The Examining Mathematical Word Problems Solving Ability under Efficient Representation Aspect

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Abstract

Word problem solving is complex process for students. Efficient instruction of word problem solving needed to efficient strategies. One of these strategies is using representation. Some students apply key words or numbers only but when they face complex word problems then they cannot apply the keywords. Therefore teachers have to teach efficient strategy such as representation. In this research is tried whether using efficient representation can lead to efficient solution. Through cluster sampling method, forty one students are selected at girly elementary school. Through math exam, their solutions are studied. Through Spearman test, results indicate that there is significant relation between efficient representation and efficient word problem solving ability. At second grade, students have used of representation, have gotten to high means and inverse, students have not used of representation, have not gotten to high means. Therefore there is significant and direct relation between efficient representation and efficient word problem solving ability.

Keywords: Word problems, mathematics, representation, ability, efficiency.

1 Introduction

Problem solving is a key subject in Standards and Focal Points. Learning how to solve story problems involves knowledge about semantic construction and mathematical relations as well as knowledge of basic numerical skills and strategies. Yet, word problems pose difficulties for many students because of the complexity of the solution process [8, 21]. Because problem solving, in particular word problems as a process, is more complex than simply extracting numbers from a story situation to solve an equation,
The purpose of this research is the study of mathematical word problems solving ability under efficient representation aspect. We will indicate that students who applied representation, better comprehended word problem solving. There are many studies for word problem solving with related strategies. Wertheimer (1985) believed that building adequate problem representation, goal-directed planning, inference and elaborating by using one's world knowledge, testing hypotheses, applying heuristics and comprehension monitoring are seen as basic operational building blocks of problem solving, as well as thinking skills [3,14,27].

Nakamura (2006), on the other hand categorized those mistakes into two different forms such as language problems and the ongoing problem solving process. These categorization proposed by them is actually the continuity of what Newman had said. This understanding can identify the influence of language factor on learning mathematics and its corresponding remedial efforts taken in the teaching and learning process [4]. Some of the questions that can be asked to the students for the purpose of recognizing their errors are:

1. Please read this problem for me. If you cannot read it just ignore it.
2. Tell me what does this question wants you to solve.
3. Tell me how you get the answer.
4. Show me how did you solve the given problem.
5. Now, write down the answer you had gotten before in the space provided [20].

