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EDUCATION ACROSS BORDERS

"CRITICAL THINKING IN EDUCATION"

31 October – 1 November 2014

KORÇË

BOOK OF PAPERS

CRITICAL THINKING

ISBN (print): 9789928146274 ISBN (on line): 9789928146212

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Title : 2nd International Conference Education Across Borders "Critical Thinking in Education"

Conference Organizers
This international conference is organized in the framework of implementing the tripartite agreement among the Faculty of Education and Philology, Korçë; the Faculty of Education, Florina and the Faculty of Education, Bitola.

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ISBN (print) 9789928146274
ISBN (on line) 9789928146212

Publishing house: **"PROMO PRINT**" Sh.p.k

ISBN (print) 9789928146274 ISBN (on line) 9789928146212

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PROBLEM SOLVING SCIENTIFIC MODES USED WHEN DOING WORD PROBLEMS

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Abstract
The negative attitude towards Mathematics may present an obstacle in students' learning and may limit their potentials. Many students become discouraged when they hear that the Natural Sciences entail knowledge of mathematics. Although the teacher and some more gifted students find the word problems easy, most students do not feel so. Instead, they develop aversion to the word problems regardless of the fact that they are essential in solving scientific problems. Word problems solving is a complex task which entails the integration of many concepts, facts and methods. Unlike to arithmetic problems presented with standardized symbols and requiring specific algorithms application, word problems are very diverse and can often be solved in several ways. Translation of word problems into math symbols is one of the most difficult parts in word problems solving, but also the most important one. Without it, math would be impossible to apply with real problems solving. This paper presents several methods for solving word problems which contribute to the development of critical thinking with students.
Key words: scientific skills, word problems, translation/interpretation, natural language, mathematical symbols

Introduction
The negative attitude towards Mathematics may present an obstacle in students' learning and may limit their potentials. Many students get discouraged when they hear that the natural sciences demand knowledge in mathematics.

Even though the teacher and some more gifted students find the word problems easy, most students do not feel so. Unfortunately, aversion is being developed with students towards the word problems the command of which is essential in solving scientific problems. In practice, the problems do not show up in the form of arithmetical equations. In order to be solved they must be translated from a natural language into mathematical symbols.

Solving word problems is a complex task which demands integration of a large number of concepts, facts, and methods. Unlike to arithmetic problems presented with standardized symbols and requiring specific algorithms application, word problems are very diverse and can often be solved in several ways.

Translation of word problems into math symbols is one of the most difficult parts in word problems solving, but also the most important one. Without it, math would be impossible to apply with real problems solving.

In the natural language, students firstly learn how to recognize words, then phrases, and finally the sentences. A similar approach is applied in solving word problems. The students firstly learn the vocabulary, and after that they go onto the phrases and sentences.

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Translating words into mathematical symbols

One of the greatest challenges in solving word problems is translating them into symbols. In table 1.1 words that refer to specific mathematical operations are presented.

Table 1.1 Word problems terminology for specific mathematical operations

+	-	.	:	xy	?	=	( )
adds and plus sum together total addition with more increased by	change decreased difference less minus subtracts extracts takes out owes decreases	by double times multiplies from product of repeats by factor percent of	divides cuts percent quotient relation divide by reciprocal value a third of a part	cubed (x3) exponent at a degree squared root (x0,5) squared (x2)	how much? how far? what? when? what value ?	is are matches is equal to the same as was were will be makes gives	all grouped quantity taken together

We always have to see the context in interpretation of word problems, because there is not always a linear relationship between words and symbols. In the next exercise, the words are used in their most general meaning. Figure 1.1 presents how the Pythagorean Theorem can be translated from a natural language into symbols. Presentation in symbols is much simpler than presentation in a natural language.

Exercise 1.1 ***Translating the words into mathematical symbols***

In the list that follows, words that are common in word problems are shown. Translate the most common mathematical meaning of each of the following words and mark it with an appropriate symbol: addition (+), subtraction (-), division (:), exponentiation (x^y), unknown (?), even (=) or parentheses ( ).

adds	decreases	how much?	part	extracts	same as
all	separated	total	to	reciprocal	third of
likewise	difference of	increased for	plus	value	triple
addition	double	what?	degree	repeats	was
equal to	divides	less	product of	divides	what?
and	equal	more	squared	decreased for	will be
matches	exponent	minus	quarter of	squared root	when?
are	times	multiplies	quotient	subtracts	with
by	gives	divides	at a degree	sum	gives
cubed	to group	decreases	relation	together	is
owes	half of	percent of	cuts		at a degree

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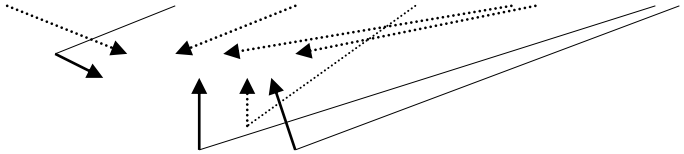
□² c = + □² □² a b

In every right triangle **the square** of **the hypotenuse** is **equal** to **the sum of the squares in the cathetus**

$c^2 = a^2 + b^2$



Picture 1.1 ***Translating the Pythagorean Theorem from a natural language into mathematical symbols***

Translating the natural language into algebraic expressions

Arithmetic is a main branch in mathematics, and the algebra is a tool for presenting arithmetics in a general form.

