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MARKDOWNS IN PERCENTAGE OR MOANS ABOUT PERCENTAGE

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ABSTRACT

In previous activities we identified misconceptions of pre-service teachers about the topic of percentages (Bassan-Cincinatus & Sheffet, 2016). Consequently, we built a teaching unit based on the constructivist approach and used the cognitive conflict method. Our main objective was to assist pre-service teachers to be aware of the fact that intuitions do not always lead to the correct solution of this issue. The teaching unit consisted of six stages. This paper will describe the various stages, present the way of experiencing, the findings as well as pre-service teachers' reflection and responses following the activity.

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INTRODUCTION

"I pay 32% of my wages as income tax, my wife pays 32% income tax and together we pay 64%. Soon we are going to pay all our wages to the Income Tax Authority". On a sale of four identical items the saleslady offered the buyer the following option: "10% markdown on each of the items or 40% markdown on one item". "It's worthwhile buying this product because it is sold with a 50% markdown. You buy two items and one of them you get free of charge". These statements, which sometimes attest to wrong understanding of the topic are only some of the various assertions which we have recently witnessed. Since we started to pay attention to difficulties of junior high school students with percentage problems, we became attentive and sensitive to this kind of comments. In the paper "With percentages the 100 is always in the denominator"- From the field to pre-service teachers (Bassan-Cincinatus & Sheffet, 2016), we presented misconceptions about the topic which we identified among pre-servicemath teachers [hereunder – "students"]. We argued that the very descriptions of the events should affect the way of teaching the topic of percentage. As a result, we decided to develop a teaching unit, which would help students to deal with this topic. We designed the unit according to the constructivist approach and used the conflict method. This paper presents the course of experiencing and the contribution of the unit to the students.

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Theoretical background

The constructivist approach in mathematics teaching

The constructivist approach advocates that knowledge is not assimilated passively but is rather built actively by learners. Kilpatrick (1987) stipulates that the theory of knowledge is meant to engage in adapting the knowledge to the experience and not in mediating between the knowledge and reality. According to him, "The only reality that we can know is the reality of experiencing" (p. 6). Kilpatrick argues that the viewpoint of constructivism embodies two principles:

1.Knowledge is acquired in an active way by recognising the object and is not absorbed passively from the environment.
2.'Attaining the state of knowing' is an adaptive process which organises the world of experiences: it does not encompass a world discovery, it is independent and has an existence of its

own as well as located outside the learners' cognition. Ernest (1996) presents four educational paradigms based on the constructivist approach. All these paradigms propose as pedagogical emphases the need for and value of the following elements:

1. Sensitivity and attention to learners' former constructs.
2. 'Diagnostic' teaching which strives to correct learners' errors and misconceptions through techniques of embarrassment and cognitive conflict.
3. Attention to meta-cognition and strategic self-regulation by the learners.
4. The use of multiple representations of mathematical concepts.
5. Acknowledgement of the importance of the assignment for the learners and of the dichotomy between popular mathematics or street mathematics and the school mathematics (an attempt to exploit the first for the benefit of the last).

The cognitive conflict method

Learners frequently manifest incompatibility between the formal algorithm and intuitive knowledge of the concepts. It limits their comprehension and performance (Tirosh, 1990). The knowledge, which learners build about the topic of percentages and the beliefs stemming from it consolidate the intuitions. In ourcase, the intuitions sometimes lead the learners to err when solving percentage problems. Demonstration of such incompatibility demands that learners re-construct their knowledge and beliefs. However, not always do learners change this knowledge easily. As Fischbein (1987) maintains, once consolidated, the intuition has qualities of stability and coercion. Stability – after being consolidated, the intuition is extensively resilient, so that it can withstand also formal learning. Coercion – the intuitive solution coerces itself on the learners. The cognitive conflict method is one of the ways designed to assist learners to experience and be aware of the existing incompatibility. According to this approach, learners should be involved in the discussion about the way they perceive the concept, evoking their awareness of the incomparability in this perception. Such a discussion aims to make learners to became aware that components of their knowledge are not compatible and they should update and adapt them over again.

Before describing the activities and their compliance with the theoretical requirements, below are some essential points which relate to the content in which we engage – percentage problems.

