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# Effects of The Use Guided Discovery Method On Solving Linear Equation in One Variable Word Problem Among Junior High Shool Form 2 Students

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**ABSTRACT:** *The study sought to assess the effect of guided discovery approach of teaching Junior High School Form 2 students' ability of translating and solving of linear equation in one variable word problems. Data were collected by administering pre-test and post-test of five linear equation in one variable word problems to 23 students. The purpose of the pre-test and post-test assessment was to measure change in students' knowledge and skills of translating and solving linear equation in one variable word problems. The results revealed that majority of the students failed to identify the unknown part of the problem, represent it with defined variable and write correct expression and then transform the expression into linear equations, find the value for the variable and substitute the value of the variable into the equation to verify their answers. With the implementation of the guided discovery approach, the students made sufficient gains in post-test scores when they solved five linear equation in one variable word problems. Paired sample t-tests analysis also revealed a significantly increased the pre-service teachers' abilities of translating linear equation one variable word problems into algebraic forms and solving them. Consequently, it was recommended that mathematics teachers should make frantic effort and teach students the skills of identifying unknown part of linear equation word problems and representing with defined variable, and then form linear equations. Since one of the most important stages of problem-solving heuristic reasoning processes is to look back, students should be encouraged to make it a point to verify their answers and choose the right answer(s) only.*

**KEYWORDS:** guided discovery, comprehension, transformation, processing, encoding.

## INTRODCUTION

Algebra is a core topic within mathematics which has been recognised as a critical milestone in students' mathematics learning (Outhred, and Sardelich, 2005) since it serves not only as a language for science, but also plays an important role in solving advanced mathematics problems (Outhred & Sardelich, 2005; Sheets & Cifarelli, 2009). National Council of Teachers of Mathematics (2000) explains that Algebraic competence is important in adult life, both on the job and as preparation for post-secondary education (Dela Cruz, & Lapinid, 2014).



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Despite the importance of mathematics, many people have problems in mathematics especially algebra. Algebra is one of the major content domains covered to promote the acquisition of mathematical knowledge and skills in school mathematics. At the Junior High School, algebra covers topics such as algebraic expressions, linear equations, relations, mapping and functions (Ministry of Education, 2007). However, the analytical skills of most students are so weak that non-routine word problems that could be modelled into algebraic linear equations in order to get it solved are left unsolved.

One Variable Linear Equation is one of the topics given at the beginning of learning algebra. Students find it difficult to change the problems into equations in order to find their solutions when the problem is given word problems. The main source of the difficulties students experienced in the problem-solving process is how to change the written word in mathematical operations and its symbolic form (Yeo, 2009). Egodawatte (2011) observes that for students to solve linear equation in one variable word problems, they need three conceptual areas in algebra, namely variables, algebraic forms, and equations, since the word problem may contain concepts related to one or more of the three conceptual areas.

In Ghana, the Education Reform Review Committee in 2002 recommends a problem-solving curriculum for pre-university education. It further recommended the application of appropriate mathematical problem-solving strategies in the teaching and learning of mathematics. The recommendations of the review committee were implemented in 2007 and since then problem solving, and by extension word problems, had become part of the mathematics curriculum in Ghana. As a result, the syllabus requires the use of mathematics in solving everyday problems. However, a decade on, much empirical evidence in Ghana continues to raise concerns about how school teachers deliver mathematics, particularly problem solving and investigations. There remains an over-emphasis on expository teaching with limited opportunities for learners to engage in activities that will enable them to use concepts, solve non-routine problems and reason mathematically (Ampadu, 2012).

Algebra is one of the major content domains covered to promote the acquisition of mathematical knowledge and skills in school mathematics. At the Junior High School, algebra covers topics such as algebraic expressions, linear equations, relations, mapping and functions (Ministry of Education, 2007). Similarly, Ibrahim and Osei (2019) report that solving word problems is a difficult task for most students in Ghana. Thus, the analytical skills of most students are so weak that non-routine word problems that could be modelled into algebraic linear equations in order to get it solved are left unsolved.

Linear equation word problems is a topic at the Ghanaian Junior High School level. The Mathematics syllabus, requires that students are taught how to solve linear equations using three methods: graphs, flag diagrams, and balancing methods. Students also translate linear equations word problems into standard linear equations and solve them (Ministry of Education, 2012). Reports also indicates that though the students are supposed to be taught algebra in the Junior High School, many of them reach the Senior High School without a good grasp of the basic concepts and skills for solving standard and contextual linear equation problems (Issaku, 2012).

According to Gómez Flórez, Pineda and Marín (2012), students' errors in mathematics especially in algebra are regarded as a form of procedural or computational error. The focus of attention in the last decade, is not just procedural errors but more towards conceptual errors and misconceptions. Searching for errors is one effort that teachers can do to overcome these misconceptions (Yeo,2009).