Schoenfeld (1987) pointed out that the knowledge of meta-cognitive and cognitive skills will help students build a thinking plan which involves strategy, skills and procedures to solve the given problems. This new thinking plan is connected to the students' understanding of the relevant mathematical concepts that will be used. While solving the problems, students will go through two phases such as interpretation of the mathematical language and the calculation process [6, 11, 25]. Newman (1977) also postulated that both language and mathematical acumen are necessary for the successful solution of mathematical exercises [20]. Furthermore, Lerman (2001), cited in Parvanehnezhad and Clarkson (2008), wrote of "strategies", which are mathematical content knowledge that learners need to bring with them to a mathematical task together with the ability to interpret and comprehend mathematical jargons and semantics in order to successfully comprehend and solve mathematics problems [1, 7, 16]. As Gagne (1979) suggested, in the process of mathematical word problem solving, student should be able to translate the concrete to the abstract and the abstract to the concrete. Therefore the mathematical word problem exam is more unique and challenging task than the ordinary mathematics task. Mathematical problem solving is a "cognitive activity" involving processes and strategies [7]. Montague (2006) defined mathematical word problem solving as a process involving two stages: problem "representation" and "problem execution". Both of them are necessary for problem solving successfully. Successful problem solving is not possible without first representing the problem appropriately. Appropriate problem representation indicates that the problem solver has perceived the problem and serves to guide the student toward the solution plan. Students who have difficulty representing math problems will have difficulty solving them. Mathematical problem solving also requires "self-regulation" strategies [3, 19]. Mayer (2003) divided mathematical word problem solving into four "cognitive phases": translating, integrating, planning and execution [13, 18, 10]. Thus, students normally find difficulty in solving word problems firstly from translating the word representations into mathematical representation. Related problem to this was students’ difficulty in deriving "mental images" which then followed by operative actions "transforming in to dynamic images, invoking images of formulae from memory" [1, 24]. Hegarty et al (1995) argued that we contrast two general approaches to understanding mathematical word problems that have been introduced by previous researchers: "a short-cut approach" and a "meaningful approach" that is based on an elaborated problem model. In the short-cut approach, which we refer to as direct translation, the problem solver attempts to select the numbers in the
problem and key relational terms and develops a solution plan that involves combining the numbers in the problem applying the arithmetic operations that are primed by the keywords or cues (e.g., addition if the keyword is "more" and subtraction if it is "less"). Thus, directly the problem solver attempts to translate the key propositions in the problem statement to a set of computations that will produce the answer and does not construct a qualitative representation of the situation described in the problem. In the meaningful approach, which we refer to as the problem model approach, the problem solver translates the problem statement into a mental model of the situation described in the problem. The problem model differs from a text base in that it is an object-based representation, rather than a proposition-based representation. This mental model then becomes the basis for the construction of a solution plan [4, 9]. Griffin and Jitendra indicated (2008) many research studies in the past decade have emphasized a model of schema-mediated problem-solving instruction. These studies have focused on (a) schema-mediated problem-solving instruction that used either number line diagrams for understanding the semantic structure of compare word problems or schematic diagrams for solving a range of word problems, (b) schema-induction instruction, (c) schema-broadening instruction with explicit instruction for supporting transfer by focus on similar problem types, and (d) schema-broadening instruction with meta-cognitive instruction. Collectively, this research shows that the effects for schema-mediated problem-solving instruction are positive [12]. Hegarty and Kozhevnikov (1999) has approved that the use of visual representations was associated with success in mathematical problem solving, whereas use of pictorial representations was negatively correlated with success [10]. Lean and Clements (1981) also found that there are different types of visual representational strategies used by students when solving mathematical problems by separating student-generated imagery into five categories: concrete imagery, pattern imagery, kinesthetic imagery, dynamic imagery, and memory of formula [17]. However Presmeg (1986) argued that concrete imagery (vivid pictorial images of objects contained in mathematical problems) may actually focus the reasoning on irrelevant details and distract the “solver” from the main element of the problem [1, 17, 23]. Duru (2011) investigated the pre-service primary school teachers’ problem solving preferences in the word problems. The study showed that the pre-service primary school teachers preferred various problem solving strategies, such as arithmetic, algebraic, use a model, guess-and-check, find a pattern, model and algebraic strategies for solving of the word problems [6]. Peker (2009) reported that having a good understanding of a problem solving process was the first step in learning how to teach it and the instruction using problem solving strategies gave the pre-service teachers a chance to learn the way how to teach. It is necessary to introduce various strategies to pre-service primary school teachers so that they can use these strategies in solving problems [22, 29]. On other hands, teachers of preschools and primary schools are noticed that one of the discovered scopes is the integration of language in particular comprehension in reading and mathematics. Although these two scopes are unequal but both are based on cognition. Seifi et al (2012) attempted to detect students’ difficulties in solving mathematical word problems from their teacher’s perspectives. Participants were 52 mathematics teachers of Arak middle schools whom were chosen randomly. The results showed that the student’s difficulties were mostly sprung from their disabilities in representation and understanding of word problems, making a plan and defining the related vocabularies. The findings revealed that, the causes of the student difficulties were text difficulties, unfamiliar contexts in problems and using inappropriate strategies. Finally teachers suggested to help students in teaching them to look for a pattern, draw a picture and rewording the problems [27]. Regard to pervious researches for word problem solving and the lack of research in this scope, we tried that studied mathematical word problems solving ability under efficient representation aspect. Bruner (1964) believed that one factor of cognitive development is the knowledge representation ability. In fact, representation in word problem solving process makes to indicate real comprehension of words and concepts in problem [2, 26]. Word problem solving is one of the important components of mathematics problem solving which incorporate real life problems and applications. However, many researches
revealed that students express great difficulties in handling a word or story problem [3]. Word problem is actually a story problem and the students normally have to relate between the known and the unknown. Reading in word problem solving is the derivation of conception from written text or word problem solving. In this dynamic process, reader communicates to text or word problem solving till success on discovery of purpose. Reader applies whatever knows for text or word problem solving such as how structures of text and its words used. Some efficiency strategies for reading of word problem solving is stated as;

1. The comprehension of relations.
2. asking questions.
3. induction and predication.
4. determination of important.
5. integration and compilation.

On other hand, after reading phase in word problem solving, representation is very important because students' comprehension is determined and it indicates correct solution. A representation is defined as any configuration of characters, images, concrete objects etc. that can symbolize or "represent" something else [13, 14]. For example the representation in "Fractions" indicates as "1/4" can refer to a diagram in which a circle is partitioned into four parts, one of which are shaded. Students usually use of number line as representation that it seems to ease the problem solving process. If teachers did not teach efficient representation for students then student/s won't comprehend problem and it will be not implemented efficient solution. The uses of visual representations in mathematical word problem are very useful. In elementary mathematics teaching and curriculum design, a representation that plays an important role in the teaching of basic whole number operations, and generally in arithmetic, is the number line [15]. Most educators and researchers agree that key to understanding, communicating, and effectively operating on mathematical concepts is connected to performing representation among these graphical, tabular, symbols and words.

