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Determining Student Difficulties in Solving Problems Related to Force and Motion Units via Hint Cards *

Seyhan Eryılmaz Toksoy [1], Ali Rıza Akdeniz [2]

Abstract

In order to improve students' physics problem solving skills, the points which students have difficulty in during the problem solving process must be identified. In this study, It is aimed to determine the points in which students have difficulty in by using clinic interview method with the help of hint cards. 17 different problems related to 10th class "Force and Motion" unit have been designated and 9-11 different hint cards which have the same titles for each problem have been prepared. 17 problems have been solved by 21 students studying at 2 different schools in Trabzon. Firstly, all students have been asked to solve the given problems by thinking out loud, then, students who were able to solve the problem have been asked to tell the process in details and clearly; the students who have failed to solve the problems were asked to retry solving the same problem by using hint cards. Students have come up with the correct solution for some problems without using hint cards, while for some other problems; they have needed to use the hint cards. Whereas these students, despite using hint cards, could not come up with the correct solution to some problems. It was clearly seen that students have used the hint cards which include formulas and steps of solution mostly. It was determined that there ought to be a hint card about unit conversions and the "sample solution" hint should be expressed more clearly. It was retained that some students have had superficial problem solving approach and they have difficulty in making plan, an important step in problem solving; some students have little awareness about their own problem solving process and that proposing hints can help to solve the problem only to a certain extent. Teachers have been suggested to teach the simplest steps of the problems in a clear way, to give students enough time to solve the problems by themselves, to help students find their own wrong steps in the solution process. Accordingly, researchers have been suggested to determine the difficulties that students who are at different levels have while problem solving on different topics.

Keywords

Problem solving
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[1] Recep Tayyip Erdoğan University, Faculty of Education, Department of Primary Education, Turkey, seyhanerylmaz@gmail.com

[2] Karadeniz Technical University, Faculty of Education, Department of Secondary Education, Turkey, arakdeniz@gmail.com

Introduction

The increase in knowledge and skills which individuals need to learn requires the learning of the ways of self-decision making, knowledge acquisition and problem solving (Özyalçın Oskay, 2007). According to Jonassen (2000), problem solving is in the center of contemporary learning theories. Gürcan Töre (2007) thinks that developing the problem solving skills (PSS) is on the basis of the educational changes in recent years. One of the most important aims of contemporary syllabus is to develop students' problem solving skills in various fields like mathematics, science and social sciences (Gürcan Töre, 2007; Unsal and Moğol, 2008).

The main aims of the physics course are to support students to understand the basic physics concepts and to develop their problem-solving skills (Singh, 2009). However, studies reveal that students do not succeed sufficiently in problem solving (Sutherland, 2002; Bozan, Küçüközer and Işıldak, 2008). Considering that one of the primary purposes of educational research is to facilitate students' learning (Bağcı, Gülçiçek and Moğol, 2004), alternative methods should be developed to enhance students' problem-solving skills. People face many problems in everyday life (Jonassen, 2000; Gündüz, 2008) and they try to solve them by using the skills which they acquire while solving problems at school (Mertoğlu and Öztuna, 2004; Nakiboğlu and Kalın, 2009; Brad, 2011; Çakıcı, 2012). When faced a daily life or a well-structured physics problem, firstly the problem status is determined. The conditions, given knowledge and asked knowledge are analyzed. Then, the ways of reaching the asked value or the solution of daily life problem is considered. The solution is attained by testing the most logical and practical way. And the solution is checked. When considering the main purpose of educational institutions is to prepare students for daily life, PSS is a skill that needs to be acquired by students (Jonassen, 2000; Gunduz, 2008). Developing student skills of solving physics problems will not only help increasing their success in physics courses, but also help them solve the problems they encounter in daily life more successfully.

Problem which is also expressed in words such as issue and matter has been defined in various ways in literature (Altun, 2000; Toluk and Olkun, 2002). In the most general sense, problem is the situation of not being able to explain an event with the existing knowledge at that very moment (Çepni, 2007). If a person has a purpose and does not know how to achieve it, he is faced with a problem and the things he does to achieve his goal are called problem solving (Baker ve Mayer, 1999; VanGundy, 2005). At that rate, problem and problem solving can be defined in different ways according to their area of use. In this study, problem and problem solving are dealt as mostly encountered structured ones in science courses and as finding the result in a numerical form by sticking to certain values (Yaman and Karamustafaoğlu, 2006). Not being able to understand the problem solving process well enough to support them is one big reason why students fail in problem solving (Jonassen, 2000). The process which the students go through while solving physics problems has to be primarily well known to develop their problem-solving skills or to improve their problem solving performance (Pimta Tayruakham and Nuangchalerm, 2009). Studies examining this process are found in literature. Expert-novice problem solver notions have been formed as a result of these studies (Schoenfeld, 1992; Leonard, Gerace and Dufresne, 1999; Sutherland, 2002; Teong, 2003; Harper, 2004; Sen, 2008; Singh, 2009). Although the definitions of these concepts change according to the researchers, generally, the ones who are more successful in solving problems are called 'expert problem solver' and the ones who fail are called 'the novice problem solver'. The ones who use problem-solving strategies effectively and consciously are defined as 'the expert problem solvers' (Sezgin Selçuk, Çalışkan and Erol, 2007). The differences between experts' and novice problem solvers' are seen in the perspective on problem-solving process, the time devoted to understanding the problem, duration of starting to solve the problem, having different solutions, field knowledge, classification of the problems and remembering/recalling the knowledge (Schoenfeld, 1992; Leonard et al ., 1999; Sutherland, 2002; Teong, 2003; Harper, 2004; Sen, 2008; Singh, 2009). The features of these differences are shown in Table 1.