Meanwhile, there are two important individual skills that are relevant for solving word problem. The first individual skill is the student need to use problem-model strategy which can enable them translate the problem statement into a qualitative mental representation of the problem situation hidden in the text ( van der Schoot, Jelle, Björn, & Anton, 2009). The second important individual skill is the student's reading comprehension abilities. Reading comprehension abilities are especially helpful in dealing with semantic-linguistic word problems such as the sequence of the known elements in the text of the word problem, the degree to which the semantic relations between the given and unknown quantities of the problem are made explicit, and the relevance of the information in the text of the word problem (Marzocchi, Lucangeli, De Meo, Fini, & Cornoldi, 2002). Helwig, Rozek-Tedesco, Tindal, Heath, and Almond (1999 ) report both mental representation skills and reading comprehension skills should be part of the mathematics education programme to enable solve mathematical word problems effectively.

**Statement of the Problem**

In Ghana, the Education Reform Review Committee in 2002 recommends a problem-solving curriculum for pre-university education. It further recommends the application of appropriate mathematical problem-solving strategies in the teaching and learning of mathematics. The recommendations of the review committee were implemented in 2007 and since then problem solving, and by extension word problems had become part of the mathematics curriculum in Ghana.

However, the Basic Education Certificate Examination (BECE) mathematics chief examiners' report indicated that most candidates were not able to write the mathematical equation from linear equation in one variable word problems; and very few made reasonable attempt at linear word problems (West Africa Examination Council, 2012, 2015, 2017, 2018). The report further indicates that the few students who attempted the problem resorted to try and error method to solve the problem. Similarly, Bukari (2019) also observes that students lack of understanding of the meaning of algebraic symbols, their barriers to change data provided into mathematical equations, their incorrect interpretation of the semantic structures of texts are as a result the misunderstanding of the relationships between quantities.

The researchers found that many students in Form 2 were struggling to cope with learning algebra. The researchers realised that the students generally were unable to translate word



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problems into algebraic form or cannot express mathematical statements into symbolic or algebraic forms.

**Purpose of the Study**

The purpose of the study was to identify errors Junior High School Form 2 students make when they translate linear equation in one variable word problems into algebraic expressions using modified Newman Error Model. The Newman's Error Levels included comprehension error, transformation error, process skills error and encoding error. Another way of trying to find out what makes algebraic word problems difficult is to identify the kinds of errors students commonly make in word problems and then investigate the reasons for these errors. In order to assist JHS Form 2 students to solve linear equation in one variable word problems, guided discovery approach was implemented as the intervention. The study therefore intended to explore the effect of the intervention on students' ability to translate linear equation in one variable word problems and solve them.

**Research Questions**

**1.** What type of errors do Junior High School Form 2 students make when translating linear equations in one variable word problems into algebraic equations?

**2.** What gains do the Junior High School Form 2 students make with the use of guided discovery approach in solving linear equation in one variable word problems?

**3.** To what extent does the guided discovery approach have effect on Junior High School Form 2 students' knowledge and skills of solving linear equation in one variable?

**Significance of the Study**

In our daily lives, mathematics is used to its full proficiency in business transactions, telecommunications, manufacturing industries, etc. In this sense, students should be able to translate mathematical word problems into mathematical symbols to enable them find solutions to them in order to fit into these areas of life.

The findings of this study would serve as a guide for teachers to vary their methodology to enable students better understand the concept of solving problems involving linear equations in one variable word problems. The use of guided discovery approach for teaching word problems involving linear equation in one variable will boost students' confidence and interest in other related topics involving equations. The outcome of this study would also improve the capabilities of students in formulating mathematical sentences from word problems and solve them with little or no guidance from the class teachers.

## LITERATURE

**Theoretical Framework**

Considering the literature reviewed, the study adopted the mathematisation theoretical framework to enable the researchers answer the research questions. Mathematisation, refers to an activity of transforming a problem into a mathematical symbolic model and vice versa, as



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well as reorganising the model within the world of mathematics (Van den Heuvel-Panhuizen & Drijvers, 2003). Mathematisation starts with comprehending a word problem usually with a real-world context. According to De Lange (2006) the process of mathematisation as it is carried out by the student has a cyclic character (see Figure 1). First, given a meaningful problem situated in reality, the student who acts as a problem solver starts the process by understanding the problem and identifying the relevant mathematical concepts within it (1). Next, based on the identified mathematical concepts, the problem solver trims away the irrelevant elements that exist in reality by formulating the problem into a mathematical model (2). The mathematical problem included in the model is solved and the student reflects on the solution process (3). Finally, the student is able to interpret the mathematical solution in terms of the original, realistic situation (4).