After first section of this paper; introduction, the remainder of the paper was organized as follows;

section 2. used research method and instrumentations; used methodology and instrumentations and the reasons of use of them will be indicated.

section 3. participants; statistical society will be determined.

section 4. data analysis method; applied statistical methods will be explained.

section 5. findings and discussion; resulted data will be studied.

and finally and conclusion; efficient strategies will be discussed respectively.

Hypothesis
There is significant relation between using efficient representation and efficient word problem solving ability.

2 Research Method and Instrumentation

In present study, it is tried that used of correlational research method. In this method, relation between two or among many variables (features or events) determined. Through this method, it could determine time relation among variables and its predication relation. Correlational research is a useful method of investigating the relational among the variables. Just having knowledge about the existence and strength of the relationship among factors is valuable because it enables researchers to the gain an understanding of the association among the phenomena. Then researchers have applied this method till could study the efficient representation on efficient ability in word problem solving. There are two variables; representation ability and problem solving ability that relation between two variables will be studied. Math
exam is considered as instrumentation in two parts. Separately math exams were written for second and third elementary grades that math exam was consisted of four and five word problems for third and second grades respectively. General score was eight and ten for third and second grade respectively. Questions were designed so that student must implement suitable representation for each question. Questions were covered whole textbook almost. Math exams were designed so that covered all mathematics scopes nearly for both grades. In these questions, students have to use of representation method and if students do not use of efficient representations then they can get to correct solution. Content reliability was proved under teachers and professors' opinions and validity of these exams is studied through Split-Half test (α= 0.75) then its result indicates that has validity. In this method, researchers ask of students that have to write whole their solution on the pages. Through this method, researchers will note to how their responses. Researchers will observe that which student has used of representation for problem solving and whether using representation was efficient.

3 Participants

Statistical society was all girly elementary schools in Chahar-Mahalobakhtiyari province in present study. Researchers have used cluster sampling method then one girly elementary school is selected that has 120 girl students and second and third grades are selected from respect school. Forty one girl students are selected of second and third grades. Mathematical knowledge and skill levels of these students are same in term of teachers' opinions and their pervious exams.

4 Data Analysis Method

After collecting data, researchers have tried that use proper tests such as; descriptive and deductive statistics. In descriptive statistics, it is explained data in term of mean, std then data is summarized in following Tables and Figure. Finally resulted data is studied under Spearman test in meaningful level of 0.05.

5 Findings and Discussion

Regard to Table 1, 2 and 3, it clears that students who have used of efficient representation, they have gotten better scores. In third grade, students often have not applied representation and it was clear that they have less scores rather second grade. Code 0 and 3 are more seen among questions for second and third grades.

Table 1: Descriptive statistics

| Grades    | N | Mean | Std |
|-----------|---|------|-----|
| Second Grade | 20 | 7    | 1.37|
| Third Grade  | 21 | 2.1  | 0.68|
Table 2: Frequency of responses for second grade

| Codes  | Frequency |
|--------|-----------|
| Code 0 | 18        |
| Code 1 | 1         |
| Code 2 | 10        |
| Code 3 | 20        |

Note:
- Code 3: The student has used representation and his/her response was correct.
- Code 2: The student has used representation and his/her response was not correct.
- Code 1: The student has not used representation and his/her response was correct.
- Code 0: The student has not used representation and his/her response was not correct.

Table 3: Frequency of responses for third grade

| Codes  | Frequency |
|--------|-----------|
| Code 0 | 21        |
| Code 1 | 6         |
| Code 2 | 1         |
| Code 3 | 1         |

After studying the normality of data for both grades, it is used of Spearman test. As it is shown in Table 4, it is obvious that there is significant relation between using efficient representation and efficient word problem solving ability (P<0.05) and inverse. Also correlation coefficient equals to 1 and 0.53 that these values near to 1. That is, there is positive correlation between number of code 3 and means.

Figure 1: Diagrams of frequency of used code 3
Table 4: The results of spearman test for second grade

| Spearman's rho | Second Grade | Mean | Code 3 |
|----------------|--------------|------|--------|
| Mean           |              | 1    | 0.53   |
|                | Spearman's   |      |        |
|                | Correlation  | 1    |        |
|                | Coefficient  | 0.53 |        |
|                | Sig. (2-tailed) | 0.01 |        |
|                | N            | 20   | 20     |
| Code 3         |              | 1    |        |
|                | Spearman's   |      |        |
|                | Correlation  | 0.53 |        |
|                | Coefficient  | 1    |        |
|                | Sig. (2-tailed) | 0.01 |        |
|                | N            | 20   | 20     |

As it clears in Table 5, it is obvious that there is significant relation between using efficient representation and efficient word problem solving ability (P<0.05) and inverse. In addition, correlation coefficient equals to 1 that these value equals to 1. That is, there is positive correlation between number of code 3 and means.

