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ELEVENTH GRADE STUDENTS' DIFFICULTIES AND MISCONCEPTIONS ABOUT ENERGY AND MOMENTUM CONCEPTS

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ABSTRACT

Physics education researchers have revealed that students have some difficulties and misconceptions in basic physics concepts in mechanics including momentum and energy. The main aim of this study is to determine the 11th grade students' difficulties and misconceptions about Energy and Momentum concepts. In order to fulfill this aim, 21 multiple-choice questions related to momentum and energy was administered to 284 eleventh grade high school students from seven High Schools in the city of Balıkesir during the academic year 2013-2014. Analysis of results showed that high school students have many misconceptions related to momentum and energy concepts. For example, students have many problems with applying or connecting relationship between the conservation of energy and momentum in any given situation.

Key Words: Energy, momentum, 11th grade students, misconceptions.

INTRODUCTION

Many physics education researchers have revealed that students have difficulties in learning scientific concepts because of their some pre-conceived ideas that mostly called misconceptions or alternative conceptions. Those kinds of alternative conceptions and mental models employed by students before and after instruction (McDermott & Redish, 1999) are highly resistant to change. It is accepted that students' beliefs and intuitions about physical phenomena, mainly derived from their everyday experience and usually unacceptable by scientific communities (Novak & Govin, 1984; Duit, 1987). All of the domains of physics, mechanics on the other hand, most studied and investigated branch of physics that students have many misconceptions about (McDermott & Redish, 1999, Duit, 2009). Among these, force and motion concepts have received much interest by researching, however, in spite of two most fundamental concepts in physics there were little research about the momentum and energy all together. Investigating the extent to which students can identify the relevant concept by combining energy and momentum concepts is a part of the rationale for identifying high school student difficulties in this study.

A study was done by Ivowi (1984) examined the misconceptions in physics of 128 students from two secondary schools in Nigeria. He asked students to find out the explanation of the real situation about the conservation of momentum and approximately half of the sample gave incorrect responses to the question. In that study, Ivowi (1984) revealed that (although the concept of momentum was related to the mass and velocity) students

related the conservation of momentum mistakenly only to the concept of velocity. In another study, Graham and Berry (1996) were examined the development of 549 students' understanding on momentum with 20 conceptual questions which involved the relationship of momentum with mass and velocity, vector nature of momentum, impulse in one dimension and the conservation principle of momentum in two dimensions for students at ages 17-18. They explained that according to their results students can be grouped into four categories: first one is those who are confused with the concepts. Second one is those who can understand the basic ideas, recognize relevant situations, and make calculations without knowing the relationships between momentum and impulse and the law of conservation of momentum. Third one is those who are progressing in the hierarchy further and can understand momentum as a vector quantity and apply the impulse-momentum theorem and the law of conservation of momentum in one dimensional problem. The last group is who completely comprehend the concept of momentum.

İngeç, Ünlü and Taşar (2002) investigated the learning sequence of the concept of momentum subject with 158 students from grades 6, 7, 8, 9, and 10 (ages 12-16). They used in-class demonstration experiments related to conservation of mass, velocity, and momentum. They acclaimed that success rate in momentum questions are much higher than others with suggesting understanding momentum does not require understanding the concepts of mass and velocity, which is thought to be necessary for understanding momentum.

Çirkinoğlu (2004), examined with using open-ended conceptual test related to impulse and momentum concepts to reveal 89 primary science students' and 124 high school students' conceptual level and misconceptions about impulse and momentum concepts. Pre and post experimental design was used. She had also conducted semi-structured interviews with 15 students. According to the results of the study, both samples have difficulties about impulse and momentum concepts and students misconceptions remained the same even after teaching the subject areas.

The concept of energy also plays an essential role in physics. Energy conservation principle is commonly stated as energy cannot be created or destroyed (Raven & Johnson, 1999) in almost all science textbooks. However, many science educators dispute that this explanation may be confusing among students if supporting concepts such as "energy transfer, energy flow, and energy transformation are not incorporated when defining energy conservation" (Mclldowie, 1995; Chabalengula et al, 2012).