Theoretical background in percentages[1]

Percent or percentage (from Latin “per centrum”) means “out of 100” or “per 100”. One percent of a quantity is $\frac{1}{100}$ of the quantity. Percentages are usually expressed by the sign: %. Some argue that percentage is another name for a fraction whose denominator is 100. For example, instead of $\frac{25}{100}$ one can say 25%. As long as the function of the fraction is to represent a part of a given quantity it can be substituted by percentages. For example: 25% of the 40 class children were absent today. How many children missed class today? Here we can replace the percentage by the fraction and say: $\frac{1}{4}$ of the 40 class children were absent today. How many children did not come to school today? Conversely, in the following phrase: "the area of the square is $\frac{1}{4}$ square meter" it is impossible to replace the $\frac{1}{4}$ by 25%. The exspration "25% square meter" has no meaning. Moreover, "One cannot substitute 25% with the number $\frac{1}{4}$ on the number axis nor write3 +25% instead of 3 + $\frac{1}{4}$ ".

We can add percentages only when they refer to the same quantity. For example: 10%of the 8th graders were absent from class due to choir practice and 30% of the 8th graders went to sport competitions. What is the total number of 8th graders who were not in class? In this case it is all right to add 10%+30%=40%. If x represents the number of the 8th grade pupils, then according to the distribution law, the following applies:

$$\frac{10}{100}x+\frac{30}{100}x=\left(\frac{10}{100}+\frac{30}{100}\right)x=\frac{40}{100}x$$

Let's refer to the quotation at the beginning of the paper:"I pay 32% of my wages as income tax, my wife pays 32% income tax and together we pay 64%. Soon we are going to pay all our wages to the Income Tax Authority". In this case it would be incorrect to add the percentage of tax paid by a certain man with the percentage of tax paid by his wife because they do not relate to the same quantity (even if both wages and/or the percentage of tax are identical).

Types of percentage problems

The elementary problems associated with percentages are divided into three main types:

Percent value: to this type belong the problems in which pupils are required to calculate the quantity "a" which constitutes p% of the initial size "b".

Calculating the percentage: to this type belong the problems where learners are required to calculate the percentage p which is the quantity a out of the initial size b.

Calculating the initial size: to this type belong the problems in which pupils are required to calculate the initial size b if p% from it is the quantity "a".

We contribute from our own experience that the problems which require calculating the initial size are more difficult for

[1]Everything said in the 'Theoretical Background in percentages' and the 'Types of percentage problems' was extensively discussed in another paper (Bassan-Cincinatus, 2016). Due to the relevance to this paper and to the reader, we opted to present it briefly also in this paper.

the pupils and their rate of success is low. Conversely, problems of calculating the percentage are the easiest.

Misconceptions about percentages

Bassan-Cincinatus & Sheffet (2016) presented three points which reflect misconceptions about percentages.

With percentages the 100 is always in the denominator - Although only in problems of calculating the percent value the 100 is in the denominator ,(in problems of calculating the percentage and of calculating the initial size the 100 is in the numerator),one anticipates to find the 100 in the denominator. This anticipation reflects intuition about percent problems. When learners comes across a solution to a percent problem which matches their intuition – the 100 in the denominator – their intuition "coerces" them to acknowledge it as correct. They immediately approve the solution and are sure it is correct. However, when the solution does not match the learners' intuition, i.e. the 100 is in the numerator, the intuition "coerces" them to reject the solution.

Reference to percentages the same as a number – (reference to percentages and calculations of them as one does with numbers). If one part is 34% of the quantity and the second part is 66% of the quantity, then the large part is bigger by 32%than the small part.

Lack of awareness of the importance of choosing the initial size – if the big number is 32% bigger than the small number, then the small number is also 32% smaller than the big number.

The activities and their adaptation to the theoretical approaches

The activity was conducted among 15 students who would teach mathematics at junior high school. Nine of them are students in the regular pathway and six in the career-changing academicians pathway. None of the latter has an academic degree in mathematics. Some of them have a degree in subjects such as biology, economics, business administration. While studying towards their academic degree they attended several courses of mathematics.

