ISSN 1648-3898

THE EFFECT OF UNIVERSITY PROCESS IN IMPROVING THE MISCONCEPTIONS OF PRE-SERVICE SCIENCE TEACHERS ABOUT MOTION

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Abstract. *In this paper, the effects of university experiences in improving the misconceptions of pre-service science teachers about motion (displacement, distance, average velocity and speed) they brought from secondary education were investigated. This descriptive study was conducted in Ahi Evran University, Faculty of Education between 2003 - 2007 academic years. Total 52 students studying in science education department took part in the study. In the data collection, 12 open-ended questions were asked to pre-service science teachers both in the 1st and 4th years. Frequency tables and percentages were used for analyzing and presenting the data. The paper concludes by arguing that university process could not remove the misconceptions of pre-service science teachers regarding the definitions and quantities of displacement, distance, average velocity, speed, and operational questions.*

Key words: *motion concepts, misconception, science education.*

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Introduction

One of the most essential aims of science education is to enable students to take advantage of the information and the techniques they acquired to explain daily events from a scientific point of view and use them in their daily lives. Thus, it is necessary for students to learn the concepts meaningfully especially at the primary education level, because the scientific concepts acquired correctly at primary education level enable lifelong learning by building up the basis of further levels of schooling.

The concepts are the first connotations that occur in mind while one is talking about a subject (Çepni, 2005). Science classes are generally composed of concepts about physics, chemistry and biology. Students gain several experiences about these concepts long before they start education. Misconceptions arise if concepts acquired from experiences do not correspond with the scientifically accepted concepts (Erdoğan, 2003). In literature, the misconceptions in science education are defined as students having misunderstanding, false information and opinions about the concepts of the course subjects (Morgil et al., 2001), the behaviors as a result of incorrect beliefs and experiences (Baki,1999), the student concepts, which are unacceptable and contrary to science (Chambers and Andre, 1997) or the personal experiences contradicting scientific facts and preventing teaching and learning of scientifically proven concepts (Çakir and Yürük, 1999). These acquired misconceptions as a result of students' experiences are major obstacles to producing new information and to forming relationships with other subjects, shortly, to providing meaningful learning experiences. Berg and Brouwer (1991) studied teachers' awareness of misconceptions of students about rotation and gravity concepts. Similarly, Boyle and Maloney (1991) investigated

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the influence of written texts on the usage and comprehension of Newton's Third Law. In another study Levin, Siegler and Druyan (1990) investigated the formation, development and the influence on the learning environment of misconceptions about the subject of motion.

Since the second quarter of 20th century, many studies were conducted inquiring the reasons and removal of misconceptions. These studies highlighted that there are same misconceptions in different education systems in different countries (Shipstone et al., 1988), and that these misconceptions could be encountered at any level of schooling from primary school to university (Kabapinar, 2007). This is also the case for Physics, Chemistry, and Biology concepts that take place in science content.

In another study (Duit, 1993; cited by Güneş et al., 2002) 1400 articles about the students' science (Physics, Chemistry and Biology) conceptions that were published between years 1977 and 1993 were classified and it was shown that most studies were conducted about physics education (physics education 66%, chemistry education 14%, and biology education 20%). Also, it was found that among the topics of physics, the mechanics subjects (25%) are the ones on which most studies were carried out. The previous studies on mechanics topics (Clement, 1982; McDermott, 1984; Shymansky et al., 1997; Tao and Gunstone, 1999; Eryilmaz, 2002; Güneş and others., 2002; Demirci, 2003; Jimoyiannis ve Komis, 2003; Gülçiçek and Yağbasan, 2004; Yıldız and others., 2006) brought out that the students had a lot of misconceptions in subjects such as motion, force, acceleration and velocity.

These studies reported that the students may adopt several false concepts while learning the concepts about physics because of some factors (learning physics laws by rote, not being able to learn the concepts meaningfully, instructors' lack in identifying the pre-existing knowledge of students and performing the necessary concept correction during the lesson, the abstract nature of physics and so forth) (Kara et al., 2003; Aydoğan et al., 2003). The students are observed to come to physics classes with prejudices so they have difficulty understanding the concepts and they pass on to the higher levels of schooling with a lot of misconceptions (Demirci, 2003).