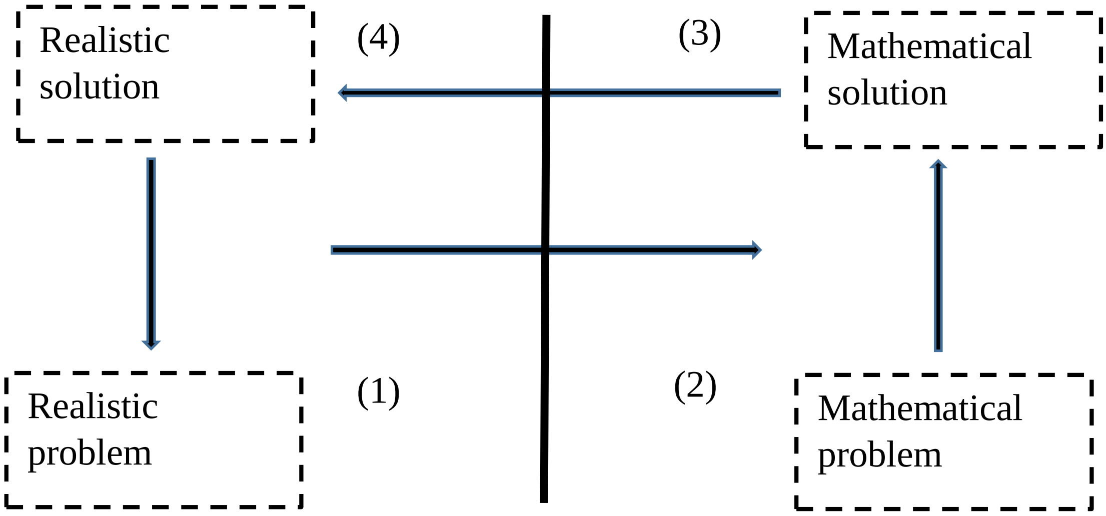


Figure 1. The mathematisation cycle (De Lange, 2006, p.17)

In this study, step 1 is concerned with translating the linear equation worded problem in one variable where the student is required to identify the unknown part of the problem and represent it with a defined variable (comprehension). In step 2, the student is required to write correct linear equation, clear fractions and open brackets (transformation). In step 3, student is required to group like terms, find the correct value of the variable (process skills). In step 4, the student is expected to substitute the value of the variable into the equation to obtain correct answer only (encoding).

**Conceptual Framework**

In order to answer the research questions, a conceptual framework of Newman's Error Analysis, NEA, (1977, 1983) model was adapted and used. The ideas in this model have been adapted because it would enable the researchers to identify problems students encounter and errors they make when translating and solving linear equation word problems in Mathematics. NEA also provided directions for where teachers could target effective teaching strategies to



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overcome them. Moreover, Allan (2010), Clarkson (1980) and Effandi, Ibrahim, and Siti (2010) agreed that the model was reliable.

