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IDENTIFY THE TYPES OF ERRORS IN SEVENTH GRADE STUDENTS IN SOLVING MATH WORD PROBLEMS

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Abstract

The key purpose of this study is to recognize the types of errors of seventh-grade students in solving mathematical word problems based on the theoretical model of Hoods and Notling (1998). This study is applied in terms of purpose and descriptive in terms of implementation. The statistical population of this study includes all seventh-grade female students in the District 15 of Tehran in the academic year of 2016-2017. The study sample is 192 seventh-grade students of one of the girls' high schools in the District 15 of Tehran. To this end, a test including word problems questions was designed, similar to the word problems of the seventh-grade math textbook. The descriptive statistics method was used to analyze the obtained information. Likewise, the face and content validity of the test was confirmed by several professors and teachers with experience in mathematics education. The validity of the questions was confirmed by the CVR content index, which was greater than 0.54, and the Cronbach's alpha coefficient of 0.722 was obtained, which indicates a good status in terms of its reliability. The results revealed that most of the students' errors in solving word problems of arithmetic and algebra and geometry are conceptual errors, followed by rule errors and then application errors. Lastly, there are errors of inaccuracy. Also, research results showed that students' errors in solving mathematical word problems are due to a lack of semantic knowledge, computational knowledge, structural knowledge, and mathematical knowledge. Being long and multi-stage is another cause of student errors.

Keywords: Types of errors, Word problems, Problem-solving, Seventh-grade students

INTRODUCTION

Problem-solving from the Math Teachers Council (2000) point of view means engaging in a task for which there is no pre-determined solution (EssamAbdou Ahmed Saleh, 2020; Aliya, et. al., 2020). In the case of word issues, this process manifests itself in understanding the issue and translating it into symbolic expressions. This transfer of the problem from linguistic vocabulary to mathematical symbols, which is somehow introduced in modeling, poses many challenges for studentsmathematical modeling means translating a real situation into a mathematical model, is a process through which mathematics is related to the real world, and is a process that in turn enters the process of solving word problems. In some cases, it poses serious challenges to students. These challenges sometimes manifest themselves in application errors in solving the word problem. Student errors are classified into three categories: random errors, structural errors, and application errors. Random errors or inaccuracies cause students to ignore some available information when solving a problem. Structural errors also include conceptual errors and rule errors that result from a misunderstanding of the concepts and rules of action associated with them or the misuse of rules, leading to misconceptions about the structure of the problem and a deep understanding of the relationships in the problem to discover ideas. The executive errors that Hoods and Nolting (1998) refer to as operating errors are errors that students make due to their inability to adapt the concepts to their practical situation, and usually due to improper performance of exercises

and manipulations; though, they may have understood the rules correctly.

The significant point about errors is that they can be a tool for teaching math. This means that teachers deliberately make purposeful errors in their teaching methods and design and manage the subject of learning to make students pay more attention to it.

According to behaviorists, conceptual errors are not particularly important because, in this view, the concepts in students' minds are not related to learning. However, errors and misunderstandings are like defective bytes in computer memory that if we do not like them, we can erase them or write on them by telling the right concepts to the students. However, from the constructivists' point of view, errors and misunderstandings are very important in teaching and learning because misunderstandings are part of the student's conceptual structure that interact with the new concept and affect the learning of new concepts. Because misunderstandings are the source of error, these effects are often negative (Strike, 1983, quoted by Oliver, 1989).

Though many students have high mathematical intelligence and talent, by replacing their misconception of math concepts with the main concept, they get wrong results while thinking that they have learned math concepts correctly, now one must think to identify these misconceptions and eliminate them, and even these misconceptions can be used as an opportunity for students to learn and receive feedback to reduce problems related to this area of learning as much as possible. In this study, the researcher intends to identify students' errors in solving word problems to be aware of students' perceptions about the subject and knowingly design a suitable teaching method to solve the problem.

