding of the word problem (use simultaneous equation, solving equations and substitution). Hence, they were able to interpret the problem into simultaneous equation and perform mathematical operation correctly.

Question 4:

The three sides of a right-angled triangle are x , $x+1$, and 5cm. Find x and the area of the triangle, if the longest side is 5cm.

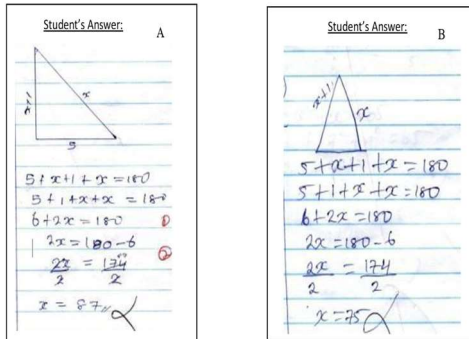


Figure 5: Difficulty to understand problem involving quadratic and triangle.

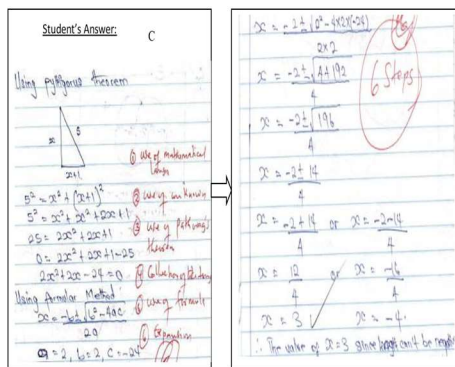


Figure 6: Skill to understand problem involving quadratic and triangle.

On the contrary, student answer C shows a good understanding of the word problem (the use of formulas and equations) and she was able to inter-connect the problems with mathematical formulas with good mathematical operations. Hence, the problem was correctly solved.

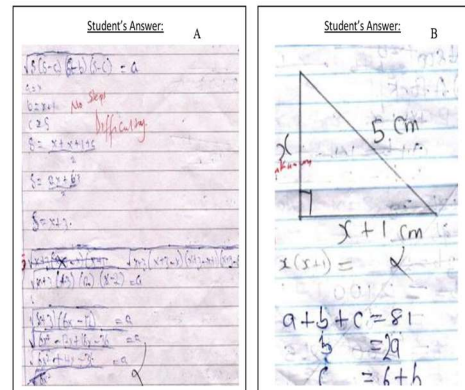


Figure 7: Difficulty to interrelate between topics and mathematical operations

From figure 7, the students were able to understand the problem and translate the word problem into a right-angle triangle which gives them a better perspective of solving the problem. However, they could not correctly represent the hypotenuse in the right-angle triangle accurately. In addition, where the student should have applied Pythagoras rule to find the unknown, the concept of sum of angles in a triangle 180° was used. It is clear that students' understanding of the problem and connection between mathematics concepts in solving word problem is lacking.

DISCUSSION

In general, students have been able to identify the unknown aspects of the problem, but the students could not understand the relationship in the problem when solving the word problem:

Firstly, referring to analysis of word solving problem difficulties, some of the difficulties found were based on students' inability to understand mathematical word problem and transformational difficulties. Firstly, students do not understand the given problems hence, the transformational difficulty. The student could not mathematically transform "the addition of 2 to both parts of the fraction" and also express the "subtraction of 3 from the denominator and numerator" mathematically. Therefore, the value of the fraction could not be determined because the candidate had poor understanding of the problem, which is traceable to inability to translate

problem into mathematical expressions or equations.

This is in line with the findings of Ramirez, et al (2019) that students have difficulty in articulating, in reading comprehension, in this case, a matter of word problem. This finding is reinforced by Permata, et al (2018) that the skill of identifying the word problems is categorized as very poor, indicator exploring the solution is also categorized as poor and skill of looking back and learning is categorized as very poor.

Secondly, students have difficulty determining problem solving plan and incomplete calculation. This is because students are accustomed to procedural work, so when asked the right concepts and application of mathematical formulas to solve word problems, students' gets confused. Students tend to solve problems by operating each number on the problem step-by-step. This finding is confirmed by Adu, Assuah and Asiedu-Addo (2015) that errors in solving linear equation word problems are largely due to their inability to comprehend and interpret the sentences in order to proceed to the process and encoding skills. This finding was also supported by Kaliky (2018) that student difficulties in problem solving arise from inability to determine the mathematical formula/concepts in problem solving.

Thirdly, students have difficulty making connections between mathematical concepts. This difficulty has an impact on word problem-solving. This is in line with the research results of Nurkaeti (2018) that students have problems determining the mathematical formula/concepts to used, making connections between mathematical concepts, and reviewing the correctness of answers with questions. Here, the students were not able to solve the story problem about the value of the unknown and area of right-angled triangle although the problem is quite easy. The results of this study clearly related to the difficulties students make between mathematical concepts and word problem. The connection in solving a word problem and mathematical concepts is very important, especially in the word problem that requires a lot of interpretation. As according to Rohmah and Sutiarto (2018) that the development of mathematics necessarily involves various connections of mathematical ideas,

understanding interrelated mathematical ideas in constructing mathematical understandings.

Lastly, students have difficulty in looking back to the truth of answers to questions. This means that the difficulty in looking at the answer aspect will not happen, if the student is correct in understanding the problem, planning, and solving the problem. Nurkaeti (2018) also found difficulty in understanding the problem, determining the mathematical formula/concepts to be used, making connections between mathematical concepts, and reviewing the correctness of answers with questions.

SUMMARY OF FINDINGS

Some of the difficulties face by the students in solving word problem includes: difficulty of mathematical problems solving in word problems involving fractions, the difficulty of understanding the problem involving plane shapes, determining the mathematical formula/concepts to used, making connections between mathematical concepts, transformation difficulty and reviewing the correctness of answers with questions among others.

CONCLUSION

Mathematical word problem solving of senior secondary school students still needs attention. Students still have difficulty in solving the mathematical word problems: determining the problem-solving plan, making connections between mathematical concepts, and checking the answers with questions. The difficulties as revealed in the literatures are associated with several factors including, poor knowledge of transforming word problem and lack of computational skill. Therefore, students should be given a variety of problems that would provide them opportunities to explore issues such as open-ended problems. On the other hand, a realistic mathematical problem-based approach, and other approaches that provide students with opportunities to solve mathematical problem should be adopted in learning word problems.

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