Some researchers state that the best way to develop science education is to determine the comprehension level of the pre-service science teachers on scientific concepts, also help them make research and observation with scientific applications, enable them to compare their pre-existing knowledge with their findings and help them correct their misconceptions by letting them gain scientific perspectives (Black, 2006). In this study, we attempted to find out whether the misconceptions (about the motion subject) of the students entering the university process brought from secondary school changed at the end of university process. Thus, it was aimed in this way to find the effects of university process on remedying the misconceptions.

The aim of the study

In the study the answers of the pre-service science teachers about motion, distance, average velocity and speed both in the 1st and 4th years were examined, the effect of university process on correcting the misconceptions were examined and the following questions were posed.

1. Is there any effect of university process (in the 1st and 4th years) of pre-service science teachers on removing the misconceptions **about the definition** of displacement, distance, average velocity and speed?
2. Is there any effect of university process (in the 1st and 4th years) of pre-service science teachers on remedying the misconceptions **about the quantities** of displacement, distance, average velocity and speed?
3. Is there any effect of university process (in the 1st and 4th years) of pre-service science teachers on misconceptions in the **solution of operational questions** about displacement, distance, average velocity and speed??

Methodology of Research

The model of the research

In this research, descriptive method was used. This method is used to clarify a given state, to make evaluations according to the standards and to find the possible relationships between the events. In such researches, the main aim is to describe and explicate the state comprehensively (Çepni, 2007). In this study the answers of pre-service science teachers about the definition and quantity of and operational questions about displacement, distance, average velocity and speed both in the 1st and in the 4th years were explored.

This research was implemented in Ahi Evran University, Faculty of Education between years 2003 and 2007. Total 52 students of Science Education Department participated in the inquiry.

Procedures

During data collection, open-ended questions that needed to be answered by the pre-service science teachers both in the 1st and 4th years were used. Data-gathering tool consisted of 12 questions covering the definitions and quantities (matching type questions) of displacement, distance, average velocity and speed, and operational questions encompassing these concepts and requiring mathematical operations (APPENDIX-1). The implementation steps of the research are explained below.

1. In September of 2002-2003 academic year, 58 participant pre-service science teachers were asked 12 open-ended questions about the definition of displacement, distance, average velocity and speed, their quantities and questions covering these concepts and requiring mathematical operations. In this way, the misconceptions of pre-service science teachers about the given concepts before they entered university were identified.
2. In May of 2006 - 2007 academic year, 52 of 58 (4th year) students who had taken part in the research in the 1st year were accessed and asked to answer the same open-ended questions.
3. The answers of 52 students in the 1st and 4th years were analyzed simultaneously with the help of standard answer key prepared by the researchers. Each correct answer was given 1 point and each incorrect answer was given 0 point to calculate total score. Through this method, the effect of university experience on removing the misconceptions of pre-service science teachers was inquired.

Data analysis

The data drawn from the answers of pre-service science teachers to the questions were analyzed and independently classified by 3 different researchers. Later, these groups were compared and brought together. Frequency distributions were derived and the opinions of the participant pre-service science teachers sustaining the results of this analysis were added. Each correct answer to the open-ended questions both in the 1st and 4th years was equated to 1 point and each wrong answer was equated to 0 point, and the difference between the answers was analyzed with t-test.

Results of Research

The findings regarding the answers given to the definitions of displacement, distance, average velocity and speed concepts

Correct and incorrect answers given to the definitions of displacement, distance, average velocity and speed were examined and frequency distributions were given in Table 1.

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Table 1 . The frequency distributions of true and false answers given for the definitions of displacement, displacement, average velocity and speed concepts.

Concepts	1st Year		4th Year	
	Correct (f)	Incorrect (f)	Correct (f)	Incorrect (f)
Displacement	44	8	44	8
Distance	30	22	27	25
Avg. Velocity	20	32	7	45
Speed	3	49	8	44

As the answers given to the descriptions in Table 1 are examined, it seems that the number of students giving correct answer to the definition of displacement both in the 1st and 4th years is 44. Besides, *regarding the definition of displacement concept*, 40 students defined displacement concept correctly both in the 1st and 4th years, but 4 students defined displacement incorrectly both in the 1st and 4th years. Some of the student answers for both cases are given below.