The course of the studies and planning of the activities were according to the following stages:

Stage 1: **Identification of correct and incorrect solutions for a given problem**.

A worksheet with the following problem and four solution of 8th grade pupils was presented. (see Appendix A).

The problem: The sum of two numbers is 464. One is 32% bigger than the other. Find the numbers.

Solution 1: $x+\frac{132}{100}x=464$

Solution 2: $x+\frac{100}{132}x=464$

Solution 3: $\frac{34}{100}x+\frac{66}{100}x=464$

Solution 4: $x+\frac{68}{100}x=464$

The students were asked to identify the correct and incorrect solutions and explain what oriented the pupil to this solution.

Stage 2: **Personal experience in solving the problem by two ways**. The problem was presented once more. The students were asked to solve the problem when once the variable x represents the small number and once the big number.

At the end of the first two stages we anticipated a breach of the balance between the intuition associated with percentages and the learners' knowledge, leading to a conflict. We anticipated that the students would feel embarrassed and would develop inquisitiveness and a wish to better understand the topic.

Stage 3: **Experience with everyday problems of 'markdowns'**. Presentation of a worksheet (see Appendix B) which discusses different cases of markdowns. Markdown in percentages of the product price (e.g. 20% markdown on every sale of a clothing item); or getting another quantity for a purchased quantity (all the special offers of 1+1, 2+1 and others). Or when there is an addition of the quantity but the product is bought at its original price (buy and get 33% more of the quantity). In each of these cases the students were requested to determine the offered markdown in percentages or in NIS.

Stage 4: **General discussion of the following topics:**
-What does a markdown mean?
-Classifying percent problems into problem types and matching a given problem to each of the discussed types.
-Which problem types the learners found difficult? Why? How do we solve them?
-Connecting experience with percentage problems with the numbers problems handled in stages 1 and 2.

Stage 5: **Additional independent practice**. Experiencing the solution of various percent problems.

*Stage 6:***Assertions, reflection, comments and impressions** of students about the entire process. We designed this plan because it meets the requirements of the constructivist approach and the cognitive conflict method.

Throughout the different stages, we paid attention to the learners' previous mental constructs, correction of their errors and misconceptions while using multiple representations of mathematical concepts and connection to everyday mathematics. Based on all the experiences and discussions, the learners should shape constructs which organise all the experiences associated with this issue. As far as the conflict method is concerned, one can see how the conflict between the formal knowledge and the intuitive knowledge is created and how the learners' awareness is turned in that direction. The breached balance motivates the learners to form a new match by using a controller on the intuition and thus settle the conflict.

Table 1. The constructivist & the conflict method

Activity stages	The Constructivist method	The conflict method
Stage 1: Identifying solutions	Attention to learners' previous knowledge	Awareness of the incompatibility between the intuitive and formal knowledge
Stage 2: Solving the problem by two ways	Attention to learners' previous knowledge	Awareness of the incompatibility between the intuitive and formal knowledge
Stage 3: Experiencing markdown problems	Using multiple representations; relation between popular mathematics and school mathematics	Diagnosing the types of problems which encompass difficulties, creating the conflict
Stage 4: discussion	"Diagnosing" teaching for correcting errors and misconceptions	Helping the learners to adapt the "correct knowledge" while developinga controller on the intuition which can sometimes be misleading
Stage 5: Independent practice	Meta-cognition and strategies self-regulation	Re-matching between the intuitive and formal knowledge
Stage 6: Assertions, reflection		Awareness of the process

Table 2. Students' answers to the problem

Pupils' solutions	The problem solution	Correct identification	Incorrect identification	Did not know whether the solution was correct or incorrect
Solution 1: $x+\frac{132}{100}x=464$	Correct	15 (100%)	-	
Solution 2: $x+\frac{100}{132}x=464$	Correct	-	15 (100%)	
Solution 3: $\frac{34}{100}x+\frac{66}{100}x=464$	Incorrect	15 (100%) (Say the solution is incorrect)	-	
Solution 4: $x+\frac{68}{100}x=464$	Incorrect	12 (80%) (Say the solution is incorrect)	2 (13.3%) (Say the solution is correct)	1 (6.7%)

The activities and adaptation to the theoretical approaches

Stage 1: **Identifying correct and incorrect solutions for a given problem**

The problem and four solutions were presented to the students. They had to indicate (without solving) which solution was correct and which was incorrect, explaining the pupil's reasons for using this way to solve the problem.

