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The effect of Mathematical misconception on students' success in kinematics teaching

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Abstract: There have been many investigations into the factors that underlie variations in individual student performance in high school physics courses. Numerous studies report a positive correlation between students' mathematical skills and their exam grades in high school physics The purpose of my study was to determine the effect of mathematical misconception that is one of the reasons the lack of students success in kinematics teaching.

Keywords: Kinematic, Mathematical Misconception

1. Introduction

There are different views about the nature and content of mathematics within the research community. Students' construction of knowledge in mathematical problem solving is reflected in their use of strategies as they attempt to master a problem situation. Various stages of the solving process will bring different sets of challenges to them. It is the construction of cognitive structures that are enabling, generative, and proven successful in problem solving (Confrey, 1991).

For many years, I teach physics and observed many students in my class. They had a good arithmetic background, and they could solve a problem using lengthy arithmetic procedures that they came up with themselves, but were hesitant to use algebraic methods. I always tried to use algebraic methods on my own to motivate them. However, my attempts were not very successful as students used their own lengthy arithmetic procedures or rather failed in using algebraic methods.

By observing the students informally, I found that they have some misconceptions that were persistent. Sometimes, they repeatedly made the same error. Also, through discussion with my fellow teachers, I realized that their explanations for these types of behaviors were surprisingly consistent with mine. However, one thing was clear to me. These misconceptions were neither inborn nor were they instantaneous. Rather, students have acquired those misconceptions during their learning process for yet unknown reasons. Whatever the reasons may be, there should be a way to identify and remedy these problems. Also observed that these students memorized only a few facts, formulas, and algorithms without understanding them conceptually, even though they could manipulate those limited number of facts in a correct or incorrect manner. Their lack of conceptual understanding prevented them from applying mathematical knowledge on physıcs problem. This was one of my own explanations for the reasons of students mathematical misconception in kinematic.

What I observed from my teaching was that even high and secondary school students commit the same mistakes as secondary school students. By then, I realized that this problem is common to many education systems in the world. Up to this time, I had seen student misconception on paper when they did classroom work, I always thought that there should be a systematic way of studying the misconception and to see what students have to admit about their own mistakes. Thinking along this line, I formed my main research question: What personal mathematical constructs cause secondary and high school students to make errors or to have mathematical misconceptions in kinematic?

At different times, I have gained from the analysis of data from different classes.

2. Evaluation of the Problems

2.1. Question

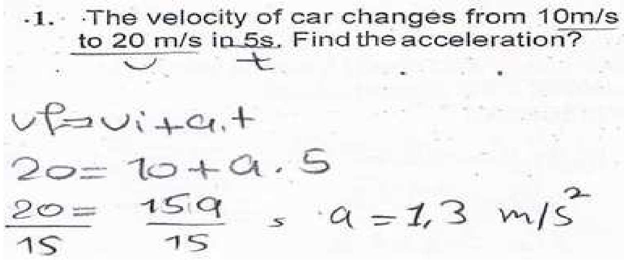
The velocity of a car changes from 10m/s to 20 m/s in 5s. Find the acceleration?

Most of the time, students understand kinematics in physics but it is difficult to express with a mathematical language for them.

the rate of students who have done the right beginning to solve the question but failed due to the misconception and successful students	Rate of correct solution (successful students)	Effect of misconception	others (Incorrect calculation , left blank or used the wrong formula)
94%	90%	4%	6%

In this problem, I aimed to see the student's ability of calculation and using natural numbers. 94% of the students wrote the correct formula but the students' success on this question is 90%. 4% of students have done the right beginning to solve the question but they couldn't reach correct answer because of some mathematical misconception. So we can say that 94% of the students had understood the topic but it was difficult to express with a mathematical language for them. Others (Incorrect calculation, left blank or used the wrong formula)

Misconceptions that I encountered in this question is adding the known and unknown terms.Known and unknown terms were added (10 + 5a = 15a)