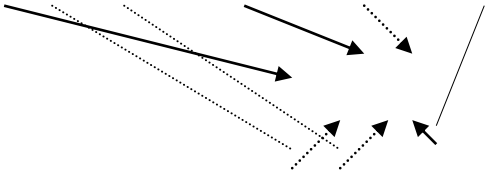
The algebra is an irreplaceable tool for solving word problems, and even though the algebraic equations are more simple expressions in the natural language, the process of translating from the natural language into algebraic expressions is not that simple.

Figure 2.1 shows how a natural language can be translated into mathematical symbols. The equation is much simpler. To be successful in solving tasks, students must learn how to translate the textual descriptions into algebraic expressions.

E = . m □² c

The energy is a product of **the mass** and **the square** of **the speed of light** in a vacuum

$E = mc^2$



Picture 2.1 Translating ***a sentence into a relativity equation***

The following exercise is designed for practicing translation of phrases into algebraic expressions. Students will learn to solve the problems better as they master the translation of phrases into algebraic expressions.

Exercise 2.1 Matching phrases of natural language with algebraic expressions

Read the phrase on the left and match it with the appropriate expression on the right. The first phrase is solved for an example.

Natural language	Algebraic expression
1. Sum of two and unknown x	d1 – d2
2. Reciprocal value of the temperature	s : t
3. Distance difference	x6
4. A relation between path and time	3h
5. The sum of lengths decreased by 5	m / 2
6. A square root of the difference a-b	1 / T
7. Height by factor 3	(d1 + d2) – 5
8. The product of two lengths squared	$\sqrt{a-b}$
9. Degree higher from x3	(l1· l2)2
10. Half of the mass	2 + x

Exercise 2.2 Formulating ***phrases of algebraic expressions from a natural language***

Figure 2.1 shows how an algebraic expression can be formulated from a description of

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a natural language. Formulate the algebraic expressions for each of the following definitions. See table 1.1 to see the correlation between the terms and the mathematical operations.

1. The perimeter of the circle (*L*) with radius *r* is equal to the product of its diameter (*2r*) and the number π.

2. The area trapezoid (*P*) is a product of the half-sum of its bases (*a,b*) and the height (*h*).

3. The area of the rhombus (*P*) with diagonals d_1 and d_2 is equal to half the product of the diagonals.

4. The pressure (*P*) is a relation between the force (*F*) and the area (*S*).

5. The product of the sum and the differenceof both expressions (*A,B*) is equal to the difference of its squares.

6. The force (*F*) is equal to the product of the mass of the body (*m*) and its acceleration (*a*).

7. Work (*W*) is a product of the force (*F*) and the distance (*d*) on which the force has effect.

8. Density (ρ) is the relation between the mass (*m*) and the volume (*V*).

9. The area of the square (*P*) is equal to the length of the square's side (*a*).

10. The current (*I*) is proportionate to the voltage (*U*), but is inversely proportionate to the resistance (*R*).

Translating algebraic expressions in natural language

It is sad to say that many of the students see the equations in textbooks as they were hieroglyphs. Luckily, they can learn to interpret them. All equations which are given below are algebraic expressions which include addition, subtraction, multiplication, division, exponentiation, or nth root. The problem is that the names of the variables are not *a, b, c* or *x, y, z,* which are most commonly met in the mathematics textbooks. Even though the symbols are different, the principles and operations are the same. Science requires that concepts expressed in a natural language be translated into algebraic expressions whereas those expressed in algebraic expressions be translated into a natural language.

The following exercise focuses on the second skill: translating algebraic expressions into a natural language.

Exercise 3.1 Formulating *phrases of algebraic expressions from a natural language*

This following exercise is designed for training translation of algebraic equations in a natural language. Two expressions are given for each equation; one is correct, and the other one is incorrect. Explain the algebraic expressions and circle the correct expressions.

1. $G = mg$	(a) As the mass increases, the weight decreases. (b) The weight of the body is a product of the mass and Earth's acceleration.
2. $E = mc^2$	(a) A small amount of material presents a large amount of energy. (b) As the mass increases, the energy decreases.
3. $P = \frac{ah_a}{2}$	(a) The area of the triangle is proportionate to the height. (b) The area of the triangle is inversely proportionate to the basis.
4. $a^m \cdot a^n = a^{m+n}$	(a) The product of degrees with equal bases is a degree with the same basis, and an index equal to the sum of the indexes of the multiplier. (b) The product of degrees with equal bases is a degree with the same basis, and an index equal to the product of the indexes of the multiplier.

ISBN (print) 9789928146274 ISBN (on line) 9789928146212

5. $V = \frac{3}{4}\pi r^3$	(a) If the radius of the ball increases 2 times, the volume will increase 8 times. (b) The volume of the ball is the sum of ¾ and the product of π and the radius cubed.
6. $\rho = \frac{m}{V}$	(a) The density does not depend on the volume and the mass. (b) The density is the relation between the mass and the volume.
7. $P = ah$	(a) The area of the rhombus is proportionate to the height. (b) The area of the rhombus is the relation between the basis and the height.
8. $\sin\alpha = \frac{a}{c}$	(a) Sine of an acute angle in a right triangle is a relation of the opposite cathetus of the angle and the hypotenuse. (b) Sine of an acute angle in a right triangle does not depend on the hypotenuse.
9. $P = \pi r^2$	(a) The area of the circle is inversely proportionate to the radius. (b) If the radius of the circle increases 3 times, the area will increase 9 times.
10. $T = 2\sqrt{\frac{l}{g}}$	(a) The period of the pendulum does not depend on the mass of the pendulum. (b) As the length is increased, the period of the pendulum is decreased.

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