Energy and momentum conservation offer an underlying framework in teaching the concepts of mechanics. Singh and Rosengrant (2003) were investigated students' understandings of energy and momentum concepts in an introductory physics course. They constructed and administered a 25-item multiple choice test and also carried out individual interviews. According to the findings of the study, most students had difficulties in conceptually interpreting basic principles related to energy and momentum. Similarly, Lawson and McDermott (1987) found out that many students have had difficulties in the interpretation of directly one-dimensional motion of the object to impulse- momentum and work-energy theorem.

PURPOSE

The main purpose of this study is to determine the 11th grade students' difficulties and misconceptions about Energy and Momentum concepts.

Research Questions

1. What are 11th grade students' difficulties and misconceptions about on Energy and Momentum?
2. Is there a significant difference between the male and female students' test scores on the Energy and Momentum Conceptual Survey?
3. Is there a significant difference among students' test scores in different type of schools on the Energy and Momentum Conceptual Survey?

Limitations

This research is limited to

1. 2013-2014 academic year,
2. The seven various High Schools with 284 students in Balıkesir,
3. The Energy and Momentum Concept Test.

METHODOLOGY

Subjects

The sample of the study has been chosen from seven high schools students in the city of Balıkesir during the academic year of 2013-2014. In the study there were 284 eleventh grade students. The distribution of sample according to school is given in Table 1.

Table 1: Distribution of Students by School

School	Female	Male	Number of students (N)	%
Science High School	30	15	45	16
Sırrı Yırcalı AnatolianHigh School	38	20	58	20
Fatma Emin Kutvar Anatolian High School	16	17	33	12
TOKİ Anatolian High School	16	21	37	13
Cumhuriyet Anatolian High School	37	29	66	23
Bahçelievler Anatolian High School	14	11	25	9
Adnan Menderes Anatolian High School	17	3	20	7
Total	168	116	**284**	100

Instrumentation

In the study, there was only one instrument, the Energy and Momentum Conceptual Survey (EMCS). The test, consists of 25 multiple choice questions, was introduced by Singh and Rosengrant (2003). It is design to cover subject areas related to work and energy, energy and momentum conservation, and collision in one dimension. The detail distribution of questions related to concept area is given in Table 2.

Table 2: Questions and their related concept in EMCS test

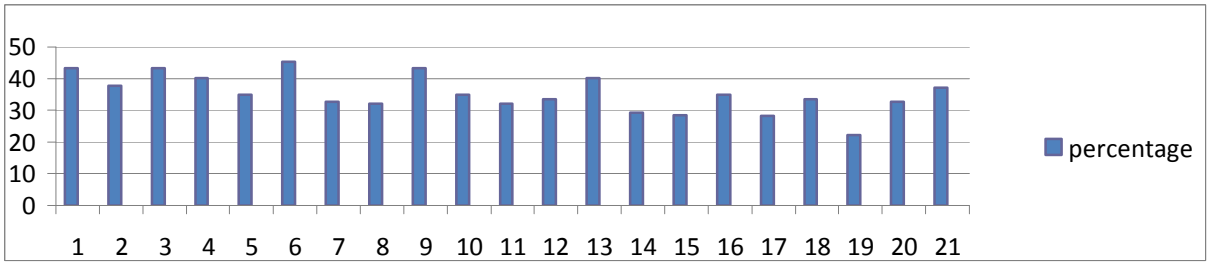
Concepts	*Related Questions*
Work-Energy	1,7,11
Conservation of Energy	2,4,8,12,13,14,16,18,19
Conservation of Momentum	6,9,15,17,20,21
One-Dimensional Collisions	3,5,10

Procedures

After translating EMCS test into Turkish. The test controlled and checked by some physics instructors and then applied to 54 11th grades of high school students as a pilot study. According to student's responses reducing the four questions the final EMCS test, consisted of 21 multiple question test, was finalized to use in the study. And then this test was applied to 284 high school students after the traditional instruction of subject matter as described in sample section. The reliability of the final version of the test was found as r=0,81.