Table 1. Differences Between Expert and Novice Problem Solvers

Perspective on problem-solving process	E: They consider problem solving as a process. N: They consider problem solving as a reminder task.
Time devoted to understanding the problem	E: They allocate considerable time to reading the problem text and analyzing it. N: They allocate very little time to reading the problem text and analyzing it.
Starting to solve the problem	E: They do not start to solve without analyzing and understanding the problem utterly. N: They start to solve without understanding utterly.
Having different solutions	E: They can solve problems in different ways. N: They do not have any different solutions.
Field knowledge	E: They have well-structured, profound field knowledge. N: They have unstructured, superficial field knowledge.
Problem classification	E: They classify problems according to knowledge they include. N: They classify problems according to events and objects they include.
Remembering/recalling the knowledge	E: Due to having well-structured knowledge, they can remember existent knowledge easily. N: Due to having unstructured knowledge, they cannot remember existent knowledge easily.

Note: *E: Expert problem solver, N: Novice problem solver*

In addition to the differences stated in Table 1, there are also differences in the steps which expert and novice problem solvers follow and difficulties they have during problem solving process. Therefore, the hints that expert and novice problem solvers may need during the problem solving process are thought to be different.

In Turkey, researches about problem solving are often concentrated upon mathematics (Caliskan, 2007). There is a need for researches about problem solving in physics course since it has problem solving in its every subject (Unsal and Moğol, 2007). There are some studies about problem solving and learning in mechanics which is one of the basic branches of physics, but there is not so much study related to difficulties in problem solving (Byun Ha and Lee, 2008). Karataş and Güven (2003) stated that, knowing/being conscious about the mistakes which students make through problem solving process provides knowledge about the help they would need. The process of solving structured problems about different topics of physics should be specified since problem solving process may change according to students and topics.

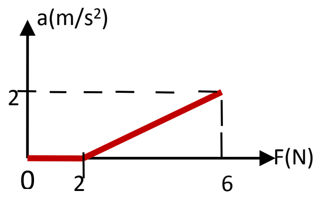
Problem-solving process begins at the moment when a person faces the problem; in order to complete the process, appropriate activities must be picked, applied and studied systematically (Öztürk, 2009). While solving the problem, one organizes and uses the concepts and skills which are previously acquired in order to reach a solution (Unsal and Ergin, 2011). In this context, problem solving is a process that requires choosing and using the appropriate cognitive strategies as well as having field knowledge. The difficulties which students have in this complex process should be determined. If teachers know the factors that support or prevent the development of students' problem solving skills, they will be able to organize effective learning activities to improve their skills (Pimta et al., 2009).

In order to determine the steps which students pursue and have difficulties in the problem solving process, students should be provided with hints regarding the stages they have difficulty in fulfilling (Pol, Harskamp and Suhre, 2008; Pol, Harskamp, Suhre and Goedheart, 2009). Not being able to complete the problem solving process because of a difficulty in performing a step can be avoided by the use of appropriate hints and thus steps that students have difficulty in the problem solving process can be identified. In this study, it is aimed to determine the student difficulties in solving problems related to "Force and Motion" unit, which gives more place to problem solving in 10th grade physics syllabus. Structured problems have been used in this research since the problems solved in physics courses at schools are also structured ones. In the research, the steps, in which students have difficulty, are specified by seeking the answer to the question "Which hints do students need during solving structured problems related to force and motion units?"

Method

In this case study type research, hints that students need during solving structured problems related to Force and Motion units have been tried to determine via clinical interview method. Clinical interview is a data collection method in which flexible questions are used to determine the thinking process, causes of the underlying reasons and basic stages of an activity (Clement, 2000). Clinical interview may continue until researcher reaches the data which he/she needs; if there is an incomprehensible answer, researcher can ask other questions over and over. This method is effective to find answers to a large part of designated questions and revealing the deficiencies in the students' problem-solving process (Karataş and Güven, 2003; Karataş and Güven, 2004; Naser, 2008; Gökkurt and Soylu, 2013). It has the potential to reveal hidden thoughts by examining students' mistakes deeply (Naser, 2008). Thoughts can be determined by interviews, the level of implementation of these thoughts can also be determined by clinical interviews. As it is seen in Gürcan Töre's research (2007), in the interviews, students may state the steps they have not completed during problem solving as if having completed them and vice versa. Therefore, clinical interview method has been applied to collect more reliable data during which hint cards have been used. Students have not only been asked what hints they would need, but they have also been asked to keep solving the problem by using hints they need.

In this study, 17 problems about 10th grade "Force and Motion" unit and different hint cards with the same titles for each problem have been prepared. Researches which involve the steps that students have difficulty in performing during problem solving have been affected while preparing the hint cards. Understanding the problem (Crisostomo, 2010; Nguyen and Rebello, 2009; Ogunleye, 2009; Soong, Mercer and Er, 2009; Nakiboğlu and Kalın, 2003), field knowledge (Soong et al., 2009; Nakiboğlu and Kalın, 2003; Ogunleye, 2009; McDermott, Rosenquist and van Zee,1987), planning (Crisostomo, 2010; Byun et al., 2008) and making process (Nguyen ve Rebello, 2009; Ogunleye, 2009) are of the steps in literature which students have difficulty during problem solving process. In this study, in order to help students understand the problem better "expressing the problem more understandable" (E.M.U.), "highlighting the important parts of the problem" (H.), "visualizing the problem status" (V.); to help while planning "symbolizing the given and asked variables" (S.), "hints for solution steps" (H.S.); to make up the deficiencies in the field knowledge "formulas that can be used in solution" (F.), "physics concepts and principles which are necessary for solution" (C.P.), "graphics knowledge that can be used in solution" (G.) have been created. In addition to them, hint of an "Sample solution" (S.S.) has been constructed for students to analyze the solution to the problem. Since the numbers of "Sample solution" hint vary between 1 and 3, hint cards ranging between 9 and 11 have been prepared for each problem. Hint cards have been made of hard cardboard cut squarely. On one side of the cardboard there has been the title of hint and there has been the content of it on the other. Problem 3 (P3) and the hints can be used during the solution are as follows.



