MATHEMATICAL MISTAKES OF SOLVING PHYSICS PROBLEMS

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Abstract: An important part of real life-mathematics problems is physics problems. In physics problems, departing from measurable macroscopic quantities, it is aimed to find other macroscopic quantities. To obtain the relations among the numbers expressed the physical quantities which are measured, using the knowledge in physics, it is needed to write mathematical equations. In this study, mathematical mistakes which are made on solution of physics problems were investigated. Research sample is 9th grade students from two high schools in Eskisehir, Turkey in academic year of 2001-02. 97 students were attended to this study. To measure the knowledge in research theme, it was used the measure with 10 items prepared by the authors.Questions in this measure were evaluated in three categories: **First Category:** Mistakes due to the wrong usage of knowledge in physics. **Second Category:** Mistakes due to conversion of units belonging to physical quantities. **Third Category:** Mistakes on mathematical operations. To examine these mistakes, it is used "How to Evaluate Progress in Problem Solving, NCTM, 1987 as a main source.

According to the conclusions of this evaluation, main mistakes which are made in solution of physics problems by students are mistakes due to conversion of units and mistakes on mathematical operations. It is observed that these mistakes found in this study are systematic. Findings show that the lecture of mathematics affects the success in the lecture of physics, highly. Because of this reason, to increase the success in lecture of physics, the mathematical knowledge which is necessary in lecture of physics must be taught the students by physics teacher. Thus, mathematical knowledge will be widely used in physics which is other discipline and consequently the success in lecture of physics will be increased.

INTRODUCTION

R.P.Feynman, Nobel laureate in physics, said "You do not know anyting until you have practiced". From this point of view, to develop their skills,the students must solve various problems connected with learned subjects. Their ability to solve problems is criterion of their knowledge of physics. Therefore students should try to solve as many problems as possible (Serway,R.A, 2000).

Research has shown that physics and mathematics are important for each other. Because physics and mathematics help students develop not only mental operations but also a greater willingness to solve problems (Goldberg and Wagreich, 1989). This willingness to solve problems is critical for students learning both physics and mathematics. The need to solve physics problems by mathematical processes makes the integration of both disciplines (Carin,A.A., 1997).Mathematics is one of the most important tools of the students who study physics. If the students know and use sufficient mathematical knowledge they will be better in physics (Chapman.S., 1946). Before attempting to solve problems,the students must understand basic concepts and principles of physics. Solving method of problems must be attentively planned. Firstly, the problem must be read several times, until the student are confident the student understant what is being asked. In developing physics problem-solving strategies, there are five basic steps which are commonly used.

First step: To draw a suitable diagram with appropriate labels and coordinate axes if needed.

Second step: To examine what is being asked in problem,to identify the basic physical principle (s) used. To construct table listing quantities given and quantities to be found.

Third step: To select a basic relationship or derive an equation that can be used to find the unknown. To solve the equation for the unknown symbolically.

Forth step: To substitute the given values with the appropriate units into the equation.

Fifth step: To obtain a numerical value for the unknown.

Verification of the solution: At the end of the solution,these questions can be answered properly: Do the units match? Is the answer reasonable? Is the plus or minussing meaningful?(Serway,R.A, 2000).

As can be seen from above steps,third, forth and fifth steps are mathematical operations. Any students who claimed that he understands physics-knowledge but hasn't sufficient mathematical background could realize first and second steps easily, but could have some difficulties to find correct result in last three steps. Finally,he will absolutely find wrong result. Thus, if the student hasn't sufficient mathematics to solve physics problem,result of the problem won't be absolutely right. In other words,if the student has sufficient mathematics knowledge, besides physics-knowledge , he could arrive correct result.

PROBLEM In this study, to make increase success in physics lecture, mathematical mistakes which are made on solution of physics problems were investigated.

METHOD Research sample is 9th grade students from two high school in Eski°ehir, Turkey in academic year of 2001-2002.97 students were attended to this study. To measure the knowledge in the subject of this research ýt was used with 10 items prepared by the authors. Answers to the questions in this measure were evaluated in three categories:

First Category: Mistakes due to the wrong usage of knowledge in physics.

Second Category: Mistakes due to conversion of units belonging to physical quantities.
Third Category: Mistakes on mathematical operations.

To examine these mistakes, it is used "How to Evaluate Progress in Problem Solving, NCTM, 1987" as a main source (Jenkins, L.,1997).

FINDINGS

The students made more mistakes in mathematical operations than the other categories on the measure applied in this research. Using the physical knowledge and data given in problems, symbolic expressions have been obtained, but because of mathematical operations which couldn't made right, it was arrived to wrong results. Mistakes which were encountered more frequently, were seen in solution of algebraic equations.

Q3: : When any object with a volume of 50 cm^3 is immersed into the vessel containing a liquid of density of d, volume of liquid sunk is 30 cm^3. If this object is immersed into a liquid of density of 3d/2, what would be volume sunk?

Using the physical knowledge given in Q3, the following correct equation was obtained:

$$30\ d\ g = V_S\ (3d/2)\ g$$

But, using this equation, the students experienced difficulties to obtain the value of V_S. From this equation, the students obtained following values of V_S:

$V_S = 30 - 3/2 \rightarrow V_S = 28.5\ cm^3$ $\qquad$ $V_S = 30\ .\ (3/2) \rightarrow V_S = 45\ cm^3$

Other category of mistake made by the students is the conversion of the units of physical quantites which is not suited to standard unit systems.

Q5: A solid object with mass of 30 g and volume of 50 cm^3 is immersed in a tank containing a liquid of density of 800 kg/m^3. What is the mass of the liquid overflow from the tank?

In Standarts International (SI) unit system, which must be used in solution of any physics problem, masses must be converted to kilograms, volumes must be converted to m^3.But, paying attention not to this reality, the students have made following mistakes in mass units:

$30\ g = 3\ kg$ or $30\ g = 0.3\ kg$

The other mistakes were made in conversion of volume units as mathematical mistakes:

$50\ cm^3 = 0.5\ m^3$ or $50\ cm^3 = 0.05\ m^3$

As can be seen, the mistakes of conversion of units in second category could be defined as the mistakes of mathematical manipulations. The category of mistake made at least consists mistakes from deficiency of physical knowledge. According to the research results, the numbers of mistakes and the percentages of mistakes of 97 students in research sample can be seen in Table 1.

As expected, the number of mistakes in mistake categories are formed as an increasing sequence. In other words, as can be seen in Table 1, the mistake categories are consecutive.

Table 1. Distribution of Mistakes on Physics Exam Applied to 9thGrade Students From Two High Schools in Eski°ehir

	Wrong usage of physical knowledge	**Conversion mistakes of units**	**Mistakes of mathematical operations**
Number of mistakes	144	225	264
Percentage of mistake	22,8	35,5	41,7

SUGGESTIONS

According to the knowledge obtained from this research, the most made mistakes in solution of physics problems had mathematical character. This result shows that mathematics is very important for physics. The language of physics is mathematics. If mathematics is lacking in physics, any reality in physics couldn't be expressed. Physics teachers must teach to students mathematical knowledge need to teach physics and musn't say to students that you must learn this mathematical knowledge in lecture of mathematics. If mathematics is used dense in lecture of physics, mathematical knowledge will be permanent. In other words, physics and mathematics are scientific branches supported each other. To increase the success in lecture of physics, it must be successful in lecture of mathematics.

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