Table 5: Frequency of responses for third grade

| Spearman's rho | Third Grade | Mean | Code 3 |
|----------------|-------------|------|--------|
| Mean           | Spearman's  |      |        |
|                | Correlation | 1    | 0.92   |
|                | Coefficient | 0.92 |        |
|                | Sig. (2-tailed) | 0.00 |        |
|                | N            | 21   | 21     |
| Code 3         | Spearman's  |      |        |
|                | Correlation  | 0.92 |        |
|                | Coefficient  | 1    |        |
|                | Sig. (2-tailed) | 0.00 |        |
|                | N            | 21   | 21     |

Regard to Tables and Fig.1, students who have used of representation, their means was higher than other students. At second grade, students have used and applied representation (code = 3) then they have gotten to high means efficiently. Inverse, students of third grade have not used of representation (code = 0) then they have not gotten to high means. Therefore, it clears that there is significant relation between using efficient representation and efficient word problem solving ability. This relation is direct.

**Conclusion**

Word problem solving is one of the important elements of mathematical problem solving which incorporate real life problems and applications. But in word problems solving, some students are faced with difficult items including:  
1. Some students are not able to adequately define mathematical problems. In these situations, teachers must give verbal instructions to solve such issues for students till they able to meet their real-world problems.  
2. Students who do not have sufficient experience in word problems solving, select a fast solution quickly and this solution may be hasty in some theological questions. In these situations, teachers need to teach students to define the problem and develop a conceptual plan. That is, teachers have to apply sufficient representations.  
3. Some students cannot use of the fixation. They do not know which problem need to use "addition" or "subtraction" operation. To address these problems, we need to teach students to see the words from another angle in problems.  
4. Lack of motivation, and the reluctance of some students to solve word problems to be seen. This is because teachers at the beginning of their training, the use of complex theological issues and by the way, the student feels his disability in his early solution to indoctrination that teachers cannot help to solve the problem. It is necessary that the teachers have to ease and consistent difficult problems to real world issues at the beginning of their training.
5. Some students understand the concepts of theological issues, they do not understand because the location of problem is palpable for them. Teachers should teach word problems from the beginning of their training on an actual procedure.

For example, "multiplication" or "division" to solve problems, teachers have to use of sensible status such as buying one ice cream from a store or so on. To use these situations in mind, students will be able to extend self-knowledge and understanding. So we can conclude that word representations suggest to solve problems via vital and important ways. In this study, we tried to study the effects of efficient representation of the mathematical word problems. The results showed that the representation will be easy to solve word problems. The representation must be taught by teachers or tutors enable students to solve word problems. Hence it is recommended for future research and teachers;

1. Theological concepts have to be taught via efficient plan or representation for mathematics education.
2. Provide and prepare educational courses for teachers or educators. These courses will be made till teachers introduced creative and fantastic methods for word problems solving.
3. Teach accurate generalization for word problems. Students have to learn that they did not any solution for any problem. This item could implement through accurate representation for word problems solving.

This study has several limitations. This research was limited to elementary grades, math textbook and girl students.

Appendix A - Math Exam for second grade

1) Maryam has 5 notebooks of 100 pages and Ali has 4 notebooks of 100 pages. Altogether, how many have they notebooks of 100 pages?

2) Zahra is 5 years older than his sister. After 5 years, Mary is 25 years old. Then how old is Zahra?

3) We have 15 apples. Of 15 apples, we gave 3 apples to Neda and 2 apples to Reza. We want to give the rest of the apples to Ali and Maryam. If we gave 2 apples to Ali less than Reza, how many apples can finally give to Maryam?

4) Today is August 25th. Next 5 days in what will be a month?

5) In a bag, we have 3 long red pencils and 8 short green pencils. We want to eject a pencil from the bag randomly. What pencil do you think is more likely to come out?

Appendix B - Math Exam for third grade

1) See the Triangle (1) and the Triangle (2). The Triangle (1) is twice the Triangle (2). Are diameters of Triangle (1) twice the Triangle (2)?
2) Suppose, we have a 10 baskets. Each one has 15 bananas. If we added 10 bananas to any of the baskets, how many will have we bananas?

3) One km distance is from your home to school and 2 km from school to store. How long is meter from home to store?

4) If you moved from home to school at 11:00 clock, after 30 minutes, you get home. 45 minutes ago, where were you?

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