The graph of acceleration- force which is drawn according to data obtained from an experiment that carried out applying force to a fixed chock on the horizontal plane is as in the figure. What is the coefficient of friction between the chock and the surface which the experiment carried out? *(g=10 m/s²)*

Figure 1. Problem 3

Hint of "Expressing the problem more understandable":

The graph shows the acceleration value gained by the object by increasing the applied force to it. The coefficient of friction of the surface which the object is on has been asked to be determined.

Hint of "Highlighting the important parts of the problem":

The acceleration-force graph which has been drawn according to data obtained from an experiment that has been carried out by applying force to a fixed chock on the horizontal plane is as figure. What is the coefficient of friction between the chock and the surface which the experiment has been carried out? *(g=10 m/s²)*

Hint of "Visualizing the problem status":

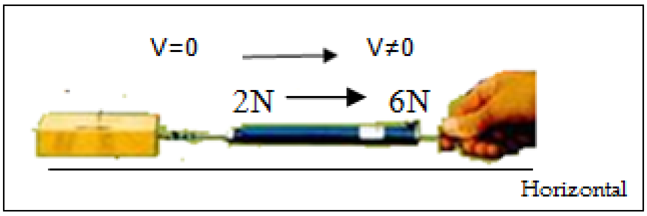


Figure 2. Visualizing the problem status

Hint of "Symbolizing the given and asked variables":

F(N) A(m/s²)

V_0 = m/s
k = ?

Figure 3. Symbolizing the given and asked variables

"Hints about solution steps"

What has to be found primarily to reach friction coefficient?
Primarily, frictional force has to be found to reach friction coefficient.

How can the frictional force applied to a chock be found?
It can be found by determining the force value which the chock started to move from the standstill position.

How can the mass of chock be found?
It can be found from the acceleration- force graph.

The hint of "Formulas that can be used in solution":
$F_{net}=ma$
$F_{net}=F-f_s$
$f_s=k.N$

$a = \Delta V / \Delta t$

The hint of "Physics concepts and principles which are necessary for solution":

Basic Law of Dynamic
The acceleration of an object/system is directly proportional to net force acting on it.

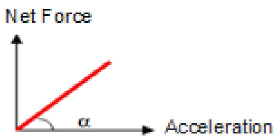
Acceleration
It is the rate of change of velocity of an object.

Net Force
It is the vector sum of all the forces acting upon a system. It is also known as the resultant force.

Friction Force
It is the force exerted by a surface as an object moves across it or makes an effort to move across it. It is calculated by multiplying the friction coefficient of surface and normal force.
$F_s = k.N$

Constant acceleration motion
It is a type of motion in which the velocity of an object changes by an equal amount in every equal time period. The distance covered in equal time periods increases.

The hint of "Graphics knowledge that can be used in solution":



The slope of a line is equal to the average velocity of the object.
$\tan\alpha = F_{net}/a = m$

Figure 4. Graphics Knowledge that can be used in Solution

"Sample solution":
Frictional force ought to be achieved in order to reach the coefficient of friction. Frictional force and mass of object can be acquired from the acceleration – force graph.

The static friction force is the minimum force that must be applied to start an object moving. When we examine the graph, the acceleration of the object is zero when the applied force is below 2N. When applied forces are below 2N, the object does not move. The maximum value of the frictional force is 2N.

The friction force is calculated by the formula $f_s = kmg$. In order to find the coefficient of friction, the value of the mass has also to be calculated. It can be found by $F_{net} = F - f_s$, Fnet= ma formula or the slope of the graph.

$F_{net} = ma$	$f_s = kmg$
$F_{net} = F - f_s$	$2 = k.2.10$
$6-2 = m.2$	$k = 0,1$
$m = 2$ kg	

Participants

This research has been conducted with 21 tenth grade students at two different schools in Trabzon. During the student selection process, great support has been received from the physics teachers. Students who are able to express themselves comfortably and have different levels of success in physics lesson have been chosen. Students from two different schools have been selected in order to reach 10th grade students who are at different success levels and are educated by different teachers. One of the 21 students has solved three problems; and others have solved one or two problems. The reason for this situation is the time that students have spared for interviews. Clinical interviews have been made with students who have had more time in order to solve higher number of problems. In total, clinical interviews have been made with students for 34 problem solutions.

Data Collection Process

Since the "Force and Motion" unit in 10th grade had been taught in the fall semester, research was carried out after instruction, in the spring semester of the 2011 – 2012 academic years. Students have been presented brief information about the purpose of the research and it has been explained that spoken words during the interviews would be secret. Participants have been selected among the ones volunteering for research and suitable time for the interviews has been arranged for each individual student. Data collection process has lasted for two weeks. All of the interviews have been recorded with a voice recorder; most of them have also been recorded with a camcorder. During the interviews, students have firstly been asked to solve the problem by thinking out loud. Then students, who have been able to solve the problem successfully, have been asked to explain the solution process. For the students who have failed to solve the problem, some hint cards have briefly been introduced and they have been asked to retry solving problem by using those hints. Students, who could not solve the problem despite using hint cards, have been asked to explain the reason why they have failed and they have also been asked to explain what kind of hint would help them to solve the problem. Interviews have taken 15 – 45 minutes: interviews with the ones who managed to solve the problem without using hint cards have taken short time; whereas, the interviews with the ones who used hint cards to solve problems have taken longer time. In the interviews, a form, which enables the student to record the problem solved, situation of solving the problem successfully, situation of using hint cards in the problem solving process and usage of hint cards while solving, has been used. This form has been filled during the solution of each problem by the researcher. Voice records have been transcribed on the day interviews have been conducted.

Data Analysis

The forms filled by the researcher and the data obtained from voice records have been subjected to descriptive analysis. Descriptive analysis involves the summarizing and displaying of the data (Sönmez and Alacapınar, 2013). The question of “What?” can be answered, but the questions of “Why?” and “How?” cannot be answered through descriptive analysis. The purpose of descriptive analysis is to present the obtained data regularly. Firstly a frame is formed, then, the data is organized according to the frame and edited data is defined and interpreted during the analysis (Yıldırım and Şimşek, 2008).