The students' answers to the problem are illustrated in the following table. All the students identified that solution 1 was correct. Nevertheless, all of them failed to identify that solution 2 was correct and that in it the variable x represented the big number. These findings are in line with what we have found in a previous study. Here too the students argued that the pupil gave an incorrect answer because: *"failure to understand the meaning of the whole which is represented as 100%", "the pupils changed the numerator and denominator of the percent", "...confused the function of the numerator and denominator in calculating the percentage".* The intuition which wishes to see the 100 in the denominator is stronger than the formal knowledge and coerces an incorrect identification of the solution.

All the students identified that solution 3 was incorrect. Moreover they noticed that the variable in the equation represented in fact the sum of the two numbers. The students claimed that in order to identify the two numbers one has to calculate 66% of 464 and 34% of 464. They also explained that in this way, the big number is almost twice bigger than the small number.

Most of the students pointed out that solution 4 was incorrect and explained that 32% of the small number are not equal to 32% of the big number.

Stage 2: **Personal experience with solving a problem by two ways.**

The students were asked to solve the problem by two ways while using one variable only, the variable x representing once the small number and once the big number.

When the variable x represented the small number, all the students gave a correct answer.

When the variable x represented the big number: only four students answered correctly. One of them used two variables while extracting the big number from them. Another tried to solve according to solution 4 although previously he identified this solution as incorrect. Only when he solved the equation and found that the answers do not match those which he had obtained in the first item he rejected the solution. He continued until obtaining the correct answer.

The third student remembered solution 2 from the previous page, placed it, solved and saw' that the results were identical to those in the first item. Consequently he presented the solution as correct (he was also aware of the fact that he had rejected this solution previously). The fourth student hesitated, deleted, hesitated, deleted and finally obtained the correct answer.

They all were surprised to see that the solution they identified as a wrong one is the correct solution for this problem. One could feel their conflict.

Eleven students solved the problem in the following way: $x+\frac{68}{100}x=464$. It is noteworthy that eight of them identified on the previous worksheet that the solution was incorrect and even explained the reason for being incorrect.. The question then is: "If they knew this solution was incorrect why did they choose it when they were requested to solve the problem by themselves?" Perhaps the resulting imbalance made them understand that something in the solutions or in their identification was incorrect. Since their intuition prevented them from accepting the answer $x+\frac{100}{132}x=464$ as correct, they concluded that their error was connected with the solution $x+\frac{68}{100}x=464$ which they had rejected previously. This is corroborated by what one of the students attested about himself: *"I am less confident about this solution method since on the previous worksheet I also rejected the solution* $x+\frac{68}{100}x=464$ *and that is why I am checking what is the answer given in item 1 when x was a small number (* $x+\frac{68}{100}x=464$ *)".* After having solved the problem and calculating the two numbers, he solved $x+\frac{68}{100}x=464$ with x as the big number.

"Now let's check the solution with x as the big number". He is aware of rejecting the solution on the previous worksheet. However, once the balance has been breached, he is willing to check whether the incorrect solution is correct after all!.

Stage 3: **Experiencing markdown problems**

The students were shown a worksheet (see Appendix C) with various problems of markdown calculations.

It facilitated experiencing with numerous aspects of percentages: finding the percentage (e.g. question No. 2b), percent value (question No. 1) and calculating the initial size (question No. 4 where one has to find out the initial size before calculating the markdown).

Question No. 4

Question No. 1

Question No. 2b

This stage consisted of a heated discussion following the active experience with the worksheet.

What does a markdown mean? A markdown is perceived as reduction of the price. This leads to the question whether adding a quantity without changing the price can also be construed as a markdown, and if it is, how we can find it?