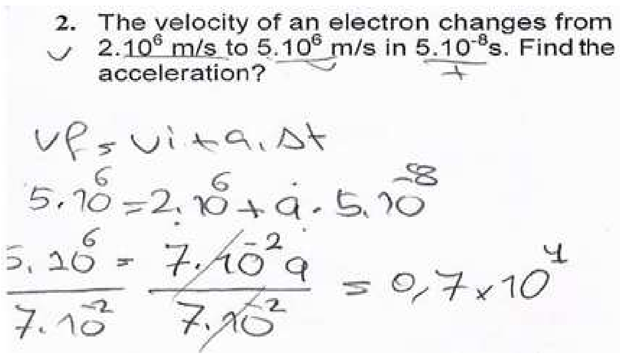
2.2. Question

The velocity of an electron changes from 2.10^6 m/s to 5.10^6 m/s in 5.10^{-8}s. Find the acceleration?

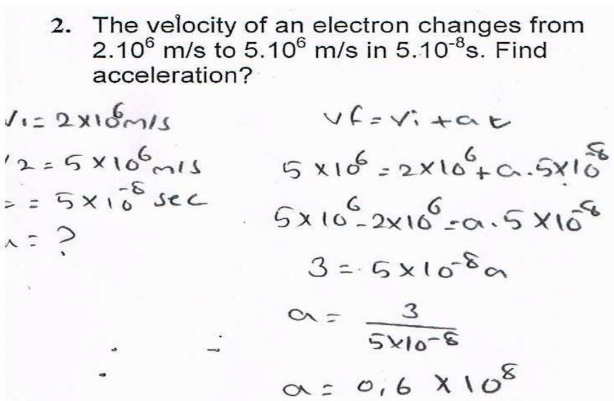
the rate of students who have done the right beginning to solve the question but failed due to the misconception and successful students	Rate of correct solution (successful students)	Effect of misconception	others (Incorrect calculation , left blank or used the wrong formula)
87%	61%	26%	13%

The first and the second questions are similar. They have just different numerical values. Success rate of achieving to right solution decreased from 90% to 61%. Some students have done the right beginning to solve the question but they couldn't reach correct answer because of the misconception. Students often have misconceptions about the exponents. Many students have memorized the general equation but they couldn't use them. The rate of students who have done the right beginning to solve the question but failed due to the misconception is 26%. The effect of misconception on this question is %26. The rate of successful students are 61%. So, depending on the performance of the ratio to eliminate misconceptions increases success up to 87%. (26% +61% =87%).

Some misconceptions that I encountered in this question



1- Misconception about adding and subtracting of power. Power of numerator and denominator was added without changing of their sign.
2- Another misconception, known and unknown terms were added too.



Misconception about adding and subtracting of power, powers were subtracted like $5.10^6 - 2.10^6 = (5-2)10^{6-6}$.

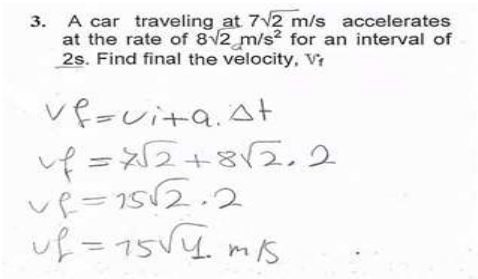
Some students have done the right beginning to solve the question, but couldn't reach correct answer because of the misconception.

2.3. Question

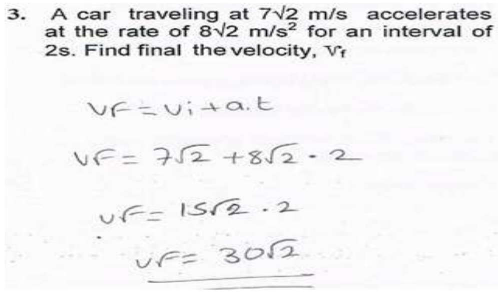
A car traveling at $7\sqrt{2}$ m/s accelerates at the rate of $8\sqrt{2}$ m/s2 for an interval of 2s. Find the final velocity, V_f.

the rate of students who have done the right beginning to solve the question but failed due to the misconception and successful students	Rate of correct solution (successful students)	Effect of misconception	others (Incorrect calculation , left blank or used the wrong formula)
86%	74%	12%	14%

In this question, I wanted to observe the abilities of students to make calculations using square root expression. I met several misconceptions. Many students started to solve using the correct formula, but 12% of the students couldn't the reach answer because of the misconception, in other words, the effect of misconception is 12%. The percentage of students, left blank, used the wrong formula or made incorrect calculation is 14%.