Theoretical foundations of research

Mathematical Word Problems

Word math problems form the core of the math curriculum. In many countries, textbooks and assessments require students to solve word problems. For example, (Garner, 2006) claimed that in the United States, a large part of the school math curriculum is devoted to word issues. The prominence of word problems is such that they have a special status in most intelligence and academic aptitude tests. Nevertheless, researchers have shown that most students, and even some students, cannot solve word problems (Lewis and Mayer, 1987). These studies have interested some researchers in mathematics education (Schoenfeld, 1985) in the pathology of this phenomenon. In their studies, they found that the prerequisite for success in solving mathematical problems and understanding the principles and concepts of mathematics is to be equipped with cognitive and metacognitive strategies.

Weist (2004) and Haghverdi (2012) have researched this issue in separate studies and have concluded that personalization and familiarization with word problems enhance the student's understanding of the word problem and increase his or her ability to solve problems. In his research, Haghverdi (2005) examined the strategies used by high school students to solve word problems and found that most students use direct translation strategies to solve such problems and found that most students use a direct translation strategy to solve these types of problems. In his latest research, h also showed a connection between the types of errors made by sixth graders and the lack of knowledge needed to solve word problems.

Word problems have been widely used in the mathematics curriculum of the first secondary school. In addition to arithmetic problems, word problems of algebra and geometry have also been used in this course. In this course, despite the development of language skills, students still face many problems in understanding and representing word issues (Pape, 2003; Bautista et al., 2009; Mayer, 1992; Haghverdi et al., 2011). First high school students, although less likely to have arithmetic procedures and skills than elementary school students, are not able to solve math word problems with similar arithmetic procedures (Meyer and Hagarti, 1996).

Among the factors affecting the solution of word problems, the role of language and how to express the problem has been further studied (Batisa et al. 2009, Davis-Dorsey et al. 1991, Dickort et al., 1985). Changing the wording of the text of the problem is one of the cases that has attracted the attention of many researchers to create a better understanding of the problem.

Many researches have examined the improvement of students' performance by applying various changes in the text of the problems. Consequently, the studies done in the rephrasing word problems can be divided into two categories to facilitate the solution process: Studies that focus on changing the context in which the problem is described

(Stern et al., 1992; Davis-Dorsey 1991; Cummins et al. 1998; and Stubb and Reusser 1995); and studies that focus on changing the sentences of verbal problems (Dickort et al., 1985; Cummins 1991; Davis-Dorsey et al. 1991, Eric, 2005; and Vicente et al., 2007).

Changing the wording of the text of the problem has been classified in different ways. According to the reviewed studies, changing the wording of the text of the problem and changing the wording of the problem has been considered and used by researchers more than in other cases.

Types of student errors

Analyzing students' errors in solving word problems is also valuable, as is examining their ability to reveal students' mental behavior to understand and solve word problems. Many researchers, including De Corteet al. (1985), Cummins et al. (1988), and Lewis and Mayer (1987), have examined students' errors in solving word problems. Both Newman (1977) and Casey (1978) have already developed frameworks for analyzing student-made errors in solving verbal arithmetic problems.

Clements (1982) concluded that students typically make two syntactic and semantic errors in solving word problems. The syntactic error occurs due to the direct translation of the problem, and semantic error results from the student's insufficient understanding of the text and language of the problem. Errors made by students at different ages vary (Salman, 2002). Fajmidagba (1986), studying the types of errors of first and second-year high school students and in studies on students, came to the common conclusion that most of the errors of these two groups fall into two categories: syntactic and semantic errors.

Newman (1977) also divided students' errors into fundamental errors and unintentional errors into two important categories. He considers errors such as carelessness, distraction, and confusion to be unintentional errors and introduces errors related to not having the mathematical knowledge necessary to solve the problem as fundamental errors. In their research, Ashlock, 1983state that there are many types of computational errors. These errors include miscalculations, improper substitutions, misdiagnosis, random answers, and errors due to carelessness and inadequate attention to the problem.

It can be mentioned that the teaching of inappropriate strategies by teachers in preceding courses causes students to solve word problems only to find numbers and keywords within the problem. Because they have not received appropriate training in understanding and recognizing mathematical word problems, they use mathematical operators without knowing the numbers in the problem. Not having enough knowledge in using the type of operator is another major cause of students' errors in solving word problems.