Year 1		Year 4	
The shortest distance between the first and the last positions of an object (E_{13})	√	The vector distance between the first and the last positions of a moving object (E_{13})	√
The distance covered per unit time (K_{17})	-	The total distance for an object to get from position a to position b (K_{17})	-

Moreover, we found that 4 students defined the concept correctly in the 1st year but incorrectly in the 4th, while 4 students defined the concept incorrectly in the 1st year but correctly in the 4th. Some of the student answers for both cases are given below.

Year 1		Year 4	
The direction-aware distance between the last position and the first position of an object (K_{37})	√	Getting from one place to another provided not turning back to the same place(K_{37})	-
Moving from one place to another (E_{20})	-	The direction aware distance between the last position and the first position(E_{20})	√

As it appears in table 1, when all of *the answers about distance* are examined, it will be obvious that the number of students giving correct definition in the 1st year was 30 while it was 27 in the 4th year. Regarding the definition of distance, 23 students gave correct definitions both in the 1st and 4th years, whereas 12 students gave incorrect definitions both at 1st and 4th years. Some of the student answers for both cases are given below.

Year 1		Year 4	
The total ground covered by an object throughout its motion (E_{13})	√	The total ground covered by a moving object beginning from the starting point (E_{13})	√
The velocity per unit time(K_{29})	-	The displacement in a particular period of time (K_{29})	-

Also, regarding the definition of distance, 7 students defined the concept of distance correctly in the 1st but incorrectly in the 4th year, 10 students defined it incorrectly in the 1st but correctly in the 4th year. Some of the student answers for both cases are given below.

Year 1		Year 4	
The total distance covered from one point to another (E_{38})	√	The displacement in a particular period of time (E_{38})	-
The displacement of the moving object per unit time (E_{21})	-	The total ground covered by an object throughout its motion (E_{21})	√

When the answers regarding *the definition of average velocity* are examined as a whole as shown in table 1, we see that the number of the students giving correct definition in the 1st year was 20 while the number of students giving correct definition in the 4th year was 7. Regarding the definition of average velocity, it was found that 3 students defined the concept correctly both in the 1st and 4th years while 28 students defined it incorrectly both at 1st and 4th years. Some of the student answers for both cases are given below.

Year 1		Year 4	
The rate of total displacement of an object on a linear route to total time (E_{39})	√	The division of total displacement of an object to time (E_{39})	√
The ratio of the total distance covered after the beginning of motion to total time (E_{50})	-	The division of total distance to total time (E_{50})	-

Besides, we saw that 17 students having defined the concept correctly at 1st year defined it incorrectly in the 4th year, and 4 students having defined the concept incorrectly in the 1st year defined it correctly in the 4th year. Some of the student answers for both cases are given below.

Year 1		Year 4	
The rate of total displacement of an object on a linear route to total time (E_{34})	√	The total distance covered by an object divided by total time (E_{34})	-
The velocity of an object in the meantime covering a distance (E_{26})	-	The division of total displacement of a moving object to total time (E_{26})	√

When we look at Table 1 for *the definition of speed*, it appears that while the number of the students answering correctly was 3 in the 1st year, it increased to 8 in the 4th year. On the other hand, 41 students defined the concept of speed incorrectly both in the 1st and 4th years. Also, it seems that 3 students defined it correctly in the 1st year but incorrectly in the 4th year, and 8 students defined it incorrectly in the 1st year but correctly in the 4th year. Some of the student answers for all the three cases are given below.

Year 1		Year 4	
Not same as velocity, velocity is scalar, speed is vector. Can be called as speediness (K_{15})	-	The change of velocity (K_{15})	-
The total distance an object covers in a certain amount time (E_{40})	√	The velocity of an object (E_{40})	-
The velocity of moving object (E_4)	-	The ratio of the total distance covered by a moving object to total time (E_4)	√

The findings regarding the quantities of displacement, distance, average velocity and speed concepts

The correct and incorrect answers to the concepts about the quantity of displacement, distance, average velocity and speed concepts have been examined and frequency distributions are given below.