Misconception in this question, the expression inside the square symbol was multiplied by 2



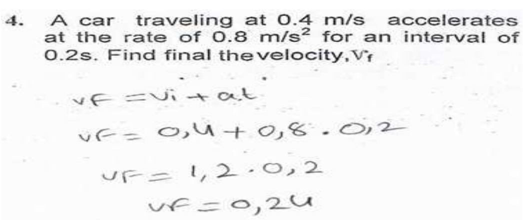
Misconception about adding and subtracting square- root expression. Misconception in this question, $7\sqrt{2}$ and $8\sqrt{2}$ were added without multiplication by 2.

2.4. Question

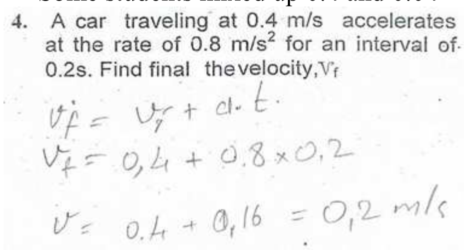
A car traveling at 0.4 m/s accelerates at the rate of 0.8 m/s^2 for an interval of 0.2s. Find the final velocity, V_f.

the rate of students who have done the right beginning to solve the question but failed due to the misconception and successful students	Rate of correct solution (successful students)	Effect of misconception	others (Incorrect calculation , left blank or used the wrong formula)
90%	77%	13%	10%

In this problem, I aimed to see the student's ability of calculation using decimal numbers. The student's success on this question is 77%. The rate of students who have done the right beginning to solve the question but failed due to the misconception are 13%. The effect of misconception on this question is 13%. The percentage of students, left blank, used the wrong formula or made incorrect calculation is 10% 0.4 and 0.8 was added before multiplication of 0.8 and 0.2



Some students mixed up 0.4 and 0.04



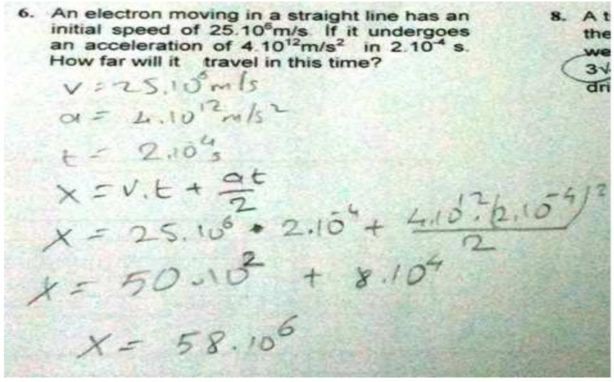
2.5&6. Questions

An object with an initial velocity of 30m/s is accelerated at 4m/s2 for 12s. What is the total displacement?

	the rate of students who have done the right beginning to solve the question but failed due to the misconception and successful students	Rate of correct solution (successful students)	Effect of misconception	others (Incorrect calculation , left blank or used the wrong formula)
5	*80%*	*80%*	*0%*	*20%*
6	*76%*	*42%*	*34%*	*24%*

5^{th} and 6^{th} questions are same too, they have just different numerical values. Success rate of achieving decreased from

80% (in 5th questions) to 42% (in 6th question) the mean of this, the students have many misconceptions about the exponents. İn 6th question, the rate of students who have done the right beginning to solve the question and successful students is 76%. But 34% of 76% couldn't solve the questions because of the misconception. We can say the effect of misconception on this question is 34%. Some students have done the right beginning to solve the question but they couldn't reach correct answer because of the misconception like 2nd question. Students often have misconceptions about the exponents. Pretty many students have memorized the general equation but they can't use them. The rate of students who have done the right beginning to solve the question but failed due to the misconception are % 34. Seeing that the effect of misconception on this question is 34%. So, depending on the performance of the ratio to eliminate misconceptions can increase student's success to 76%. The percentage of students, left blank, used the wrong formula or made incorrect calculation is 24%