Difficulty coefficient is a measure of the degree of difficulty of the questions that make up a test. Difficulty factor has a value ranging from 0 to 1. When difficulty factor approaches 1 test question thought as easy, then it approaches 0, it is thought difficult (Demirci & Çirkinoğlu, 2004). According to Energy and Momentum

Conceptual Survey test, obtained from this study, difficulty coefficient was ranged between 0.22 and 0.45 and average difficulty level of 0,352 (see, Graphic 1).



Graphic 1: Difficulty coefficient(in %) of Energy and Momentum Concept Test

RESULTS

After analyzing data, students' average EMCS test score was found as 32,5%. Distribution of students' answer according to each question is given in the Table 3.

Table 3: Students' answers related to each question(in percent)

Question	A (%)	B (%)	C (%)	D (%)	E (%)	Total correct (%)
1	15	**43**	21	5	15	43
2	11	11	34	7	**37**	37
3	12	**42**	13	13	16	42
4	**39**	12	7	21	20	40,1
5	19	18	20	**35**	8	34,9
6	10	13	12	18	**46**	**46**
7	17	12	**32**	20	17	32
8	**32**	20	16	11	19	32
9	5	17	15	**44**	18	44
10	19	13	20	10	**34**	34
11	13	13	19	**30**	25	30
12	21	20	**31**	12	14	31
13	14	13	13	**40**	17	40
14	**30**	18	25	13	10	30
15	19	19	**29**	12	15	29
16	28	**35**	9	13	11	35
17	19	12	19	16	**28**	28
18	**33**	13	21	14	13	33
19	29	11	**21**	23	11	**21**
20	18	**33**	18	15	9	33
21	18	11	15	12	**38**	38

As shown in Table 3, in general, all of the correct answer percentage was below the 50%. The most correct answer is given in question 6 with 46%. This question related to conversation of momentum concept while at least correct answer is given in question 19 with 21%. Also this question is related to conservation of energy concept. The test results reveal that students lack a coherent understanding of energy and momentum concepts and have difficulty applying them to different physical situations. Some detail results according to concept by concept are given the following part.

Questions related to Work and Energy Concepts (1,7,11)

Items 1, 7 and 11 can all be answered based upon the conservation of mechanical energy, because there is no work done by non-conservative forces. According to the students' responses only 43,3% of students had a correct answer rate to the first questions while 32% of the students gave the correct answer to the 7th and 11th questions. While 43,3% of students answered the 1st question correctly, 21% of students gave the wrong answer which is C option. They said that removing the bag from the ground up or doing it from a long way distance would directly impact the work done.

Questions related to conservation of energy concepts (2,4,8,12,13,14,16,18,19)

All questions in this category, especially 2nd, 14th and 16th questions were given correct answers by 38%, 29% and 35% respectively. The wrong choice in the 2nd question was C answered by 34% of students. In 2nd question, two men with the same mass start sliding in same height but different inclination path, then the question asks largest speed at the bottom. The choice of B and C were chosen by 18% and 25% respectively. 18% of students answered that the man whose mass is less would be faster at the bottom of the slide while 25% marked that the man with higher mass would be faster and come first at the bottom of the slide assuming that kinetic energy of the moving object depends on the path of incline plane. In the question 16th, the correct answer was given by 35% of the students, the wrong choices were chosen by 28%, 9%, 13%, and 11%, respectively. It can be imply that students have difficulties related to energy conservation. Also it can be said this idea misconception of "the longer moving path, the more kinetic energy of the system".

Questions related to Conservation of Momentum Concepts (6,9,15,17,20,21)

By selecting E choice in 6th question students answered 46% correctly. This question related to mass, speed and also relation to momentum. However, the 15th question arises judging that the Momentum Conservation cannot fully be understood. As seen answer from the 15th question, the proportion of A and B choice which were wrong answer, it is understood that the 38% of students have difficulties about Momentum Conservation. Although, the most correct answer is given in this question however it easy far away from desired level.