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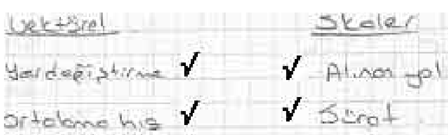
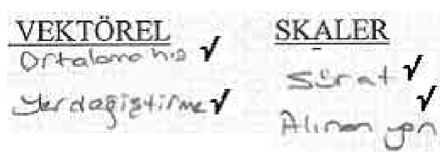
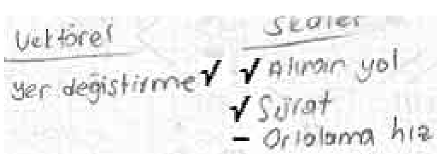
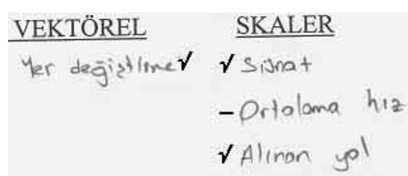
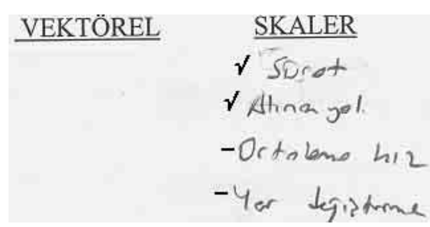
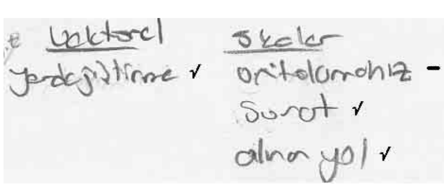
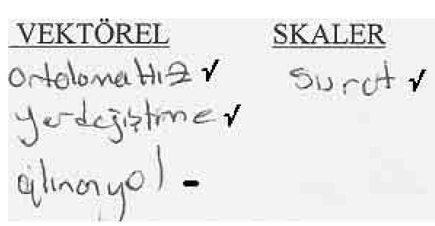
Table 2. The frequency distributions of correct and incorrect answers about the quantities of displacement, distance, average velocity and speed concepts.

Concepts	1st Year		4th Year	
	Correct (f)	Incorrect (f)	Correct (f)	Incorrect (f)
Displacement	46	6	42	10
Distance	31	21	31	21
Avg. Velocity	30	22	29	23
Speed	31	21	42	10

As table 2 is examined, it is clear that while the number of the students answering correctly to the quantity of displacement is 46, it is 42 in the 4th year, and for the quantity of the distance, the number of the correct answers is 31 both in the 1st and 4th years. In addition, the number of correct answers for the quantity of average velocity is 30 in the 1st year, 29 in the 4th year; the number of the correct answers for the quantity of Speed is 31 in the first year while it increases to 42 in the 4th year. Some of the student answers are below.

Year 1	Year 4
 (K_7)	 (K_7)
 (E_{16})	 (E_{16})
 (K_1)	 (K_1)
 (K_{11})	 (K_{11})

For displacement, it occurs that 38 students described displacement as a vector quantity (true) both in the 1st and 4th years but 2 students described displacement as a scalar quantity (false) both in the 1st and 4th years. It appears that 8 students described displacement as a vector quantity in the 1st but as a scalar quantity in the 4th year while 4 students described displacement as a scalar quantity in the 1st but as a vector in the 4th year.

For the distance, 21 students described distance as a scalar quantity both at 1st and 4th years (true), 11 students described the quantity of distance as a vector quantity both in the 1st and 4th years (false). 10 students described distance as a scalar quantity in the 1st but vector in the 4th, while 10 students defined the distance as a vector quantity in the 1st but scalar quantity in the 4th year.

For the quantity of average velocity, 21 students appeared to define velocity as a vector quantity both in the 1st and 4th years (true), 14 students defined the average velocity as a scalar quantity both in the 1st and 4th years (false). 9 students defined average velocity as a vector quantity in the 1st but a scalar quantity in the 4th year. 8 students described the average velocity as a scalar quantity in the 1st but as a vector in the 4th year.

For the quantity of speed, 23 students stated that speed is a scalar quantity in both 1st and 4th years (true), while 2 students stated it as a vector quantity both in the 1st and 4th years (false). 8 students described it as a scalar quantity in the 1st but as a vector in the 4th year, while 19 students defined the distance as a vector quantity in the 1st but as a scalar quantity in the 4th year.

The Findings Regarding the Operational Questions about Displacement, Distance, Average Velocity and Speed

After the answers given to the operational questions about displacement, distance, average velocity and speed have been examined, the frequency distributions given in Table 3 below were found.