Types of percent problems and matching a given problem to each of the discussed types. The students were shown the terms of various types of elementary percentage problems: percent value, calculating the percentage and calculating the initial size. The problems which the students solved and the terms were matched. The calculation methods in each case were presented, emphasising that only the problems of calculating the percent value have the 100 as the denominator. We drew the students' attention to the fact that when they were requested to solve the problem and the variable x represented the small number, this was a percent value problem. However, when the variable x represented the big number, this was a calculating the initial size problem.

Which problem types the learners found difficult? Why? How do we solve them? Problems of calculating the percent value and calculating the percentage were easier than problems of calculating the initial size. A discussion about question No. 6 comprised the complete solutions including the equations and results. We discussed the similarities and differences between the problems.

Question No. 6 demonstrates four examples of markdowns and in each example the students had to calculate the markdown in percentages.

Example A

Example B

Example C

Example D

At first sight, it seems that in all examples the markdown is the same. The first two are equaland this applies also to the two other examples.

Example A. Two people are paying and three people are flying. Hence, the markdown in percentages is $33\frac{1}{3}\%$. One flight ticket out of three flight tickets.

Example B. For every sale of two products, one gets an identical product free of charge.

Here too the markdown in percentages is $33\frac{1}{3}\%$. One product out of three products.

Example C. A free of charge addition of 33% to the quantity.

If this refers to a 33% markdown, then one calculates out of the original quantity (see Illustration A).

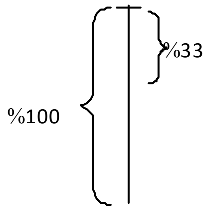

Illustration A

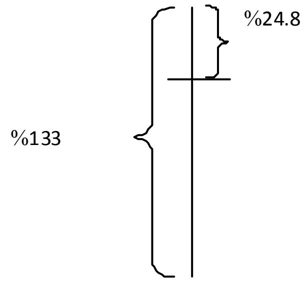

Illustration B

However, in this example, when one buys a product and gets a larger quantity at the same price (the original price), the markdown is the addition in quantity out of the total new quantity. The new quantity equals 100% of the original quantity + the addition 33% of it (see Illustration B). Nevertheless, the markdown is: $\frac{33}{133} \bullet 100 = 24.8\%$.

Example D. A markdown of 33% of the price. In fact, the markdown is already known. During the discussion, all the students concurred that the problem of calculating the markdown in Example C was the most difficult. They saw the similarity between Example C and the problem in which they were asked to find the numbers when the variable represented the big number. Indeed, in Example C, they had to calculate the markdown percentage but the markdown percentage could not be obtained without relating to the initial size.

Stage 5: **Independent practice.**

Problems 9-13 on the worksheet distributed at stage 3 (see Appendix C).

Stage 6: **Assertions, reflection, comments and impressions**

At the end of the activity we asked the students to relate to the process which they had undergone. The references were from different aspects: the mathematical dimension, teaching education dimension, teachers' role, the experiential process they experienced, the benefit they derived from the program and the emotional dimension.

"In every question of fractions, you need first to understand the fraction to which you refer".

"It is important to know and distinguish between the three major types of percentage calculating problems… I must point out that the type which entails particularly numerous problems is 'calculating the initial size'. That is why it is recommended and necessary not to hurry and clarify it with more attention while teaching it".

"I thought I knew the topic of percentages very well and all of a sudden I am no so sure anymore…"

"I am glad we talked about this topic. What would I have done if during a lesson a pupil asked me such a question? It would be rather embarrassed".

"An experiential and instructive process but I would not deliver it to the pupils".

"I realised what I did not know".

To sum up, in this activity too we identified incorrect intuitions about percentages which sometimes lead to errors. Within the framework of the activity, we built a teaching unit in order to structure and expand the knowledge of percentages while relating to these intuitions.

In order to demonstrate the contribution of the process both to the teaching of percentages and to the students, below is a quotation taken from the words of one student.

"… The lesson dealt with verbal questions in the field of percentages. Using verbal questions, unlike merely calculation exercises, attribute contents to the problem. Indeed, sometimes verbal questions have an insignificant content… However this lesson engaged in verbal questions whose content was concrete. Dealing with markdown facilitates a rich and multidisciplinary learning of the aspects of percentages… Using a concrete content which is relevant to our everyday life makes the topic meaningful and important to the learners. When the content is concrete, the learners acquire a control tool and probability estimate of a result according to their daily and intuitive knowledge, issues which are mentioned as part of the curriculum.