Questions related to Collision in One Dimension Concepts (3,5,10)

Item 5 probes the understanding of momentum conservation in an elastic and inelastic collision choosing the popular distractor B it was believed that the block in which the bullet gets embedded moves faster because the bullet transfers all of its kinetic energy to the block in the inelastic collision. The students answered especially in C option, that the mass of the bullet stucked to a piece of wood increased and the one with higher mass has also higher momentum. Items 3 and 10 were designed partly to evaluate whether students can identify the appropriate system for which momentum is conserved and indicated that many students were confused about it. Many believed that the momentum and kinetic energy are conserved for each object. Incidentally, in the test response to item 10, 57% noted that a person standing on ice will remain stationary when hit by a horizontally moving ball of its kinetic energy to the block in the inelastic collision. Most students ignored that momentum concept is vectoral, energy is scalar quantities.

In order to determine difference between the male and female students' test scores on the Energy and Momentum Conceptual Survey test the independent sample t-test was used. Male and female students' average test scores and standard deviations are given in table 4 and the summary of independent t-test results are given in Table 5.

Table 4: Male and female students' average test scores and standard deviations

		N	Average	Std. Dev.	%
Total	female	168	7.35	4.768	35
	male	116	7.46	4.986	36

Table 5: The summary of independent sample t-test results by gender

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Top.	Equal variances assumed	.195	.659	-.180	282	.857	-.106	.586
	Equal variances not assumed			-.179	240.143	**.858**	-.106	.591

p>0,05

According to the independent t-test results shown in Table 5 concluded that there was not statistical significant difference between the genders was found from energy and momentum conceptual survey test.

Also, in order to determine if is there any significant difference between students' test scores in different type of schools on the Energy and Momentum Conceptual Survey the one way ANOVA test was used. The summary table from this result is given in Table 6.

Table 6: One-Way ANOVA Test Results among Schools

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3273.628	2	1636.814	135.990	**.000**
Within Groups	3382.203	281	12.036		
Total	6655.831	283			

*p<0,05

According to one-way ANOVA Test results based on the types of schools on the Energy and Momentum Conceptual Survey Test score, there was a statistical significant difference between the types of schools. In order to determine statistical differences between schools Dunnett's T3 "post hoc" test was performed. The summary of Dunett's T3 test results is given in Table 7.

Table 7: Test results between the groups, Dunnett's T3

	(I) Turu	(J) Turu	Mean Difference (I-J)	Std. Error	Sig.
Dunnett T3	1	2	-.323	.985	.983
		3	6.877*	.838	**.000**
	2	1	.323	.985	.983
		3	7.200*	.578	**.000**
	3	1	-6.877*	.838	.000
		2	-7.200*	.578	**.000**

*. The mean difference is significant at the 0.05 level.

It was found that there was a statistical difference between "science high schools and Anatolian high schools.

CONCLUSION

In this study, 11th grade students' difficulties and misconceptions about Energy and Momentum concepts was investigated. 21 multiple-choice questions related to momentum and energy was administered to 284 eleventh grade high school students from seven High Schools in the city of Balıkesir during the academic year 2013-2014.

After analyzing data, students average Energy and Momentum Conceptual Survey test score was found as 32,5%. It was found that most of the students have failed to recognize the significance of relation between energy and momentum and they have difficulties in qualitatively interpreting the basic principles related to energy and momentum and in applying them in physical situations. In order to determine difference between the male and female students' test scores on the Energy and Momentum Conceptual Survey test the independent sample t-test was used but there was not found any statistical significant difference between the genders.

Also, in order to determine if is there any significant difference among students' test scores in different type of schools on the Energy and Momentum Conceptual Survey the one way ANOVA test was used. According to one-way ANOVA Test results based on the types of schools on the Energy and Momentum Conceptual Survey Test score, it was found that there was a statistical significant among the type of schools. And then in order to determine statistical differences between schools Dunnett's T3 test used. It was found that there was a statistical difference between "science high schools and Anatolian high schools.

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