Table 3. The frequency distributions of correct and incorrect answers given to the operational questions about displacement, distance, average velocity and speed.

Concepts	1st Year		4th Year	
	Correct (f)	Incorrect (f)	Correct (f)	Incorrect (f)
Displacement	40	12	40	12
Distance	39	13	40	12
Avg. Velocity	2	50	3	49
Speed	--	52	3	49

As table 3 is examined, while the number of the true answers given to the operational question about displacement both in the 1st and 4th years is 40, the number of the true answers given to operational question about distance in the 1st year is 39 and in the 4th year it is 40. As the questions about average velocity are examined, the total number of true answers was found to be only 2 in the 1st year and only 3 in the 4th year. In addition, it was detected that no students gave correct answer to the operational question about speed in the 1st year and only 3 of them could give a correct answer in the 4th year.

Regarding displacement, 32 students gave correct answers to the operational question both in the 1st and 4th years, 4 students gave incorrect answers both in the 1st and 4th years. 8 students appeared to answer correctly to the operational question about displacement in the 1st year but they answered it incorrectly in the 4th year. In contrast, 8 students appeared to answer correctly to the operational question about displacement in the 1st year but they answered incorrectly in the 4th year. Some of the student answers are below. It appears that 33 students gave correct answers to the operational question both in the 1st and 4th years while 6 students gave incorrect answers in the 1st and 4th years. While 6

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students gave correct answers to the operational question in the 1st year, they gave incorrect answers in the 4th year. 7 students appeared to answer correctly to the operational question about displacement in the 1st year but they answered incorrectly in the 4th year. Some of the student answers are below.

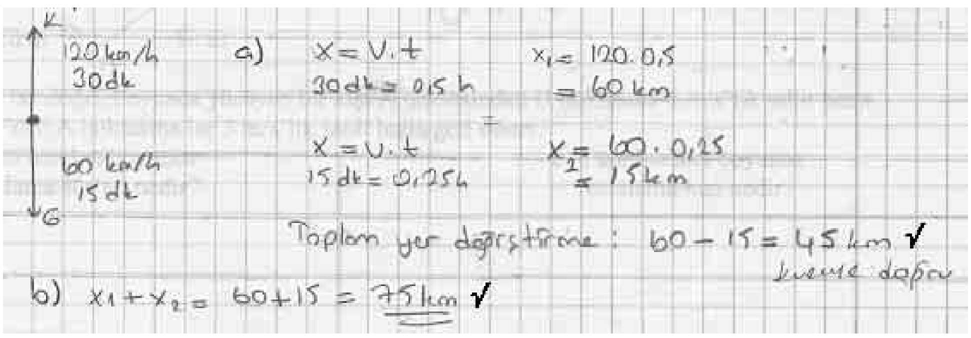
■ Bir motosikletli 120 km/s hızla 30 dakika kuzeye daha sonra 60 km/s hız ile 15 dakika güneye gidiyor.

a) Motosikletlinin toplam yer değiştirmesi nedir?	b) Motosikletlinin aldığı toplam yolu bulunuz?

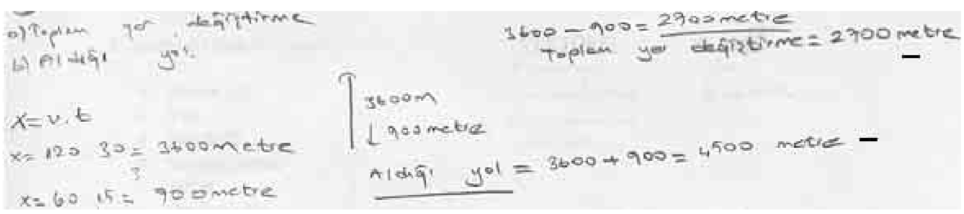
A motorist rides North for 30 minutes at 120 km/h then South for 15 minutes at 60 km/h.

a) What is the total displacement of the motorist?	b) Find the total distance the motorist takes?