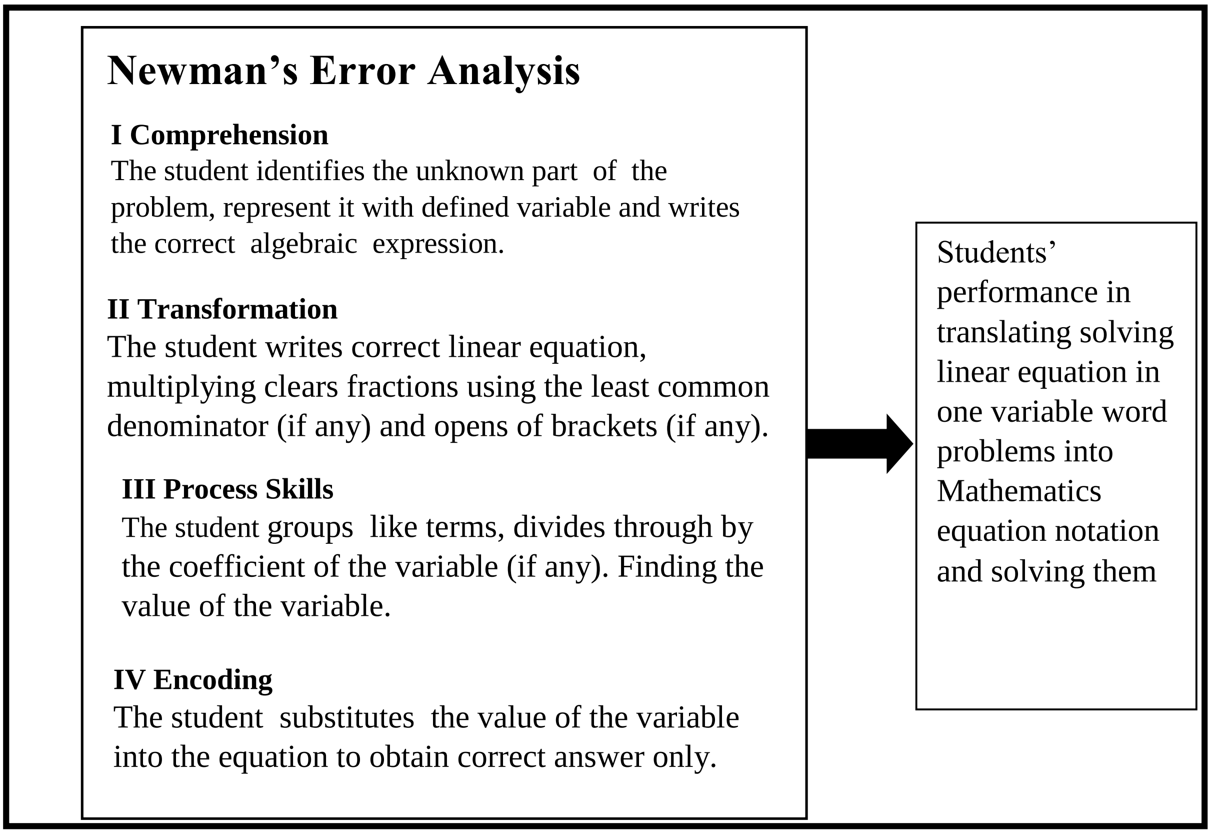


Figure 1. Conceptual Framework adapted from Newman (1977, 1983)

**Student Management of Equations-Related Word Problems**

Calvin (1990) defines equation as a statement of equality of mathematical expressions. Calvin added that, it is a sentence in which the verb is *equals* (=) to link the two algebraic expressions. Also, Laud (1995) defines linear equation as a statement where one algebraic expression in first degree equals another.

According to Pawley, Ayres, Cooper, and Sweller (2005), translating words into equations is important in many areas of mathematics but the identification of relevant information, matching key words with corresponding algebraic symbols and constructing a relationship between them is difficult (Pawley et al, 2005). Pawley et al. (2005) examine Junior High School Form 2 students' equation formation and found that around 90% of the errors made, in two separate studies, were due to variable reversal.

With regard to syntactic difficulties, statements like *a number added to six equals* nine, with the unknown appearing near the beginning of the statement, have a clear syntactic structure that makes them amenable to a sequential left to right approach that is typically determined by



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word order and known generally as a syntactic translation (MacGregor and Stacey, 1993). However, statements *like in ten years Sara will be sixteen years old*, where the unknown has to be inferred, are generally irresolvable by means of syntactic translation. With respect to semantic difficulties, statements like *six times a number is equal to a second number* allude to a different problem whereby, failing to acknowledge that *n* cannot be in both terms or thinking that 2 represents the second number, students write equations of the form $6n = n$ or $6x = 2$ (Mestre, 1988).

**Students' Difficulties in Solving Linear Equation Involving Word Problem**

Understanding linear equations and algebraic relationships is the basic to preparing students for success in higher algebraic concepts. It is believed that students need to develop representational techniques for a profound understanding of, and fluency with linear equations. (Silver, 2000). Therefore, it is essential to understand students' facility with translating verbal representation of linear equations into mathematical symbolic forms and finding their resultant solutions.

According to Bautista, Mulligan, and Mitchelmore (2009), studies have stressed that problem-solving skill in mathematics is quite difficult for students to attain due to some factors. One of the factors is related to translating word problems into its mathematical symbols and equations (Ambrose, 2010). These include the following: misinterpretation of the mathematical problem, lack of comprehension of the problem posed, incorrect use of operation, carelessness, interchanging of values and lack of vocabulary (Cruz, & Lapinid, 2014).

Portal and Sampson (2001) observe that students find it difficult to solve word problems because they are not sure and cannot decide on what operation to use. They further argued that although mathematics is the most indispensable tool, many students try to learn it without much success because they manipulate word problem according to memorised rules with little or no meaning.

Also, many students resort to guessing or using other inappropriate strategies as they attempt to solve word problems (Dickson, 1989). This points out that students find it difficult to solve a world problem when they are not introduced to the skills and concepts and when they are confronted with the problem for the first time.

**Students Errors in Translating Linear Equation Word Problems into Mathematical Symbols**

According to Bardillion (2004), translation from words to symbols is undeniably one of the critical solution processes in solving word problems. However, one common problem Mayer (1989) observes about translating sentences into symbolic language is that individuals end up remembering materials that are consistent only with their prior schemas.

To identify the difficulties encountered by students in translating linear equation worded problems into mathematical equations, Cruz and Lapinid (2014) administered a 20-item problem solving test to students. Scores obtained from the test measured their performance

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level in translating worded problems while interpretation of their mistakes identified their difficulties in translating worded problems. Results indicated that 40% of the respondents are below the satisfactory level in translating worded problems. However, students made the following errors: carelessness, lack of comprehension, interchanging values, and unfamiliar words are some of the common difficulties encountered by the respondents in translating worded problems.

Similarly, Adu, Assuah and Asiedu-Addo (2015) examine nature of errors students make when translating solving linear equation word problems into mathematical notations and solving them. A test, comprising 10 linear equation word problems, were administered to 130 students. The errors students made were identified based on the modified Newman Error Hierarchical levels (NEAL), which comprised reading, comprehension, transformation, process skills and encoding errors. The results revealed that majority (60%) of the students attempted most of the questions with a few (2%) arriving at the correct answer which implies students have difficulties in tackling linear equation word problems. It revealed that about 75% of the students made comprehension errors; 86% made transformation errors which occurred during the translation of the statement to algebraic form; 84% made process skills errors which occurred during computation process, and finally 86% made encoding errors which occurred at the final stages of the work. The proportion of students reaching the encoding level was very few (< 30%). In conclusion, it can be argued from the results that students' errors in solving linear equation word problems are due, largely, to their inability to comprehend and interpret the sentences in order to proceed to the process and encoding skills.

