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RESEARCH ARTICLE

THE EFFECT OF SOLVING WORD PROBLEMS IN DIFFERENT WAYS ON THE LEVEL OF UNDERSTANDING AND ACHIEVEMENT IN MATHEMATICS AMONG HIGH SCHOOL STUDENTS

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ABSTRACT

The differences between the academic achievements and motivation level of 10th grade students in solving word mathematical problems with different solution methods were examined in this research, as the examined solution method is using tables versus solving by linear solution, solution through graphs and solution through series. The research rational is to clarify that the table method solution is preferred better than the other methods in academic achievements. The main research goal was to examine the differences in the academic achievements of the students, and in the student's level of motivation in mathematical studies, in the context of solving word mathematical problem in different ways (linear solution, table solution, graph solution and series solution). The central research question was: how does the method of solving word problems with different ways (linear solution, table solution, graph solution and series solution) on 10th grade student achievements and motivation. The comparison is between the tables solution methods versus other methods (linear, graphs and series). 100 10th grade students from Arab schools in northern Israel that learn the subject of mathematics participated in this research. The research sample is composed by four classes: class number 1 solved the tests according with the linear problem solution; class number 2 solved the tests according with the table solution method; class number 3 solved the tests by the graph solution method; and class number 4 solved the tests by using the series solution method. The research used a general mathematical test and an examination of word problems involving six verbal problems questions regarding traffic and three questions regarding percentage. The research findings indicated that distinct differences in the students' academic achievements were found while using the table solution method versus the different solution methods of linear solution, solution using graphs and solving by series, it was found that solving using tables is preferable to other methods. The research contribution indicates that the table solution method improves student achievements versus the other solution methods in solving word problems. The table solution method has been found as the most efficient way to improve student achievements. However, not the table solution method or any other solution method showed an effect on student motivation.

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INTRODUCTION

Mathematics is a subject considered as difficult and complex, that creates various difficulties among students, so that these difficulties make it harder on the students to deal with a variety of mathematical tasks that affect the students' academic achievements and motivation accordingly. This is why a fundamental change is required in order to change the way the subject is perceived and will create interest and a positive learning experience. Teaching mathematics and student achievements in this subject, are of a direct and co-depended connection in the teaching/learning processes the teaching staff uses in the classroom.

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The teachers have a great influence on the motivation and interest of students via the diverse teaching methods that combine development of thinking and challenge (Guri-Rosenblit, 2004). In mathematical studies there is a great emphasis on the ability of middle-school students to solve word mathematical problems mostly due to the fact that the field has been defined as one of the hardest and the ability to succeed in it involves great effort, both from teachers and students learning mathematics (David, 2007). On the other, Stacey and MacGregor (2000) noted that one of manifested difficulties in learning, is that due to the prior experience of the students to solve arithmetic problems, while studying mathematics they show a really compulsive tendency to calculate.

The students do not show an attempt to understand the meaning of the variables and using letters and symbols, but rather skip strait to the calculations, even when the problems are uncalculated (Kutscher, 1996). An immediate approach to the calculation strategy puts the students in a dead end, especially when it comes to an equation with variables on both ends of the equation. There is a difficulty among the students to understand the meaning of using letters as representing variables and numerous times they use the same letter to represent entirely different variables, in the same equation (Stacey & MacGregor, 2000). Solving conventional word problems is considered as one of the important subject in mathematics which many students encounter and struggle with. Difficulties in word problems comes from several factors: difficulties in reading comprehension and encoding of verbal information into mathematical terms; difficulties in finding a plan - a method for solving, due to a failure to master problem-solving strategies, as a result of insufficient or incompatible teaching; a faulty implementation of the solution plan, due to failures and mathematical deficits (Gazit and Patkin, 2011).

The research goal is to examine the effect of the different solution methods to word problem on academic achievements and motivation among 10^{th} grade students. Choosing 10^{th} grade students derived from them learning word problems about traffic, percentages and problems about purchasing and selling. The choice was also due to the various difficulties 10^{th} grade students encounter, especially in the subject of word problems that causes a lack of motivation as well. From my experience as a teacher in middle schools and high schools, I encounter a prominent lack of motivation among the students, mainly in studying mathematics. Various solution methods are being examined in the research from a point of view that addresses the achievements of the learners, deriving directly from the method. This study focuses on the examination of the use of different solution methods for solving word problems and their effect on academic motivation and achievements of the students, so that one of the hypotheses and arguments shows that, different solution methods have an effect on academic motivation and achievements of the students.