Year 1

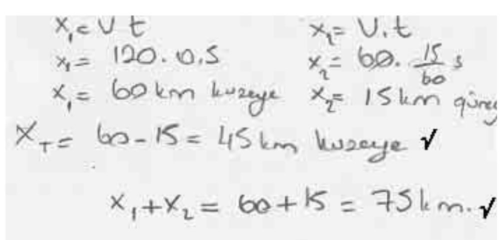


(K19)

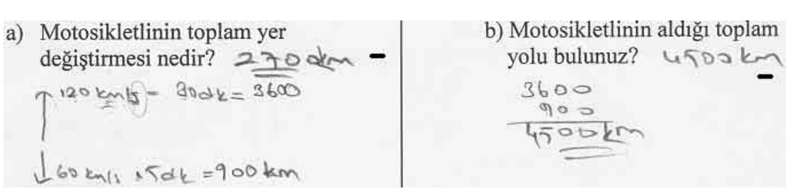


(K3)

Year 4

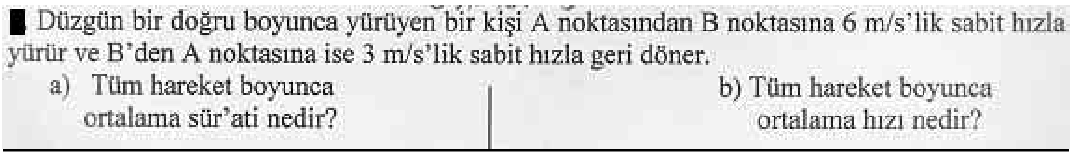


(K19)



(K3)

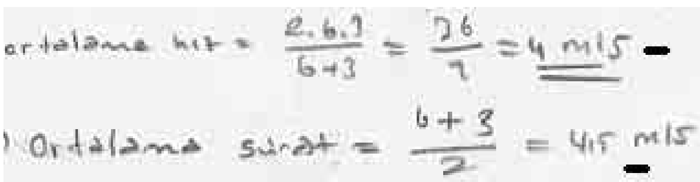
It was detected that 47 students gave incorrect answers to the question about the average velocity both in the 1st and 4th years. 2 students gave correct answers to the same question in the 1st but incorrect answers in the 4th year. It occurred that 3 students gave incorrect answers in the 1st but correct answers in the 4th year. Some of the student answers are below.


Düzgün bir doğru boyunca yürüyen bir kişi A noktasından B noktasına 6 m/s'lik sabit hızla yürür ve B'den A noktasına ise 3 m/s'lik sabit hızla geri döner.

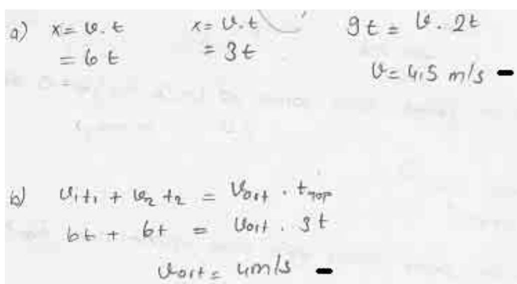
a) Tüm hareket boyunca ortalama sür'ati nedir?

b) Tüm hareket boyunca ortalama hızı nedir?

Year 1

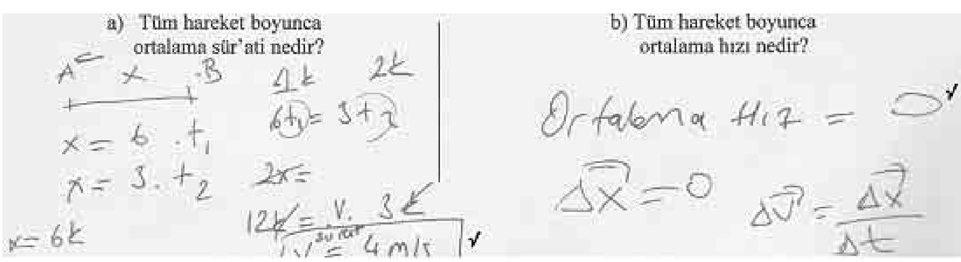


(E13)

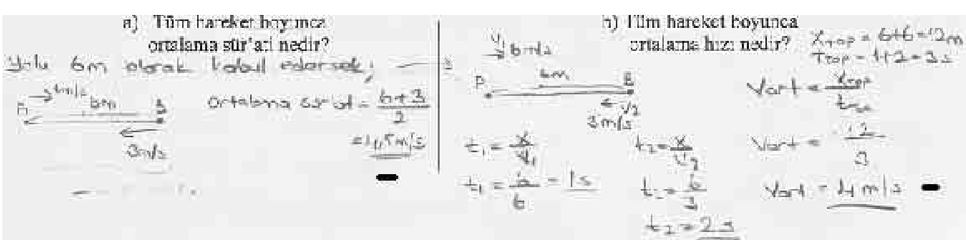


(E16)

Year 4



(E39)



(K23)

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Discussion

As a result of the study, we found that the university process couldn't remedy the misconceptions of pre-service science teachers of study about displacement, distance, average velocity and speed.