First of all, in the data analysis, codes such as S-1, S-2 have been given to each student who participated in the research. After having the interviews transcript, problems solved by students, situations of solving problems successfully and hints used during problem solving process have firstly been analyzed by researcher who conducted the interviews, and then by another researcher. The same codes have been seen to be occurred by analyzing the data regarding problem solution status (true / false) and hints used; and similar codes have been seen to be occurred by analyzing the data regarding to the title of the hints. The hints which have helped students solve problems and students’ opinions about the titles of hint cards have been presented by citations.

Findings

The findings obtained from the data analysis which are related to situations of students' ability in solving problems with/without using hint cards, hints which they have used whilst the problem solving process, relationship between the hints and the ability to solve problems and students' opinions about hints are presented in this section. Students’ problem solution statuses with or without using hints are given in Table 2.

Table 2. Using hints to solve problems

Number of problems solved correctly		**Number of problems solved incorrectly / cannot be solved**	
With the help of hints	**Without the help of hints**	**With the help of hints**	**Without the help of hints**
13	11	10	-

When analyzing Table 2, it is seen that students have come up with the correct solutions for 11 problems without using hints and 13 problems with using hints. Nevertheless, students have not been able to reach the correct solution for 10 problems despite using hints. Students, even though they could not solve the 2 problems, they have been reluctant to continue with the help of using hints

Although there has not been a prepared hint card about unit conversions, 3 students have needed a hint about it. Since assisting students on this subject during the interviews, a unit conversion (U.C.) has been added to the hints used. Problems solved by students, problem solving statuses and hints used during solutions are presented in Table 3.

Table 3. Problem Solving Statuses and Hints Used in Solutions

Problem	Students who solve the problem	Problem Solving Statuses	Hint cards used during and at the end of the solution (*)
P1	S-1	Correct	F. - S.
	S-2	Correct	-
	S-3	Correct	-
P2	S-1	False	F. - C.P. - H.S. - S.S.
	S-2	Correct	-
	S-4	Correct	-
P3	S-5	False	G. - C.P. - H.S. - S.S.
	S-6	False	F. - S. - H.S. - G. - C.P. - S.S.
P4	S-7	Correct	F. - E.M.U.
	S-4	False	F. - H.S. - G. – C.P. - S.S.
P5	S-7	Correct	U.C.
	S-8	Correct	F.
P6	S-9	Correct	U.C.
	S-3	Correct	-
P7	S-9	Correct	G.
	S-10	Correct	
P8	S-10	Correct	-
	S-11	Correct	F. - V. - C.P. - G. - S.
P9	S-10	Correct	-
	S-8	False	H.S. - F. - V. - G. - S.S.
P10	S-11	Correct	F. - H.S. - G. - S. - S.S.
	S-12	Correct	F.
P11	S-13	False	G. - F.- H.S. - S. -S.S.
P12	S-14	Correct	E.S.
	S-15	Correct	F. - G.
P13	S-14	Correct	S.S. - U.C.
	S-16	False	S. - F. - H.S. - S.S.
P14	S-17	False	F. - E.S.
	S-18	False	F. - H.S. - S. - C.P. - E.M.U. - S.S.
P15	S-19	Correct	F.
	S-20	Correct	F. - G.-H.S. - S.S.
P16	S-21	Correct	E.S.
	S-16	False	F. - S. - H.S. - G. - S.S.
P17	S-21	Correct	S.S.

(P: Problem)

* *Abbreviations of the hints are explained in methodology section.*

When Table 3 is analyzed, it is seen that F., H.S., G. and S. hint cards have been used frequently. Students have not used E.M.U. and V. hint cards often. Students have never used the H. hint card. The hints used and correct solutions and are shown in Figure 5.

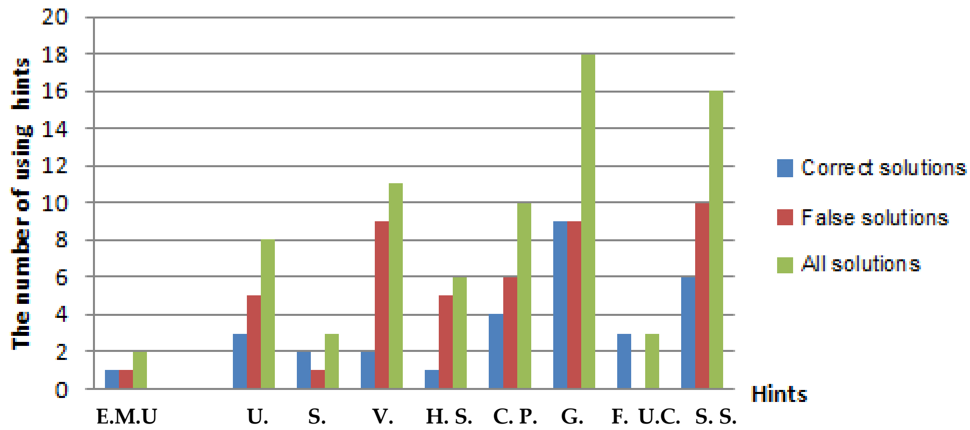


Figure 5. Used hints and solutions' status of being correct

Looking at Figure 5, it is clearly seen that all of the students who have solved problems incorrectly examined the sample solution and most of the students who have solved problems correctly have not examined the sample solution. When hint V. has been used, correct solution for two problems and false solution for one problem have been reached. Students have used hint U.C. 3 times and have come up with the correct solution every time they have used it. All of the other hints have been used more in problems solved incorrectly.

Students have stated that they have been able to do the functions of hints E.M.U., V. and H. by themselves and they did not need them. Some students have expressed this situation as follows.