Ramirez, Sales, and Tindowen (2019) found that translating worded problems is considered as one of the most difficult tasks for students. Besides, it becomes a big hindrance in learning Mathematics since translation from words into symbols is undeniably one of the solution processes in solving word problems that is critical and vital. Moreover, Ramirez, et al. (2019) administered test items to second year teachers' education students to identify their difficulties in translating linear equation word problems into mathematical expressions. The results revealed that students lacked comprehension, lacked vocabulary, use incorrect operation, interchanged values and were careless. Similarly, Allan (2005), also found that some of the students in his study were unable to express some of the answers in the acceptable form.

Rauzah , Kusnandi and Jupri ( 2019) used Newman error analysis model to analyse data collected from Junior High School students on how they solved word problem of one variable linear equation. The results revealed that the most common errors students made was the comprehension error (40%) because students do not read and understand the problem carefully, students do not write what is known and what is asked in the question early and students are not accustomed to work on the word problem-shaped questions.

**Solving Linear Equations in one Variable**
In order to address difficulties students encountered when solving word problems involving linear equations in one variable, Teye (2020) carries out action research on a sample of 32 students. The researcher used guided discovery method as the intervention which lasted for



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five (5) weeks. Paired sample t-test was used to compare the mean scores of students' pre-test and post-test. The result showed that improved performances of the students after the intervention. Similarly, Tuffour (2014) employs Constructive Teaching and Learning Approach as an intervention through an action research to improve on how students translate word problem into linear equation in one variable and solved them. The analysis of the pre-test and post-test results showed 28.46 and 59.47 respectively. This revealed that the Constructive Teaching and Learning Approach implemented assisted students to solve linear equation in one variable world problems.

**Guided discovery method of teaching**

According to Mayer (2003); there are three levels of guidance in teaching:
-Pure Discovery – The student receives representative problems to solve with minimal teacher guidance.
-Guided Discovery – The students receives problems to solve, but the teacher provides hints and directions about how to solve the problems to keep the student on track.
-Expository – The final answer or rule is presented to the student.

The guided discovery method is a teaching technique that depends on the learners' activity and the teachers' direction in order to reach the targeted educational goal. It is a powerful instructional approach that guides and motivates learners to explore information and concepts in order to construct new ideas, identify new relationships, and create new models of thinking. According to Markaban (2008) guided discovery method expose students to a situation where they are free to investigate and draw conclusions, do conjecture, intuition and experimenting. This makes the teacher to serve as a guide helping students to use the idea(s), concepts and skills they have learnt to discover new knowledge. Nwagbo (1999) explains that guided discovery method, an example of constructivist learning, is an approach to enquiry where the teacher provides illustrative materials for students to study on their own, posing leading questions to enable the students to think and provide conclusions on their own. According to Ugwuanyi (1998), a learner is active in discovery learning, and provides for individual difference as well as makes the process of learning to be self-sequenced, goal directed, with the goal perceived and the pace self-determined.

**Steps in guided discovery learning**

1. Teacher presents divergent questions and assesses the students by providing them the environment for discovery (Athira, 2017).
2. Invention: at this stage, with the help of the teacher, the students find the meaning and structure of ideas (Athira, 2017).
3. Discovery: the student applies what he learned in exploration and invention stages to new situation (Athira, 2017).



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## METHODOLOGY

### Research Design

The design of this quantitative study was a single- group pre-test-post-test pre-experimental design. In this type of design, one group of subjects was given a pre-test, then the treatment and then the post. Pre-test and post-test are the same just given at different times (McMillan & Schumacher, 2010). In addition, the researcher made use of practical action research method as the appropriate medium of getting insight of the problem. The action research method assisted the researcher to investigate the problem Junior High School Form 2 student encountered when solving linear equation in one variable word problems. It also allowed for the systematic implementation of intervention, monitoring and evaluation which helped students develop the strategies of translating and solving linear equation in one variable word problems (Mills, 2000).

### Population

The population of the study was all Junior High School Form 2 students at E.P. Basic School in Akatsi South of the Volta Region of Ghana.

### Sample and Sampling Procedure

The sampling technique employed in this study was purposive sampling. Purposive sample is a non-probability sample in which selection is made based on features of a population and the objective of the study. Purposive sampling is appropriate in occasions where investigators need to select participants who have particular characteristics needed for the study. Regarding purposive sampling method, investigators select people who are believed to provide the data needed (Fraenkel & Wallen, 2006). Therefore, twenty-three Basic 8 pupils of E.P. Basic School were purposively selected because they made various errors when they were taught word problems of linear equation in one variable. In addition, Basic 8 students are also potential candidates who periodically take part in Trends in International Mathematics and Science Study (TIMSS) organised every four years.