Findings

The results of this research are accessible in three parts. In the first section, students' responses are analyzed. In the second part, the causes of their errors in solving word problems are examined. In the third part, there are examples of students' errors.

Part 1: This section comprises analyzing students' answers to test questions.

1. Students' performance in solving arithmetic word problems

Problem 1. The air temperature in Tehran is 5 degrees above zero, and the air temperature in Mashhad is 8 degrees colder.

A) What is the temperature of Mashhad?

B) Calculate the average temperature of the two cities (using the appropriate strategy)

Table 1. Number and percentage of the relative frequency of students' errors in solving problem 1, parts a and b

	Types of errors	Number of errors	Percentage of the relative frequency of each error to total errors
Problem 1 Part A	Inaccuracy errors	11	24%

	Conceptual errors	28	61%
	Rule errors	7	15%
	Application errors	0	0%
Problem 1 Part B	Inaccuracy errors	6	6%
	Conceptual errors	28	27.5%
	Rule errors	68	66.5%
	Application errors	0	0%

Problem 2: A building consists of 7 floors on the ground floor and three floors below the ground floor. Maryam is on the 2nd floor. She went up three floors, then went down two floors, and from there, she went up five floors. Which floor is Maryam on now? (Using the right strategy)

Table 2. Number and percentage of the relative frequency of students' errors in solving problem 2

Types of errors in problem 2	Number of errors	Percentage of the relative frequency of each error to total errors
Inaccuracy errors	13	27.5%
Conceptual errors	21	44.5 %
Rule errors	5	10.5%
Application errors	8	17.5%

Problem 5. We have two containers with 24 and 36 liters, and we want to fill these two containers with cups 1 and 2 and ... 36.
A) Which cups can be used for each container?
B) Specify the common cups of these two containers.
C) What is the largest common cup that can be filled with these two containers?

Table 3. Number and percentage of the relative frequency of students' errors in problem 5

Types of errors in problem 2	Number of errors		Percentage of the relative frequency of each error to total errors	
1- Inaccuracy errors	A	15	A	16.5 %
	B	16	B	20.5%
	C	3	C	6%
2- Conceptual errors	A	40	A	44.5%
	B	25	B	32%
	C	14	C	28.5%
3. Rule errors	A	28	A	31%
	B	34	B	43.5%
	C	27	C	55%
4-Application errors	A	7	A	8%
	B	3	B	4%
	C	5	C	10.5%

Question 6: In a computer game, bead A moves six by six, and bead B moves nine by 9. At the beginning of the game, both beads are at zero. In which number do these two beads fit together again?

Table 4. Number and percentage of the relative frequency of students' errors in problem 6

Types of errors in Problem 6	Number of errors	Percentage of the relative frequency of each error to total errors
Inaccuracy errors	1	2%
Conceptual errors	39	67%
Rule errors	3	5%
Application errors	15	26%

2. Students' performance in solving algebra word problems

Problem 3. The entrance fee for a parking lot is 5000 Tomans, and 400 Tomans is paid for each hour of car parking

A) Write the parking cost of each car for *n* hours in algebraic terms.

B) If a car is parked in this parking lot for 5 hours, how much should the driver pay when leaving?

Table 5. Number and percentage of the relative frequency of total errors of students in solving the problem 3

Types of errors in problem 3	Number of errors		Percentage of the relative frequency of each error to total errors	
1- Inaccuracy errors	A	4	A	5 %
	B	10	B	11 %
2- Conceptual errors	A	70	A	83 %
	B	78	B	83 %
3. Rule errors	A	10	A	12 %
	B	2	B	2 %
4- Application errors	A	0	A	0
	B	4	B	4 %

Problem 4. Zahra and Maryam have bound 64 volumes of books. If Zahra had bound 12 more volumes of books, how many volumes of books have they each bound?