Literature Review

Verbal Problem Solution: Word problems are problems in which the mathematical question is translated into words. The data are verbally given to the respondent, and the respondent should conclude a mathematical answer from them. Word problems facing the respondent with several difficulties: the main difficulty in solving verbal problems is the need to translate the question, from a regular verbal syntax to a mathematical syntax. The difficulty encompasses a transition from a rich and occasionally ambiguous language, to a poor and unambiguous language. Another difficulty stems from the understanding that identical terms can have different meanings in a verbal context and mathematical context. The students are required to "harness" their intuitive thinking, in the favor of cognitive strategies (Margolin and Ilani, 2008). Word problems constitute for a long time an important element in middle school curriculum. Nonetheless, studies show that the traditional ways to present and show word problems frequently bring the students to look for key words or expressions indicating a certain action or an algorithm, rather than relying their prior acquired mathematical knowledge and solve the problems by using it (Jacobs & Ambrose, 2009).

The ability to implement mathematical skills in verbal problems requires a unique way of coping from the student, since the student needs to decide what is the relevant information and hoe to use it. Dealing with the information given in the problem, requires an ability to use mathematical considerations along with using mathematical literacy. Mathematical literacy addresses the ability to recognize, formulate and interpret problems while using mathematics (Kramersky, Mizrahi, 2004). It was found that Reading Comprehension constitutes a most essential element in word problem solution, hence the difficulty is in Reading Comprehension and in encoding verbal information to mathematical terms/symbols (Gazit and Patkin, 2011). Word problem solution includes skills of mathematical context construction, between different problems or the various elements of a specific problem. This skill enables the students to find contexts between problems and transfer information from problems learned before to other problems (Ovadia, 2014). The more that the learning will deepen in contexts, the higher the problem solution skill will be. In solving word problems, the student creates an integration between two languages, the verbal and the mathematical and therefrom the great difficulty for children. The mathematical language is far more accurate than the verbal language in which the student needs to learn a rich and extensive linguistic vocabulary. In mathematical problems the child needs to translate the natural language he or she knows and familiar with, to a mathematical lingo and deconstruct it in accordance to the presented question (Margolin&Ilani, 2008).

And the central base in solving different word problems is the lack of a predetermined algorithm in the problem. Actually, there are three solution techniques in problems solution which should be used in order to lead to solution and result: the first is the knowing skill, the second is the implementation skill and the third is the clarifying skill. In the knowing skill, for instance, the solver should know sorting of order and shapes, properties, numbers, and certain shapesin order to lead to the exercise's solution, the student needs to demonstrate knowledge about what is being asked in order to progress a solution. In clarification, the solver should demonstrate logical techniques that will allow him or her to solve more complex problems in certain conditions, and this requires an especially high cognitive ability. In solving complex problems, a creative thinking should be used since it entails many elements through which the solver reaches the solution required of him or her, and uses as much knowledge and manipulation as possible to reach the solution in an unconventional special way (Magen-Naggar, 2014).

Different Ways to SolveWord Problems: Ways of solving word problems according to many scholars' reference are related to the student's various abilities, as well as to the teacher's abilities. With regard to the different strategies for dealing with solving mathematical problems, in her study, Kapah (1998) points out different strategies for dealing with solving mathematical problems. She conducted a staged experiment; a. Stage of the discovery of the previous information by answering a pre-questionnaire in solving word problems; b. A stage of learning in which the students were exposed to the learning strategy; c.The implementation stage in which the students answered a questionnaire of word problem solution which combines the learned strategy; d.The stage of discovering the learned knowledge in which the students answered a questionnaire in solving word problems. The main

findings of the study showed that there were significant differences between the two study groups in the scholastic achievements before and after the experiment. It appears that the study group studied according to the problem mapping strategy achieved better scores after the experiment than the group studied according to the (SKLB) strategy that achieved lower scores after the experiment (Jacobs & Ambrose, 2009).

Solving Word Problems via Table Solution Method: Solving word problems with tables with which students work on the deconstruction of every word problem into parts, solving word problem by this strategy will make the students to identify key words assisting them to choose the correct action, draw a representation, perform calculation, find the right label and examine the logicality for every word problem (Schwanebeck, 2008). Garderen (2004), defined this method as a method of interactive teaching, usually used in reading comprehension, and applied it to mathematical word problems in stages: Clarification, exploration, summarization (placing data by table) and planning. This process allows students to discuss their thinking with others. Cooperative work allowed her students to see the thinking processes of other students.