### Instrument

A test comprising five question involving linear equations in one variable was adapted from previous researchers and administered to students. Students were instructed to translate the linear equation in one variable word problem into mathematical notation and then solve them. The pre-test was used to assess Junior High School Form 2 students' errors they made when translating linear equation word problems into mathematical notations and how they used their problem-solving abilities to solve the equations they formed. Post-test was also used to assess students' performance in solving linear equations in one variable after the intervention was carried out.


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**Intervention**

The researchers during first and second weeks of the intervention period, exposed the students to terms used in word problems that represent addition and subtraction in word the problems. The students were put in small groups and guided to translate the mathematical statements that involve addition and subtraction into mathematical expressions. In the third week, the researchers guided the students to translate word problems which depicted multiplication and division into algebraic expressions. During the fourth week, the last week of the intervention, the researchers guided students to identify the algebraic expressions in linear equation in one variable word problems and the remaining part of the problem which would bring out the linear equation. Students later used the idea and translated five given linear equation in one variable word problems into equations and solved them.

**Data Collection**

The researchers held face to face discussion before the pre-test was administered to the students. The researcher administered five test items for the pre-test before the intervention was administered. Students were also asked to solve the equation they formed individually for 50 minutes. They were informed that their solutions would not be graded so that they would feel free to solve problems. The students' solutions were also analysed using Newman's five fixed sequence of Error analysis.

**Comprehension**

In the analysis, a stroke (/) each was given to a student who was able to identify the unknown part of the problem, define a variable and use the variable to write correct expression was testing (C) and a cross (x) was given to a student who could not write correct expression (did not have an idea of) the unknown component of the question was testing ($C^1$).

**Transformation, Process Skills and Encoding**

In the final analysis, a stroke (/) each was given to a student who was able to transform the problem (T), carry out the process skills (P) and encode the answer correctly (E ) at each stage while a cross (x) each was given to a student who failed to transform the problem ($T^1$ ), failed to carry out process skills ($P^1$) and failed to encode the answer correctly ( $E^1$) at each stage. In addition, students' solutions to the problems were scored independently using a numerical scale and the scores were later analysed to determine the extent to which basic 7 students could solve word problems in Mathematics.


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**Table 1:** Description of skills and their categories under the modified Newman Error Model

| S/n | Criteria | Newman's Error Levels |
|---|---|---|
| **1** | Identifying unknown part of the problem and represent it with a defined variable.<br>Writing of first-degree algebraic expression | Comprehension |
| **2** | Writing correct linear equation<br>Multiplying through by LCD to clear fractions (if any)<br>Opening of brackets (if any) | Transformation |
| **3** | Correct grouping of like terms<br>Dividing through (if any)<br>Finding the value of the variable | Process skills |
| **4** | Substituting the value of the variable into the equation to obtain correct answer only. | Encoding |

**Data Analysis**

With regard to data on students' errors, the frequencies were converted into percentages for each criterion and were used for the analysis. Data collected from students were examined based on the criteria set according to the Newman Error Hierarchical levels. Paired-samples t-test was conducted on pre-test and post-test scores to determine the extent which guided discovery approach have effect on Junior High School Form 2 students' knowledge and skills of solving linear equation in one variable word problem.

## REESULTS

**Research Question 1:** What type of errors do Junior High School Form 2 students make in translating linear equations in one variable word problems into algebraic equations?

**Linear Equation in One Variable Word Problems**

1. The sum of two numbers is 54. One exceeds the other by 14. Find the number.
2. When a certain number is subtracted from 10 and the result is multiplied by 2, the final result is 4. Find the numbers.
3. The sum of three consecutive odd numbers is 57. Find the numbers.
4. A father's age is four times that of his son. In five years', time, the father will be three times as old as his son. What are their ages?
5. The sum of three numbers is 81. The second number is twice the first, and the third is six more than the second. Find the number.

As shown in Table 4.1, it was revealed that 18 students representing 78.3% and 17students representing 73.9% failed to identify the unknown part of the problem to be represented with a variable for questions 5, 3 and 4 respectively. Only 9 students representing 39.1 % were able to identify the unknown part of the problems 1 and 2 and represented them with variables.



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Generally, majority of the students, 16 representing 70.5% of the students failed to construct appropriate first-degree algebraic expressions to enable them write linear equations in one variable and then solve them.

**Table 4.1: Percentage of students who comprehend the problems**

| Comprehension | C (%) | C[1] (%) |
|---|---|---|
| Problem 1 | 9 (39.1%) | 14(60.9%) |
| Problem 2 | 9 (39.1%) | 14 (60.9%) |
| Problem 3 | 5 (21.7%) | 18 (78.3%) |
| Problem 4 | 6 (26.1%) | 17 (73.9%) |
| Problem 5 | 5 (21.7%) | 18 (78.3%) |
| **Mean** | **7(29.5%)** | **16(70.5%)** |

Table 4.2, shows that majority of the students, 21 students representing about 91.3%, 16 students representing 69.6% could not transform problems 5,4 and 2 respectively. Only 10 students constituting about 43.5% could transform the problem 3. Generally, majority of the students, 16 constituting 67.8 % failed to write the correct linear equation from the word problem, multiply through by the appropriate least common denominators (LCD) to clear fractions and also perform operations to open brackets.