Table 6: Number and percentage of the relative frequency of total errors of students in problem-solving 4

Types of errors in Problem 4	Number of errors	Percentage of the relative frequency of each error to total errors
1- Inaccuracy errors	5	3.5%
2- Conceptual errors	118	82.5%
3. Rule errors	14	10%
4- Application errors	6	4%

3. Students' performance in solving geometry word problems

Problem 7. We have a water source in the form of a cylinder with a radius of 4 meters and a height of 10 meters. How many liters is its volume? (It is necessary to write a formula and draw a shape.)

Table 7. Number and percentage of the relative frequency of total student errors in problem 7

Types of errors in Problem 7	Number of errors	Percentage of the relative frequency of each

		error to total errors
Inaccuracy errors	14	8.5%
Conceptual errors	7	4%
Rule errors	86	50.5%
Application errors	63	37%

Problem 8. The water source is in the form of a prism with the base of a right triangle, and with sides 3, 4, and 5 and a height of 8 meters, the triangle's base is on the ground. If we paint this source at the cost of 3000 Tomans per square meter, how much do we have to pay to paint its walls? (It is necessary to write a formula and draw a shape).

Table 8. Number and percentage of the relative frequency of total student errors in solving problem 8

Types of errors in Problem 8	Number of errors	Percentage of the relative frequency of each error to total errors
Inaccuracy errors	5	5%
Conceptual errors	23	23%
Rule errors	62	63%
Application errors	9	9%

Problem 9. In a checkered coordinate board game, Mobina moves her bead from a square with the coordinates of A=(4 and -3), first, five squares to the left and two squares down, and in the second move, eight squares to the right and seven squares to the top. Where is the Mobina bead now? Call this point B and write the coordinates of the vector AB (draw the figure).

Table 9. Number and percentage of the relative frequency of total student errors in solving problem 9

Types of errors in Problem 9	Number of errors	Percentage of the relative frequency of each error to total errors
Inaccuracy errors	10	6.5%
Conceptual errors	93	60.5%
Rule errors	22	14%
Application errors	29	19%

Part 2, This section examines the causes of students' errors in solving math word problems. This was done by reviewing the interviews and the data collected.

1. The cause of students' errors in solving the arithmetic word problems

Major student errors with 41.5% of all the errors made in such problems were related to conceptual errors. It can be said that inability to draw correctly and accurately resulted from students' lack of semantic knowledge.

2. Cause of students' errors in solving algebra word problems

The major errors of students with 83% of the total errors made in such problems were related to conceptual errors. It can be said that the inability of students to create an algebraic equation and the algebraic word problems into mathematical symbols and signs is due to their lack of structural knowledge. Computational errors, especially in solving algebraic equations, are related to students' lack of computational knowledge.

3. Cause of students' errors in solving geometric word problems

The major errors of students with 40% of the total errors made in such issues were related to rule errors. It can be said that students' inability to draw a correct and accurate form resulted from their lack of semantic knowledge. Their unfamiliarity with formulas related to volume and area is due to students' lack of mathematical knowledge. Computational errors and their inability to convert measurement units result from students' lack of computational knowledge.

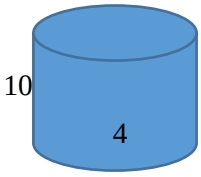
Part 3, In this section, an example of students' errors in solving word problems is given.

In the following example, there is a conceptual error in the first and second questions, and the

student has not been able to correctly convert the word problem into an algebraic one.

3	The entrance fee for a parking lot is 5000 Tomans, and for each hour of car parking, the amount of 400 Tomans is paid. A) Write the parking cost of each car for that hour in algebraic terms. *400 n* x *5000 = 2000* B) If a car is parked in this parking lot for 5 hours, how much should the driver pay when leaving? *When leaving, s/he must pay 2 thousand Tomans* *400* x *50000 = 2000*
4	Zahra and Maryam have bound 64 volumes of books. If Zahra has bound 12 more books, how many books have she bound each? *Maryam has bound 44 volumes of books. 64/2 = 32* *32 + 12 = 44* *44 + 20 = 64* *Because she has bound 20 volumes of books.*

In the following example, the student has a rule error in the first question and has not written the volume formula correctly. In the second question, the student has a mistake in using the color cost in the volume calculation operation