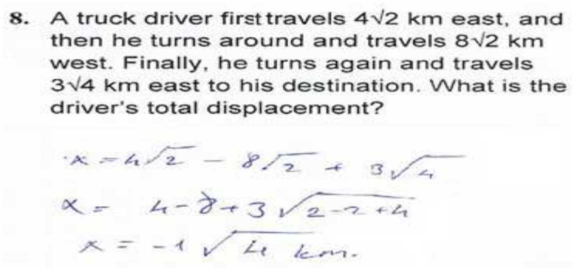


Misconceptions that I encountered in this question is additions of exponentials. The powers were added while the bases were added too. Both exponents must have the same base before they can be added.

2.7&8. Questions

	The rate of students who have done the right beginning to solve the question but failed due to the misconception and successful students	Rate of correct solution(successful students)	Effect of misconception	Others (Incorrect calculation , left blank or used the wrong formula)
7	96%	96%	0%	4%
8	86%	65%	21%	14%

A lot of the students have the misconception about the adding and subtracting square root expression. Some students ignored the sign of the square root operation $\sqrt{a}-\sqrt{b}=\sqrt{(a-b)}$ some.



7th and 8th questions are same, they have just different numerical value, natural numbers are used values in 7th question and square root expressions are used in 8th question. Success rate of achieving decreased from 96% to 65%. 10% of the students have problems in representing the direction in 7th question.

Natural numbers was used in the 1st, 5th and 7th questions. The rate of average student's success of these questions is 88.7%. The rate of average student's success of other questions 2,3, 4, 6 and 8 are 64.5%. The average effect of misconception on these questions is 21.2%.

	Questions	The rate of students who have done the right beginning to solve the question but failed due to the misconception and successful students	Rate of correct solution (successful students)	The effect of misconception
1	The velocity of car changes from 10m/s to 20 m/s in 5s. Find the acceleration?	94%	90%	4%
2	The velocity of an electron changes from 2.10^6 m/s to 5.10^6 m/s in 5.10^{-8}s. Find the acceleration?	87%	61%	26%
3	A car traveling at 7√2 m/s accelerates at the rate of 8√2 m/s² for an interval of 2s. Find the final velocity,V_f	86%	74%	12%
4	A car traveling at 0.4 m/s accelerates at the rate of 0.8 m/s² for an interval of 0.2s. Find the final velocity,V_f	90%	77%	13%

	Questions	The rate of students who have done the right beginning to solve the question but failed due to the misconception and successful students	Rate of correct solution (successful students)	The effect of misconception
5	An object with an initial velocity of 30m/s is accelerated at $4m/s^2$ for 12s. What is the total displacement?	80%	80%	0%
6	An electron moving in a straight line has an initial speed of 25.10^6m/s. İf it undergoes an acceleration of $4.10^{12}m/s^2$ in 2.10^{-12} s. How far will it travel in this time?	76%	42%	34%
7	A man first moves first toward east 4 m then toward north 3 m and finally toward west 8 m. What's the magnitude of displacement?	96%	96%	0%
8	A man first moves first toward east $4\sqrt{2}$ m then toward north $3\sqrt{2}$ m and finally toward west $8\sqrt{4}$ m. What's the magnitude of displacement?	86%	65%	21%

3. Conclusion

The intention of my study was to explore students' misconceptions. The Effect of Mathematical Misconception on student's success in kinematics teaching. In general, students understand kinematics in physics, but it's difficult for them to express with a mathematical language.

To identify the misconceptions of the explained topic and to eliminate them will increase the student success. The training can be arranged for teachers in this issue. Common mistakes and misconceptions can be included in the guide books. When a new rule or concept is taught, the student should be warned about the common misconceptions by giving example. Students should see the difference between right and wrong.

Teachers should teach to apply mathematical rules, rather than asking them to memorize these rules. Many students memorized the general equation without understanding. Memorizing the rules for operations, without sufficient understanding, only undermines students' abilities to make sense of more advanced concepts. Memorizing the rules for operations is increasing just the coefficient of students' learning difficulties in kinematics.

To ensure can be more useful to express their thoughts on a problem solving process when the Students learned new concepts. Students are encouraged to solve problems with expressing their own thoughts.

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