**Table 4.2: Percentage of students who transformed the problems (N=23)**

| Transformation | T (%) | T[1] (%) |
|---|---|---|
| Problem 1 | 9(39.1) % | 14(60.9%) |
| Problem 2 | 9(39.1%) | 14(60.9%) |
| Problem 3 | 10(43.5%) | 13(56.5%) |
| Problem 4 | 7(30%) | 16(69.6%) |
| Problem 5 | 2(8.7%) | 21(91.3%) |
| **Mean** | **7 (32.2%)** | **16 (67.8%)** |

In Table 4.3, only 9 students representing 39.1% were able to process problem 2. It was also clear that 21 students constituting about 91.3% were not able to process problem 5. It was also revealed that out of the 23 students who were to process the problems, as many as 20, representing 87% failed to process problem 4. From Table 4.3, 18 students representing 78.3% failed to process the linear equation in one variable problems.



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**Table 4.3. Percentage of students who Processed the problems (N=23)**

| Process Skills | P (%) | $P^1$ (%) |
|---|---|---|
| Problem 1 | 7(30.4%) | 16(69.6%) |
| Problem 2 | 9(30.4%) | 14(60.9%) |
| Problem 3 | 6(26.1%) | 17(73.9%) |
| Problem 4 | 3(13.0%) | 20(87.0%) |
| Problem 5 | 2(8.7%) | 21(91.3%) |
| **Mean** | **5 (21.7%)** | **18 (78.3%)** |

One of the important problem-solving heuristic reasoning processes students often ignore is the verification answers obtained in a problem solved. Table 4.4 shows that among the five problems solved, only 7 students representing 30.4% could encode problem 1. Generally, only 2 students representing 12.1% verified their answers and chose the correct answer only and after solving their linear equations in one variable word problems.

**Table 4.4. Percentage of students who Encoded the problems (N =23)**

| Encoding | E (%) | $E^1$ (%) |
|---|---|---|
| Problem 1 | 7(30.4%) | 16(69.6%) |
| Problem 2 | 0(0.0%) | 23(100.0%) |
| Problem 3 | 3(13.0%) | 20(87.0%) |
| Problem 4 | 3(13.0%) | 20(87.0%) |
| Problem 5 | 1(4.3%) | 22(95.7%) |
| **Mean** | **2(12.1%)** | **20 (87.9%)** |

**Research Question 2:** What gains do Junior High School Form 2 students make with the use of guided discovery approach in solving linear equation in one variable word problems?

As shown in Table 4.5, JHS Form 2 students obtained a mean score of 1.86 (SD = 1.059) for their pretest and a mean score of 6.04 (SD = 0.522) in the posttest. Thus, the average score of JHS Form 2 students is found to be 4.18 (SD = -1.537). The gain score constitutes 18.2% of 23, the highest possible score in the test. Moreover, the minimum score in the pretest (0) went up to 5 in the posttest recording a gain of 5. The maximum score also went from 4 to 7 with a gain of 3.

**Table 4.5.** Pretest, Posttest, and Gain Scores fo the Whole Group

| | **Pre-test** | **Post-test** | **Gain (Posttest- Pretest)** |
|---|---|---|---|
| **N** | **23** | **23** | **23** |
| **Mean** | **1.86** | **6.04** | **4.18** |
| **Standard Deviation** | **1.059** | **0.522** | **-1.537** |
| **Minimum** | **0** | **5** | **5** |
| **Maximum** | **4** | **7** | **3** |


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**Research Question 3:** To what extent does the guided discovery approach have effect on Junior High School Form 2 students' knowledge and skills of solving linear equation in one variable?
Table 4.6 shows a paired samples t-test conducted to evaluate the effect of the guided discovery approach intervention translating and solving linear equation in one variable word problem. Before conducting paired samples t-test, the normality assumption was verified. The findings showed that there was a statistically significant increase in total scores from pre-test (M = 1.86, SD = 1.059) to post-test (M = 6.04, SD = 0.522), t (22) = -16.760, p < .05.

**Table 4.6.** Paired Samples Results for Pre-test and Post test

| | M | SD | SEM | Lower | Upper | t | df | P(0.05) |
|---|---|---|---|---|---|---|---|---|
| | -4.183 | 1.197 | 0.250 | -4.700 | -3.665 | -16.760 | 22 | 0.000 |

## DISCUSSION

In terms of the errors students made in translating linear equation in one variable word problem, majority of JHS Form 2 students,70.5% made comprehension errors. Most comprehension errors occur because students used variables to represent the unknown in the problem but failed to construct the correct expressions which were in turn used to write appropriate linear equations in one variable. This finding of the study agrees with earlier findings in the research of Rauzah , Kusnandi and Jupri ( 2019), Adu, Assuah and Asiedu-Addo (2015), Ramirez, Sales, and Tindowen (2015), and Lapinid (2014) which reported that students made comprehension errors when they translated linear equation in one variable word problems into algebraic expression.