We were requested to write in what way we would explain the solution of a certain problem by two ways and hence we were required to specify the way. Reference to the way enhances the understanding by obliging you to validate your arguments, highly reduces insignificant and fast answers. On the other hand, it emphasises for the pupils what is the important part of the exercise and decreases the value of miscalculations (obviously when these are not the essence of the exercise content).

Most certainly for future teachers, but also for pupils, it is essential to present several typical errors as well as a number of possible solution methods and ways for coping with them. This facilitates reaching a wider variety of pupils with different mathematical perceptions and at the same time requires pupils to approach the topic from several angles.
And…

Generally speaking… I must point out that I enjoyed it very much… Naturally, when you started and I realised that the lesson was about percentages, all my 'snobbism' was awakened and it was clear to me that I knew everything you would teach… and then… you shook me with this exercise and I am very glad about it. The lesson clarified to me and indicated for me the inconsistency in understanding this specific topic. It also underscored for me the importance of an in-depth examination of a solution which initially seems entirely incorrect…"

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Appendix A

Numbers and percentages

The8th grade pupils received the following problem:

The sum of two numbers is 464. One is 32% bigger than the other. Find the numbers.

Below are four different solutions to the problem. Please describe your opinion and each solution and give an explanation:

- Correct or incorrect solution?
- On what did the pupils based themselves when solving in this way?

Solution 1: $x+\frac{132}{100}x=464$

Solution 2: $x+\frac{100}{132}x=464$

Solution 3: $\frac{34}{100}x+\frac{66}{100}x=464$

Solution 4: $x+\frac{68}{100}x=464$

Appendix B

Numbers and percentages

Below is the problem:

The sum of two numbers is 464.
One is 32% bigger than the other.
Find the numbers.

A) Solve the problem. Let x represent the small number.
B) Solve the problem. Let x represent the big number.
Use only one variable

A)How would you explain to the pupils the way of solving the problem when x represents the small number? (Use only one variable)
B)How would you explain to the pupils the way of solving the problem when x represents the big number? (Use only one variable)

Appendix C

Markdowns or Moans

Worksheet

1. A certain product of "Natural Formula" which is offered on sale costs NIS 18. What would be its price after a 30% markdown?

2. What is the reduction on "Four Ambrosio bottles" when the price was reduced from NIS300 to NIS49?
   a. in **NIS**.b. in **percentage**

3. When you buy two "Mor Mouth" products, what is the markdown on each of the products when the second product is sold with a 50% markdown? Please explain.

4. What is the markdown percentage on "Gillette Series" when an addition of 20% is given free of charge?

5. When you buy two "Mor Mouth" products, what is the markdown on each of the products when the second product is sold with a 50% markdown? Please explain.

6. a. What is the markdown percentage on "Gillette Series" when an addition of 20% is given free of charge?

b. If the special offer at "Klik" was "2+3", would the markdown be also identical? Please explain.

7. If the ad of "Elnett by L'Oreal" hair spray, which is sold with a 30% markdown, stated that the markdown is 30% on the second product, could we say that the total markdown is 15%?

8. Please write correct and incorrect assertions to one of this ads and explain.

Percentages Reductions or Knowledge reorganization

In previews activities that we made, we found misconceptions that math teachers to be, held while dealing with percentage word problems. As a result we have decided to help math teachers to be to deal with this subject.

We created a teaching unit, based on the "radical constructivism" approach, and the "cognitive conflict" method, and with it the following stages:

1. Identifying correct and incorrect solutions for a given problem.
2. Experimenting in solving a problem in two different techniques. Both these stages should make the students wonder about their percentage understanding.
3. Experimenting with different kinds of problems of 'percentage reduction'. In this stage the students are suppose to come up with their assumptions as to how to solve percentage problem, based on their own experience.
4. Debate, in which we combine the recent experimentation in percentage problems to the given problem in stage 1 and 2.
5. Extra self drill.
6. Remarks and evaluations of the whole process, given by the students.

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