Solving Word Problems via Graph Solution Method: Solving mathematical word problems through graphs bases on two major elements: a) inter-mathematical connections - solution basing on Triangular Imagination Solution, this solution begins with a graphic representation of the problem; b) combining internal and external mathematical connections - recruiting concepts from the world of physics and the integral domain for the solution (Elbaum-Cohen and Cooper, 2015).

Solving Word Problems via Series Solution Method: Mathematical series that require coping with unconventional thinking challenges, raise questions that do not have a predetermined algorithm and which requires a certain degree of breaking of normal thinking frames and moving to a thinking process with creative characteristics, searching for a new and unknown model of a solution from a data series that display familiar items, though not in a predetermined context. The solution requires unbiased independent assumptions before choosing the solution for the open question. Among the numerical series, most common use is the use of the Fibonacci series. In this series, every number after the first two is the sum of the two preceding ones: and it is possible to calculate the differences and see that the difference between two consecutive numbers, starting with the second and third numbers, is equal to the previous number (Bishara, 2014).

Types of Word Problems

Traffic Problems - ways to solve word problems related to traffic: In this kind of problems there is a more focused reference to the various traffic terms, Linear velocity - defined as the rate of change in the position of a body in linear motion expressed in length units divided by time; Angular velocity - characteristic of circular motion, defined as the rate of change in the rotation angle of a rotating body. Solving word problems consists of three main stages: (a) selection of unknowns; b) The construction of a mathematical model of the problem using equations or inequalities with the selected unknowns; c) Finding the unknown's value or the requested combination of unknowns (Samobol, Steinberg, Hefetz and Orberstein, 2012).
Katz and Katz (2013) noted more ways of examining word-related problems regarding traffic:
Using a system of two equations with two unknowns; Using a set of three equations with four unknowns; Use in proportion; Using a system of equations with three unknowns; Using linear function and triangular imaginations; Using an equation with one variable.

Buying and Selling Word Problems - ways to solve word problems regarding buying and selling: Buying and selling problems include simple fractions, decimals, percentages, and rational numbers. Markovits and Sowder (1991) note that there are three such levels: A) the basic understanding that different representations of a fracture can appear together in an accepted mathematical expression; B) understanding that it is permissible to make a transfer from one symbolic representation to another; C) the complete expressed understanding of the connection between the representations. Moss and Case (1999) suggested starting to teach the rational numbers of the percentage concept, with an emphasis on the students' intuitive knowledge of this subject, and then teaching the concept of simple fraction and decimal number. The researchers suggested using linear measurement and encouraged the use of percentage points (25%, 50%) and the cross-sectional method as a computational strategy to strengthen conceptual understanding in percentages and rational numbers in general.

Buying/Selling Word Problems (with percentage): The subject of percentage is one of the most useful subjects in math curriculum. Despite the importance of the subject, research literature attests lack of understanding and confusion when using the percentage concept and its application among students and even among adults. Parker and Leinhart (1995).
The concept of percentage is used for describing a part of a quantity. Since percentages describe a part of a quantity they are not count like fractions. Fractions have numerous roles and only one of them is a description of a part of a quantity, hence one can replace the fraction with a percentage only when it describes a part of a quantity, "percentages are nothing more than other names to numbers however they differ in one thing: in most cases they are used as operators (Shmueli, 1993)." Robinson and her colleagues in 2000 (Robinson, Thaisy, Inbar and Koran, 2001) already give a different reference to the percentage "Sometimes the percentage is represented as an additional name for a fraction (simple or decimal), but while fractions represent numbers, the percentage represents a fraction of quantity."

Academic Achievements in Word Problems: According to Ovadia (2014), students that are not experienced with learning skills and strategies regarding solving complex math problems, is one of the causers to low achievements among math students. Studies show that weak students who were taught by non-routine mathematical teaching methods, managed to solve word problems by using strategies representing skills, such as- they managed to implement mathematical knowledge containing several math subjects at once, they used a logical linkage, or a rich representation technique of solution to one math problem. Furthermore, it was found that weak students developing the non-routine thinking, will succeed in problem solution. The teaching method affects in a significant and controlled manner on math students. In general, teachers incline to give challenging chores, the require a high cognitive level for high-achieving math students. On the other, when it comes to the struggling students the teachers were found as less challenging, they are in class in order to bring them with small

and basic steps that will lead the students toward the solution. The high-achieving students, are more exposed to frontal hours in which the teacher teaches in class, while the teachers in the low-achieving classes, engage mostly with behavior disorders and discipline on the part of the students and therefore the students do not receive many teaching hours. This is also evident in the mathematical achievements of these students. Achievements in mathematics are necessarily related to the teaching method of the teacher (Ovadia, 2014).