The next common error JHS Form 2 students made were transformation errors in the course of translating linear equation in one variable word problem into mathematical notations. Majority of the students, 91.3% failed to write the correct linear equation from the word problems, multiply through by the appropriate least common denominators (LCD) to clear fractions and also perform operations to open brackets. This finding of the study is in line with the findings of Adu, Assuah and Asiedu-Addo (2015) which reported that majority of students made transformation errors in clearing fractions and opening brackets.

JHS Form 2 students also made process skills errors which occurred during computation process. In the process error, majority of the students, 78.3% failed to group of like terms in the linear equations in one variable and therefore, could not find the value of the variable chosen. This finding of the study is corroborated by the findings of Adu, Assuah and Asiedu-Addo (2015) which revealed that students have difficulty simplifying algebraic equations.

The final error JHS Form 2 students made was encoding error. During the encoding stage, only 12.1% of the students verified their answers after solving their linear equations in one variable


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to choose the correct answer only. Consistent with this finding is the findings of Adu, Assuah and Asiedu-Addo (2015) which also report that only a few students reach the encoding level when they solved linear equation in one variable word problems. Moreover, the finding also agrees with that Allan (2005), who found that some of the students in his study were unable to express some of the answers in the acceptable form.

The results of the study indicated that the guided discovery approach has potential to influence JHS Form 2 students' knowledge and skills of translating and solving linear equation in one variable word problems. More specifically, JHS Form 2 students made sufficient gains in post-test scores on solving linear equation in one variable word problems significantly increased at the end of using the guided discovery approach revealed statistically significant increase in total scores from pre-test (M = 1.86, SD = 1.059) to post-test (M = 6.04, SD = 0.522), $t(22) = -16.760$, $p < .05$. The findings of the present study are consistent with the action research study conducted by Teye (2020) which employs guided discovery method as the intervention showed significant increase in total scores from pre-test to post-test.

## CONCLUSION

The evidence from the findings of the study revealed that majority of `Junior High School Form 2 students in course of translating linear equation in one variable word problems made errors ranging from comprehension (inappropriate definition of variables), transformation (incorrect linear equation in one variable), process skills (not able to find the value of the variable in the equations) and encoding (not verifying answers and choosing the correct answer only). The use of guided discovery method as the intervention gave a mean score of 1.86 (SD = 1.059) for their pretest and a mean score in the posttest is 6.04 (SD = 0.522). The gain score constitutes 18.2% of 23, the highest possible score in the test. The use of guided discovery approach as an intervention, revealed a statistically significant increase in total scores from pre-test (M = 1.86, SD = 1.059) to post-test (M = 6.04, SD = 0.522), $t(22) = -16.760$, $p < .05$.

### Recommendations

During the process of translating and solving linear equations in one variable word problems, teachers should ensure that students identify the unknown part of the problem and represent it with a defined variable. Students should be guided to write first degree algebraic expressions considering addition, subtraction, multiplication and division cases. Students should finally connect the algebraic expression with another to obtain a linear equation in one variable.

One of the most important stages of problem-solving heuristic reasoning process is to look back and examine the solution that was obtained. Although most students are taught to check their answer, they are rarely asked to reflect on how they arrived at the solution (Adiguzel & Akpinar, 2004). It is therefore, recommended that teachers who teach mathematics at the Junior High School should encourage students to make it a point to verify their answers and choose the right answer (s) only.

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## Implications for Research

The Mathematics Chief Examiners' report often indicates that most candidates were not able to write algebraic linear equation from linear equation in one variable word problems. The study was conducted to inform National Council Curriculum and Assessment (NaCCA) of Ghana Education Service of the errors students make when they translate linear equation in one variable word problem and solve them to enable pay attention to teaching strategies in the curriculum and students' text books to assist them to overcome these errors.

The study is aimed at equipping Mathematics teachers at the Junior High Schools level with special skills and knowledge of translating and solving linear equation in one variable word problems to address the challenges Junior High School pupils face when solving linear equation in one variable word problems. Moreover, curriculum leaders together with the teachers at would also discuss the findings and implement the outcomes during their school- based and cluster- based in-service training sessions to educate other teachers of how to translate linear equation in one variable word problems and solve them.

The study is also aimed at informing the in-service unit of the Ghana Education Service to effectively organize INSET with appropriate materials and resources in order to equip teacher with the relevant content knowledge and pedagogical content knowledge to understand pupils' conceptions and misconception and as well as acquire sufficient knowledge and skills to assist them prepare effective lesson notes, select and use appropriate TLMs in teaching and learning linear equation in one variable word problems.

The study also sought to inform teacher training institutions to integrate appropriate strategies of teaching linear equation in one variable word problems to assist students to avoid making errors when translating linear equation in one variable word problems as well as solving them.

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