"This (highlighting) is unnecessary. At least, I can understand and I can do it myself. "(S-6, P3)

"I believe that I am visualizing, and at this moment I do not need to visualize." (S-4, P4)

"Highlighting is useless for me; I'm already highlighting the important parts. Expression with pictures is also meaningless. "(S-13, P11)

When hint G. has been used, correct solutions have been reached 4, false solutions have been reached 6 times. Some students have not been able to find where the "area" mentioned in the hint is on the graph given in the problem. Some students could determine the area and calculate it, but they could not explain the meaning of this operation. It has been stated on the hint card that "Area between graphic parts and time axis lets to find the displacement.", but some students could not find the area on the graph. One of the students' thought about this is as follows.

"The area under the line gives the displacement, I made the mistakes there, at last section, and I would find that area… I made mistakes about the graphical knowledge, it was indicated under the line and I just calculated that area. "(S-9, P7)

When students have succeeded in coming up with the correct solutions, they have mostly used the hints comprising formulas and graphical knowledge, symbolizing the variables in problem. Some students' thoughts whose have use hints about formulas are given below.

"We are a generation that grows with examination, behold we are more likely to use more formula for solving the problem by the shortest way in order to spare more time to other questions. Before taking each exam, we sit for an hour and memorize the formula; almost nothing is in my mind at this moment. "(S-4, P4)

"I mostly benefit from formulas because physics is mainly based on formulas. If I know the formulas, I will be able to do. "(S-1, P1)

For the problems which have been solved incorrectly, solution steps, graph knowledge, formula and the concept knowledge have been used widely. All of the students having solved the problems incorrectly examined the sample solution, but many of the students having solved the problems correctly did not do so. Hint regarding graphic knowledge has been used in two correctly solved and one incorrectly solved problem. Some students, who have been unable to solve problem or solve it incorrectly, did not want to continue to solve even by using hint. Some of the students' expressions about this situation are as follows.

"Even if I use hints, I cannot solve…" (S-8, P9)

"I do not want to see this question ..." (S-16, P13)

The title of "Sample solution" hint has been understood as the solution of a similar problem by some students. When the students have been asked if they would need other hints apart from the available one, some students wanted to have a solution of a similar problem and meanings of unit conversions and symbols. Some students have stated that they would not need another hint and that they would have needed to study by themselves. Students have also stated that sometimes they could not specify what hint they needed. Some of the student opinions regarding this situation are as follows.

"There would have been no need for explanation if a sample solution had been given instead of hints. For instance, if another example with different numbers had been given, it would have been easier to make reasoning. "(S-6, P3)

"I would solve if we did a few examples from book, I mean from the book or something. And actually, I've already done so before the exam. There was even a very similar question in the exam and I've solved it. But now, I have nothing about it in my mind. It is the subject of the first semester, anyway."(S-13, P11)

"There were formulas in my mind but I did not understand what to do, I mean I forgot... I do not know which one I should use." (S-1, P1)

"I do not know. I do not know what I need." (S-6, P3)

Discussion

Possible reasons of the conclusions obtained from the research and aspects overlapped/decomposed points of the research in the literature are presented in this section.

When considering the hints students need about formula that can be used in solution, hints devoted to solution steps, graphic information that can be used in solution and symbolizing the variables given and asked, it can be said that students have difficulty in solving physics problems about force and motion in the following moments. Students' mostly using the 'formula' hint – which can be applied in solution – shows that they have a superficial problem solving approach, which is a characteristic of novice problem solvers'. Students think that knowing the physics formulas merely are sufficient enough to solve a physics problem (Brad, 2011; Eryılmaz, Akdeniz and Kaya, 2011; Surif, and Mokhtar Ibrahim, 2012). There is a positive relationship between the students' problem solving skills and topic knowledge (Chang, 2010). Nakiboglu and Kalin (2009) determined that students' with little topic knowledge have difficulty in solving problems. It has been expressed in literature that one difference between novice and expert problem solvers is that experts have more knowledge and related mind structuring (Schoenfeld, 1992; Leonard and others., 1999, Sutherland, 2002; Teong, 2003; Harper, 2004; Gerace and Beatty, 2005; Şen, 2008; Singh, 2009). Thus, it is thought that not being able to solve a problem is an indicator of lack of knowledge about that topic. Students' using the formula hint mostly supports this thought. Nevertheless, reaching the correct solution by only the half of the students who use this hint shows that students cannot solve problems even though they know the formula. This shows that topic and formula knowledge is only the prerequisite but not enough to solve the problem (Friege and Lind, 2006). Students' using the hint related to solution step shows that they have difficulty in planning, which is an important phase of problem is solving. This result tallies with other researches (Crisostomo, 2010; Byun at al., 2008). Using hints regarding solution steps may often indicate that students do not devote enough time to understand the problem and plan; but want to skip up to the solution step directly. Using the hint regarding the symbolizing and the variables in problem by students may also indicate that they have difficulty in determining the variables. Another reason of this situation may be that although students can explain the concepts, they do not know the physical expression that denotes them.

It has determined that some students need a hint regarding unit conversations. The reason for this may be the presenting of magnitudes belonging to the same unit system in problems faced by students or writing only the symbols while symbolizing the information in problem. In the researches, it has been specified that some students make mistakes in the problems which contain magnitudes from different unit systems (Park and Lee, 2004; Yenilmez and Yılmaz, 2008; Tambychik and Meerah, 2010; İnce , Çağırgan Gülten and Kırbaşlar, 2012). Due to attention deficit about units, students come to a wrong conclusion even though their problem solving steps are correct. Writing the symbols only while expressing the units in the problem or proposing the magnitudes in the same unit system may be the reason why students do not pay attention to the units in the problem. Thus, students do not examine the units of magnitudes in the problem but they only take numerical values into consideration. Some students see units as diffusiveness (Yıldırım and Ilhan, 2007) and make mistakes while solving in the event that numerical magnitudes belong to the same unit system (Yenilmez and Yılmaz, 2008).