Research Questions: How does the method of solving word math problem in different ways affects (linear solution, table solution, graph solution and series solution) student achievements? Are the differences in the achievements are related to the solution method?

MATERIALS AND METHODS

Populationand Sample: the research population included students of four 10th grade classes from an Arab school in central Israel. The sample included 100 students, learning math with the same teacher. The classes were randomly selected from different field of specialty.The students in four classes are characterized as having a similar math ability level, thus there is no distinct gaps between the classes. The research population was divided to subgroups, three experimental groups and one control group, each group included 25 students. The first group solved the tests by the solution methods with the linear method; the second group solved the tests by the solution methods with the table method; the third group solved the tests by the solution methods with the graph method; and the fourth group solved the tests by the solution methods with the series method.

Research tools

Part A: A general math test and an exam in word problems. This research tool included two exams and tests, the first included 6 questions of word problems regarding traffic, while the second test (see appendix 2) included 3 different questions about percentage.

RESULTS

Analysis of the findings of the first research hypothesis: This research hypothesis claimed that differenced will be found in the students' academic achievements, while using different solution methods (linear solution, table solution, graph solution and series solution). For the examination of this hypothesis, a test for examining the variances of repeated measurements was The findings in Table 2 above show that there was a significant difference between the mean scores of the four groups ($F(3,98) = 6.612$, $p < 0.01$). It was found that the average score of students who used the table solution was the highest with an average of 81.71, after it and without major differences the other three methods, linear with average achievements 73.48, graphs with average achievements 73.26 and series with average achievements 73.84.

DISCUSSION

The research goal was to examine the effect of different methods to solve word problems on the academic achievements and motivation among 10th grade students. Moreover, this research examined the dissimilarities in student academic achievements and the student's level of motivation in learning math, in the context of solving word math problems in different ways (linear solution, table solution, graph solution and series solution). The findings from the research question indicated that there are differences between the three experimental groups in academic achievements in both tests, though in two groups the differences are not statistically distinctive (the graphs and series methods group, in comparison to the differences in the table method group), however, differences were not found in the control group. The findings regarding the achievements of the three groups experiment students indicated that there were differences between the scores of the preliminary test and the those of the second test. Additionally, the findings indicate that there are distinct dissimilarities in achievements of students that used the table solution method in comparison to the other three methods. Addressing the differences between the findings of the four groups that solved with four solution methods, shows that the different ways of teaching methods have an effect on solving word problems (linear solution, table solution, graph solution and series solution).

This finding is consistent with the claims and the findings of Kapah's research (1998) in which she presents different strategies to cope with word problem solution, the main research findings shows that there are distinct differences between the two research groups in academic achievements prior the experiments and after it was held. It is indicated that the research group that studied according with the problem mapping strategy scored better grades after the experiment than the other group that studied according with the SSM method (schematic solution method for word problems which bases on decoding the mathematical text and deriving meaning from it by decoding graphic symbols understanding the explicit content, understanding the linguistic situation) that achieved lower grades after the experiment. A different finding that supports the present research findings, appears in the words of Patkin and Gazit (2009) who emphasize that, one of the popular strategies for word problem solution is the solution strategy that is divided into four stages when in the first stage it is necessary to understand the problem "Understanding the Problem"; in the second stage the examination of the relationship between the different variables of the problem is required, and try to achieve a solution based on the data

Table 2: Averages and Standard Deviations of the Students' Scores in All Study Groups (Pre-Test and Second Test) in the Four Different Solution Methods, and the F Test Value for Repeated Measurements

F	Standard Deviation	average	Kind of method	N	Research variables
6.612**	13.86	73.48	linear	25	Group 1
	10.18	81.71	table	25	Group 2
	15.50	73.26	graphs	25	Group 3
	14.45	73.84	series	25	Group 4