The studies implemented in higher education reveal that the misconceptions of university students still persist even after an education on the subject is given and several applications are performed (Shymansky et al., 1997; Yılmaz et al., 2002). This study aligns with the previous studies and reveals that it would be more difficult to remedy the misconceptions in university process if they were not remedied at primary and secondary schools.

The reasons why there are no changes in the misconceptions of the students through university process are predicted to stem from the following factors:

a) The students can encounter these concepts only in *Physics-I* and *Physics-I lab* courses which are offered in parallel in fall term of the 1st class at university.
b) The lack of a complete scheme of links between the *Physics-I Course* and the *Physics-I laboratory* leads to a disconnection between the course and the lab and hence it becomes challenging for the students to build a relationship between the theoretical knowledge and the experiments in the laboratory.
c) Besides, maintaining traditional teaching methods in field courses falls inadequate to remedy the misconceptions despite the existence of laboratory courses.

Considering the fact that similar misconceptions can be encountered at every stage of schooling from primary education to university (Kabapınar, 2007), it should not be forgotten that only showing, telling or writing the correct knowledge would not be very effective in correcting the misconceptions of students in physics concepts as well as in other science concepts (McDermott,1984). Bayraktar (2009) investigated in his work the misconceptions of pre-service teachers about force and motion. For this aim, he used Force Concept Inventory (FCI). Findings of this study showed that the pre-service teachers commonly had many misconceptions. Indeed, the misconceptions of the students seem to continue even after traditional education (Kabapınar, 2007)

Therefore, if the instructors of Physics-I course pay more attention to Physics–I laboratory which was developed parallel to the course content and if they set a relationship with the operational lesson, they can help remedying the misconceptions. Moreover, in order to remedy the misconceptions about science education at university:

a) It is necessary to use concept teaching methods (concept maps, concept nets and analogy etc.) which can be effective to detect the student misconceptions and reinforce subjects with examples from daily life and,
b) Also it is necessary to support the theoretical courses by giving enough time and chance for repetition, experiments in the lab, interactive activities, and other interactive resources (video shows, computer simulations etc.).

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ISSN 1648–3898

APPENDIX 1

ANSWER SHEET

No	Questions	Answers	
1	Define displacement, distance, average velocity and speed?	a) Displacement: The difference between the last and the first positions of an object. b) Distance: The total length of the route a moving object covers. c) Average Velocity: The amount of displacement Δx in a particular time interval Δt. d) Speed: The rate of total distance covered in a particular time interval to total time elapsed.	
2	Write down the quantities of displacement, distance, average velocity and speed?	**Vector**	**Scalar**
		Displacement	Distance
		Avg. Velocity	Speed
3	A motorist rides North for 30 minutes at 120 km/h then South for 15 minutes at 60 km/h.	a) What is the total displacement of the motorist? 120 km/h X 0.5 h = 60 km (north) 60 km/h X 0.25 = 15 km (south) $\Delta x = X_2 - X_1$ = 15-60 = 45 km (north)	What is the total distance covered by the motorist? 120 km/h X 0.5 h = 60 km (north) 60 km/h X 0.25 = 15 km (south) Distance covered = $X_1 + X_2$ = 60 + 15 = 75 km
4	A person moving along a line walks from point A to point B with a constant speed of 6 m/s and then returns from point B to point A with a speed of 3 m/s.	a) What is the average speed of the person during the entire motion? Speed==$(2.V_1XV_2)/ V_1+V_2$ = 2.6.3/6+3 = 36 / 9 = 4 m/s	a) What is the average velocity of the person during the entire motion? $\Delta x = X_2 - X_1$ = AB-AB = 0 m $\Delta V = 0$

Received 12 December 2008; accepted 27 August 2009.

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