It has been determined that students use the hints in understanding the problems the least. They may understand and solve the question easily if they use these hints. In order to solve the problem, the first thing should be to understand it, but still it will not be enough to reach the correct solution (Tambychik and Meerah, 2010). On the other hand, it has been determined by different researchers that one of the difficulties which high school students mostly has is understanding the physics problems (Harskamp and Suhre, 2007; Nakiboglu ve Kalin, 2009; Ogunleye, 2009; Tambychik and Meerah, 2010; Gokkurt and Soylu, 2013). Students sometimes try to find the solution of a problem without trying to understand the problem but by writing the numerical values into the formulas (Redish, Saul and Steinberg, 1998; Altun and Arslan, 2006; Gunduz, 2008; Sen, 2008). In this study, students who cannot solve the problem use hints generally aimed at physics knowledge or formulas.

Students have been able to solve some problems without using hint. This may be due to making the research after the students have studied the subject at school or courses. Jonassen (2000) stated that problem solver's familiarity with type of problem is the biggest determiner of problem solving skills. In such a case when students have come across similar problems previously, as Mayer (1982) stated, schematic knowledge one of the knowledge can be used while solving a problem develops. When a student faces with a problem, he/she constitutes the schematic knowledge by classifying through thinking the relation with similar problems. In this way, if he/she detects the appropriate schema when he/she faces with a problem, he/she can reach solution more easily and quickly. Quilici and Mayer (2002) have stated that the ability of solving encountered problems by using a solution they already know is an important skill. When considered from another perspective, students' thoughts about similar problems help solving problems instead of understanding them and making plan, students memorize the solution ways and implement them when necessary, (Nakiboğlu and Kalın, 2009). It can be said that learning the problem types and their solutions can both be helpful for students and can also block them to learn problem-solving itself. In this study, some students who cannot solve the problem want the solution of a similar problem to be presented as a hint in order to help them solve the problem. This situation indicates that students solve the problems he/she has faced by applying the solution of similar problems. It is very likely to see researches that show the problems solved previously help students understanding the new problem and solving it (Nakiboğlu and Kalın, 2009; Ozcan, 2011).

Using hints has not been helpful enough for students to solve some problems. One reason of this situation may be that students are unable to identify the hints they need. In other words, students' awareness about their problem solving process is insufficient. However, there are not only problems that students cannot solve even if they get help, but also problems that can be solved with help (Pol, 2009). Therefore, the situation of students' failure at solving problems despite using hints can be examined with zone of proximal development, defined by Vygotsky (1978) as "the distance between the level of actual development that is determined by independent problem solving and the level of potential development that is determined by problem solving with help of adults or more capable peers." According to Vygotsky (1978), development is similar to an infinite cylinder, its floor constructed from the problems which person can solve without getting any help and its ceiling constructed from the problems which person cannot solve even if he/she receives support. According to this view, a person's development is endless. On the other hand, there are problems which students cannot solve even if they receive support at all levels (Ozden, 2011). In this sense, it can be said that the benefits of providing students with hints in order to solve the problems are limited with the zone of proximal development.

Students did not want to use hints in two problem solutions although they could not solve them. They think that hints would not help them for solution. This indicates that student' beliefs towards problem solving influence the problem solving skills. As stated by Jonassen (2000), the affective factors such as attitudes and beliefs about learner's problem solving skills influence the problem solving skills substantially. In literature, there are researches that state the factors are effective at problem solving. Knowledge about the subject and willingness for problem solving (Bozan, Küçüközer and Işıldak, 2008), fear of problems and thinking that they are difficult (Karal, Çebi and Pekşen, 2010), cognitive awareness (Öztürk, 2009), self-efficiency (Hoffman, 2010), interest and motivation (Pol et al., 2009) are some of these factors. These factors may be effective on the use of hint during problem solving. If students are unwilling to solve the problem or think that it is too hard for them to solve or have low motivation; they might not want to use the hints to solve the problem.

Due to the misunderstanding of the title "Sample Solution" hints by some students, it has been decided to change. It has been determined that the title new title ought to be "model solution" in similar studies, and hints about units and symbols of physical quantities should be added. Each student may need different kind of help; a problem may be very easy for one student and very difficult for another. Different students may need different hints to solve the same problem.

Conclusion and Suggestions

In this section, the conclusions obtained from finding interpretations and recommendations for these conclusions are presented. During problem solving, students mostly need formulas that can be used in solution, solution steps, graphical knowledge that can be used in solution and symbolizing the variables in the problem. This may indicate the students' insufficiency in these issues / steps while solving problems. Using the 'formula' hint mostly shows that students think that knowing only the formulas is enough to solve physics problems. Yet, only the half of the students' who used this hint being successful in coming up with the correct solution shows that students sometimes cannot solve the problems even if they know the formulas. It can be said that students see problem solving as "substituting the data in the formulas" and that this approach does not completely work out for solving the problems. Students' using the hints regarding the solution steps and symbolizing the data mostly shows that they have difficulties in defining the variables. To prevent this situation, teachers may further highlight their use in daily life and ask students to make sentences that include the concepts they have learnt during instruction of physics concepts and principles. After teaching the 'acceleration', students may be asked to give examples such as "Reducing the velocity regularly when Mehmet comes close to the box office while going on the highway with his car". Symbols representing the concepts can be repeated frequently; when the names of concepts are uttered, their symbols can also be expressed. Reasons of why the concepts are expressed with symbols can be explained evocatively, activities which appeal to different intelligence can be designed.

Students' not using the hints in order to understand the problem shows that they do not give importance to this step while solving problems. Students are not aware of the fact that the main problem of not being able to solve a problem is to not understanding it. Enough time for students to understand the problem should primarily be provided in classrooms, and then when students are sure to understand, the solution plan should be done. The problem may be stated clearly in the understanding step, it may be visualized, dramatized if possible or the presented and asked values may be summarized.