**p<0.01

presented, in other words "Making a plan for finding the connection between the data and the unknown"; in the third stage the plan must be carried out and checking every step; The fourth step is called "Reviewing", this stage means that it can be used to examine the resulting solution, in the words of Polya "Retrospective review". As the different solution methods are, they have pointed out the efficiency of the methods in solving math word problems (though at different levels), which helped the students to understand the word problem, analyze it to components and solving it. This finding rose in the book of Polya (1961) "How to Solve it" in which he offers a four-stage strategy for solving math problems: a) understanding the problem; b) conducting a plan to find the connection between the data and the unknown. If the connection will not be direct – in this case one needs to gather auxiliary problems, and finally to reach a plan for the solution; c) conducting the plan – checking every step – whether it is carried out according to the plan; D) Reviewing - examining the resulting solution. Despite the effect of the solution method appearing in the three-groups experiment, both in the table solution method and the graphs method, as well as the series method, it seems that the most efficient solution method rose from the experimental group using the table solution method.

The results of the table solution method in the experimental group (the second 10^{th} grade) showed that the average achievement of students in this group improved after using the table solution method. This finding is in line with the findings of Schwannebeck (2008), which in her study the students learned to solve word problems by deconstructing each word problem into parts. She noted that a table-based solution made students identify keywords that would help them choose the right action, draw a representation, make a calculation, find the correct label, and check the logical for each word problem. Her research focused on examining the effect of a table-based solution on student performance when solving word problems. Solution through graphs was found somewhat good among the experiment group students (10^{th} grade number 3) that improved their academic achievement a little. This finding indicates that this solution method id popular among students but is difficult to use since it requires analysis of different mathematical connections. This finding coincides with the words of Alboim-Cohen and Cooper (2015) who noted that, word math problem solution via graphs bases on two major elements: a) inter-mathematical connection – solutions basing on Triangular Imagination Solution, this solution starts with a graphic presentation of the problem; b) combination of inter and external mathematical connections – gathering terms from the world of physics and the integral domain for the solution. The third solution receives inspiration from the physical/mathematical connection between the terms "doubt" and "fact". From the necessity of looking for a graphic solution, the link between "work" and "area under a graph" that is familiar from the field of physics came up. Reference to the findings of the series solution method is identical to the findings of the graphs solution method, thus a minor change occurred in the students' achievements in the experiment group (10^{th} grade number 4) who used this solution method since this method obligates a high-order thinking. This finding accord with the words of Bashara (2014) who noted that, mathematical series that require dealing with unusual thinking challenges, evoke questions with no predetermined algorithm and that require a certain extent of braking ordinary thinking molds and moving to a type of thinking characterized by creative features, searching for a new and unknown solution model from data series presenting familiar items, but not in a predetermined context. The solution requires independent assumptions without preconceptions, before the student chooses the solution for the open question.

Recommendation and Practical Recommendation

The main research conclusion shows that, word problem solution regarding traffic and percentage is more efficient when students use table solution method, this is expressed by the students' solutions that based more on the table solution method rather than the linear solution method or the graphs and the series methods, this is evident based on the improvement in the academic achievement of the students in the group of table solution method. Due to the findings of this research, and due to the contribution reflected from the efficiency of the different solution methods and strategies and especially from the table solution method, this research offers several practical conclusions, these are the conclusions:

- As in other solution strategies and methods in math, by using these solution strategies (especially table solution), students can work in small groups as well, which greatly affects the development of their mathematical understanding and their achievements in accordance. Hence, students should be allowed to solve word problems in pairs or groups, creating a learning environment in which the students will be actively involved, the advantage in working in small groups in accordance to the table strategy is the effectivity and efficiency in comparison to other solution methods.
- The role of the math teacher and according to any strategy he uses in his classroom instruction, allows him to let the students act independently without his intervention, this also applies to the different solution methods (tables, graphs, and series). This is particularly evident in the ability of the teacher to create an explorative student who deals with a variety of verbal problems regarding buying and selling and other subjects.
- The teacher must nurture the students' different abilities, especially the basic mathematical abilities (the ability to understand the problem, the ability to observe keywords, the ability to represent the various symbols and the ability to solve) regarding the content of buying and selling and buying and selling in percentages. It is essential that students have the skills required to be successful solvers of word problems, but more importantly, they must think and believe they can solve word problems.
- Improving the quality of teaching in mathematics is an important and significant tool in improving the students' mathematical learning experience, which improves their mathematical understanding and achievements as well as their motivation.

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