7	We have a cylindrical water tank with a base radius of 4 meters and a height of 10 meters. Its volume is a few liters. (Writing formulas and drawing shapes is required). *Base * radius / height* *4 * 3.14 =12.56 / 10 = 125.6 (volume)*  *I realized that I had to get the volume of the cylinder.*
8	The water tank is in the form of a prism with the base of a right triangle and with sides 3, 4 and 5 meters and a height of 8, the base of the triangle is on the ground. If we paint this tank at a cost of 3,000 Tomans per square meter, how much do we have to pay to paint its walls? (Writing formulas and drawing shapes is mandatory). *5 + 4 + 3 = 12* *12 * 3000 = 36000* *36,000 * 8 = 485* *I realized that I had to calculate the amount we had to pay to paint the wall.* *We have to pay 485 Tomans for painting.* (Explain).

CONCLUSION

This study revealed that inaccuracy and anxiety of the exam, low speed in solving the problem, poor reading skills, and indifference and daydreaming of the student while solving the problem cause random errors. The most important errors of students' inaccuracy in the arithmetic word problems are carelessness in counting on the axis of numbers, incorrect placement of problem numbers, misplacement of numbers; for example, the student knows the counters of a number well, but in writing, s/he leaves out some of them. The most important students' inaccuracy errors in solving algebraic word problems are writing more or fewer zeros in front of numbers, incorrect placement of numbers

in the equation, inaccuracy in addition and subtraction of natural numbers despite having skills in this type of addition and subtraction. The most important students' inaccuracy errors in solving geometric word problems are writing more or fewer zeros in front of numbers, adding and subtracting natural numbers, and counting on the number axis.

The results indicated that in arithmetic word problems, the most important conceptual errors are not learning the axis of numbers (representation of integers), lack of understanding the concept that temperatures above zero are written with a positive sign and temperatures below zero are written with a negative sign, lack of understanding the concept of counters of one number as well as common counters of two numbers and the largest common counter of two numbers, the lack of understanding the concept of multiples of one number and also the common multiples of two numbers and the smallest common multiple of two numbers. The most important conceptual errors in algebraic word problems are students' inability to convert word problems into mathematical symbols and signs and their inability to solve algebraic equations. In the geometric word problems, the most important conceptual errors are the lack of sufficient mathematical knowledge to solve geometric problems such as lack of understanding of the concept of area and perimeter, inability to draw geometric shapes, lack of familiarity with the coordinate axis and its four-way sign, lack of understanding of the concept of coordinates of a point as well as a vector.

This study revealed that in arithmetic word problems, the most important rules errors are lack of correct learning of the rules of addition and subtraction, multiplication and division of integers, and the rules of calculation of greatest common divisor and least common multiple. In algebraic word problems, the most important rule errors are non-learning or incomplete learning of the simplification of algebraic expressions and the numerical value of an algebraic expression and solving an algebraic equation. In geometric word problems, the most important rule errors are using wrong formulas, such as incorrectly writing area and volume formulas, or in vector problems, they do not add and subtract vectors correctly.

The students' most important application errors in solving algebraic, geometric, and arithmetic word problems, are their inability to match mathematical concepts with real-world concepts. For example, obtaining a negative number for the cost of building paint or parking costs, obtaining a number greater than the cups specified in the problem for the largest common cup, and other errors indicating the student's inability to relate mathematical concepts to the real world.

This study shows that students make the most syntax errors in solving word problems of algebra, which is consistent with Haghverdi's research (2012). Because in the arithmetic word problems, only four main operators are used for calculations, while in the algebraic word problems, the unknowns of the problem are determined by adopting variables and assigning data to them and forming an equation, and then solving them. During this process, in addition to manipulating algebraic expressions, arithmetic operators are also used, so students' errors in solving this type of problem include a wider range of errors than errors in solving arithmetic word problems. So, they have common errors.

Based on the research results, it is suggested to math teachers to teach math topics along with pointing out common errors in that topic. Pay enough attention to students' prerequisites and identify and correct errors in this area to create meaningful new learning. Likewise, the way the teacher presents the teaching materials should be appropriate for the student's level.

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