Presenting hints to students is not always enough for them to solve problems. While sometimes hints are insufficient for students to solve problem, sometimes the students cannot identify what hint they need to solve a problem. Providing the students with fully scaffold that they may need in the problem solving process is quite difficult due to the individuality of the problem solving process. Teachers ought to pay much attention to the phase of determining the hints and they should be presented to students individually in the problem solving process to provide in the best possible way (Harskamp and Suhre, 2007). Since problem solving process is individual, teachers should exhibit the simplest points in a very clear way and use also more than one solution way in the classroom. It should be taken into great consideration that the some basic operations, which teachers see as a very simple one and think that students can do, can be difficult for some other students. Students' being unable to determine the hint which can help them solve shows that they lack in the awareness about their problem solving process. In order to construct and develop this awareness, teachers can provide their students with enough time to try to solve the problem by themselves before solving it on the board; and the teacher can ask students who solve the problem incorrect to identify where they make mistakes after solving the problem on the board.

Students think that a similar problem's solution would help them when they are unable to solve the problems. This shows that students think the ways of previously solved problems, rather than understanding the problem and making a solution plan. It can be said that students solve the problems by applying available solutions of similar problems. To prevent this, before solving problem, teachers can ask students to describe the solution plan in detail by asking them questions about what they understand from the problem and which solution steps they will follow for solution. Some students believe that they would never be able to solve the problems. In this case, students do not want to take any assistance to solve the problem and cannot solve it consequently. Students' beliefs towards problem solving affect their problem solving skill. For enhancing students' beliefs towards problem solving, teachers should consider that there are students who are at different levels in classroom. Problems which can be solved by students at the lowest level should be included in lessons; each step should be exhibited on board clearly while problem solving and daily life problems should be paid attention to be given place.

In this research, it is seen that using hint cards help collecting data about the difficulties students have during problem solving more than only conducting interviews. However, all hints that students' need can be specified in more detail if student views are taken into consideration while preparing the hint cards. One disadvantage of this method is that it takes more time. Instructional environment / materials, which can provide more than one student with the hints they need during problem solving, should be designed. Both students can be helped during the process of problem solving and the steps that students have difficulty at solving problems can be determined by the use of environment/material designed by the help of technology. Whether the difficulties which students face during problem solving depends on the subject and on students' age or not can be searched by future researches with participants of different ages and in other topics of physics. Physics instruction can be improved by informing teachers about the results of these researches.

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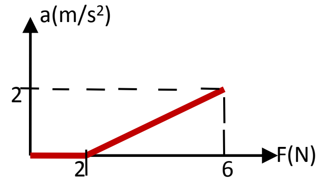
Appendix 1. Turkish Problems

1- Zehra yatay bir zeminde duran 2 kg kütleli kutuyu, bir süre 10 N' luk yatay kuvvetle itmektedir. Bu itme sonucunda kutu 4 m/s ^{2}'lik ivme kazanmaktadır. Buna göre, kutuya etki eden sürtünme kuvveti kaç N dur?

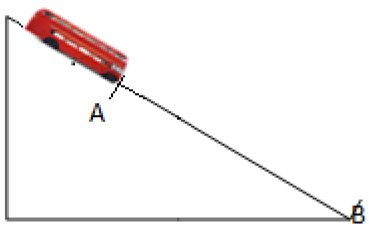
2- Öğrenciler yatay düzlemde yaptıkları deneyde 1 kg kütleli cisme 8 N'luk yatay kuvvet uyguladıklarında, cismin 5 m/s^2 lik ivme kazandığını tespit etmişlerdir. Buna göre, deneyin yapıldığı yüzeyin sürtünme katsayısı kaçtır? *(g=10 m/s ^{2}alınız)*

3-
Yatay düzlemde duran bir takoza kuvvet uygulanarak yapılan deney sonucunda elde edilen verilere göre çizilen ivme-kuvvet grafiği şekildeki gibidir. Deneyin yapıldığı yüzey ile takoz arasındaki sürtünme kat sayısı kaçtır?*(g=10m/s^{2}alınız)*



4- Ahmet çamaşır makinesinin arkasına diş fırçasını düşürmüş ve almak için, 4 s boyunca 20 N luk yatay kuvvetle makineyi itmiştir. Bu itme sonucunda 10 kg lık makine 2 m yer değiştirdiğine göre makineye uygulanan sürtünme kuvveti kaç N'dur?

5-

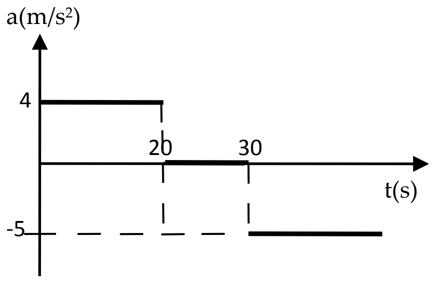


Öğrenciler fizik dersinde yaptıkları deneyde şekilde görüldüğü gibi oyuncak arabayı, arabanın ön ucu A noktasındayken serbest bırakmışlar ve arabanın hareketini gözlemlemişlerdir. Öğrenciler oyuncak arabanın ön ucu B noktasına gelene kadar geçen süreyi 2s ve IABI uzunluğunu 50 cm ölçmüşlerdir. Buna göre, araba B noktasına geldiğinde hızı kaç m/s olur? *(Yüzey sürtünmesini ihmal ediniz)*

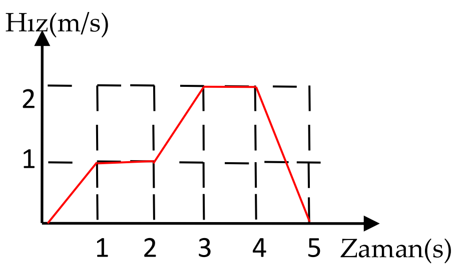
6- Burak otomobiliyle 72 km/h sabit hızla doğrusal bir yoldan evine giderken, yolunun üzerinde büyük bir taş olduğunu fark etmiş ve frene basmıştır. 2 m/s^2 lik sabit ivmeyle yavaşladığına göre, Burak yavaşlamaya başladıktan sonra 4 s içinde kaç m yer değiştirmiştir?

7-

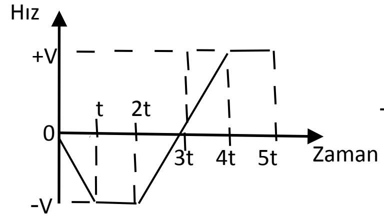
Markete gitmek için arabasına binip yola çıkan Ayşe nin hareketine ait a-t grafiği şekildeki gibidir.Ayşe giderken yolda bir kedi olduğunu farketmiş ve frene basarak kediye çarpmadan durabilmiştir. Buna göre,Ayşe frene bastıktan sonra durana kadar kaç m yol almıştır?



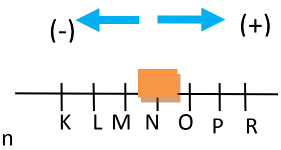
8- Melisa atletizm yarışları için doğrusal bir pistte antrenman yapmaktadır. Melisa'nın harekete başladıktan sonraki ilk 5 s'ye ait hız-zaman grafiği şekildeki gibidir. Buna göre, Melisa 5 s sonunda başlangıç noktasından kaç m uzaklaşmıştır?



9-



Şekil-I

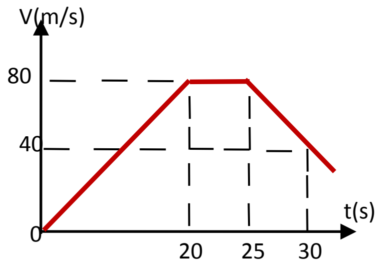


Sürtünmenin ihmal edildiği yatay bir düzlemde, bir cisme uygulanan kuvvet ve cismin hareketi arasındaki ilişkiyi gözlemek için yapılan deney sonucunda şekil-1 deki grafik elde edilmiştir. Cisim deney başladığında N noktasında, t süre sonunda M noktasında olmaktadır. Buna göre, 5 t süre sonra cisim hangi noktada bulunur?

(Noktalar arası uzaklıklar eşittir)

10-

Fatma doğrusal bir yolda kırmızı ışıkta durmaktadır. Yeşil ışığın yanmasıyla başlayan Fatma'nın hareketine ait hız-zaman grafiği şekildeki gibidir. Fatma'nın ilk 30 s deki ortalama hızı kaç m/s dir?



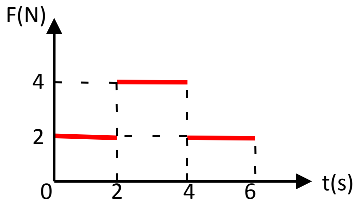
11-

Otomobiliyle doğrusal bir yolda sabit bir hızla giden Kenan düzgün yavaşlayarak, yavaşlamaya başladığı andan 10 s sonra durmaktadır. Durmadan önceki 2 s içerisinde 20 m yer değiştirdiğine göre, Kenan'ın yavaşlamaya başlamadan önce sahip olduğu hız değeri kaç m/s'dir?

12-

Yapılan deneyde sürtünmesiz yatay düzlemde duran 500 g lık kitabı hareket ettirmek için uygulanan yatay kuvvetin zamana bağlı grafiği şekildeki gibidir.

Buna göre, 6. s sonunda kitap kaç m/s lik hızla hareket eder?



13-

Birbirine dik iki yolda bir otomobil ile bir polis aracı vardır. Polis aracı sabit ve 108 km/h hızla kavşağa yaklaşan otomobili kavşakta durdurmak istemektedir. Bunun için polis aracı 625 m uzağında durduğu kavşağa gitmek için 2 m/s² ivmeyle hızlanmaktadır. Polis aracı otomobilden 5 s önce kavşağa gelip otomobilin yolunu kestiğine göre, otomobilin kavşağa uzaklığı kaç metredir?

14-

Bir yolda 180 km/h sabit hızla giden bir Mercedes otomobilin önüne 310 m uzaktaki bir benzin istasyonundan aniden bir kamyon çıkmıştır. Mersedesteki sürücünün kamyonu görmesinden frene basmasına kadar 1 s (refleks zamanı) geçmiştir. Mercedesteki sürücü 5 m/s² lik sabit ivmeyle yavaşlayarak durmuştur. Kamyondan kaç m uzakta durabilmiştir? (*Kamyonun yola çıkınca durduğunu varsayınız)*

15- Bisikletiyle gezen Ahmet 2 m/ s lik hızla bir yokuşun yukarısına, 10 m/s hızla gezen Mehmet ise aynı yokuşun aşağısına gelmiştir. Yokuşu Ahmet 0,5 m/s^2 lik sabit ivme ile hızlanarak inerken, Mehmet hızını saniyede 0,5 m azaltarak çıkmaktadır. Ahmet ve Mehmet 20 s sonra karşılaştıklarına göre yokuşun uzunluğu kaç metredir?

16- İnişe geçen bir uçağın hızı 60 m/s'dir. Uçak tekerlekleri piste değdikten sonra pist üzerinde sabit hızla 300 m ilerlemiş ve sonra 2,5 m/s^2 ivme ile yavaşlayarak durmuştur. Uçağın piste inişi ile duruşu arasında kaç s geçmiştir?

17- 10 m/s sabit hızla bisikletiyle gezen Ali yavaşlamaya karar vermiş ve pedal çevirmeyi bıraktığında bisiklet yoldaki sürtünme ve rüzgâr direnci etkileriyle 0,2 m/s^2 lik ivmeyle yavaşlamıştır. Bu sabit ivmeyle hareketine devam ettiği düşünülürse, bisikletin hızının 4 m/s ye inmesi kaç s sürmüştür?