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Grade 10 Students' Misconceptions about Impulse and Momentum

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ABSTRACT

Studies focusing on teaching of science concepts show that students are unable to learn the scientific meaning of the target concepts while they are constructing newly acquired knowledge with their prior experiences during or after teaching and as a result misconceptions emerge (Novak & Gowin, 1984). In the light of this fact, many studies have been carried out on misconceptions in science education. However, the researchers have not come across with enough studies about misconceptions on momentum in physics during the review of literature.

This study aims to reveal grade 10 students' misconceptions about impulse and momentum. In order to achieve this aim, a conceptual understanding test, which involves 8 open ended questions, was administered to 139 students from randomly selected 5 secondary schools in the city centre of Balıkesir during the academic term of 2003-2004. In addition, semi-structured interviews were conducted with 8 students to penetrate the ideas given in response to conceptual understanding test questions and to learn the points that students experience learning difficulties.

Analysis results show that 30% of the students confused the concept of momentum with the concept of impulse and 24% of them used the concepts of energy, power, force and acceleration instead of momentum in scientifically unacceptable way in the conceptual understanding test. Four of the students interviewed stated that "momentum is a repulsive force" which was in accord the responses given in the test. Moreover, it was found that 68% of the students were unaware of the vector nature of momentum.

Implications of teaching of momentum were drawn for science educators and curriculum developers in the light of the findings.
Keywords: Misconceptions, Conceptual Understanding Test, Impulse and Momentum

INTRODUCTION

Many researchers studying in science education area indicate that students experience difficulties in learning scientific concepts due to pre-conceptions (misconceptions, alternative ideas), which resist to be changed, and are described as scientifically incorrect or unacceptable (Novak & Gowin, 1984; Duit, 1987).

Recently, studies which aim to increase students' learning levels have been emerged. Many of those, which include physics topics, focus on mechanics and electricity ideas. Mechanic on the other hand, is an area of physics in which students have many misconceptions before teaching and they also experience difficulties in understanding the concepts involved (Duit, 1987; Galili, 1995). The sub-topic of impulse and momentum in mechanics is considered to be simple but in fact it is a complex topic when the related concepts are not emphasized efficiently and is taught with traditional teaching methods in which algebraic notions are mostly used. Therefore, studies which diagnose the points that students experience difficulties in understanding and define the misconceptions about momentum and aim to increase the quality of learning by remedying those misconceptions are required in this area.

Studies based on mechanics mainly include dynamics and work-energy topics in science education. Besides the concept of momentum was not touched on these studies, the scarcity of up-to-date research examining misconceptions on impulse and momentum also requires attention.

One of the studies about impulse and momentum by Lawson and Mc Dermott (1987) investigates the impulse and momentum equation in one dimension. In this study, it was aimed to explore the development of 28 students' learning on momentum in two physics classes of one university by defining their conceptual understanding step by step. Two demonstration experiments related to the changes in momentum and kinetic energy were used as data collection instruments.

Lawson and McDermott (1987) attribute the increase in students' basic misconceptions to the traditional instruction of momentum as one dimensional motion and to being unable to emphasize vector and conservation of momentum properties mostly as a result of the interviews conducted on two groups of students. Their study showed that most of the students struggled in applying correctly theorems of work-energy and impulse-momentum to the objects experiencing a constant force in one dimensional motion. Consequently, it was revealed that many students were unable to make a connection between the simple observed motion and algebraical form learned in the classroom.

In another study, the development of 549 students' understanding on momentum was examined by Graham and Berry (1996). The researchers constructed a conceptual understanding test with 20 questions which involve the relationship of momentum with mass and velocity, vector nature of momentum, impulse in one and the conservation principle of momentum in one and two dimensions for students at ages 17-18 in this study.

According to the analyses results, Graham and Berry (1996) emphasize that geometry should be preferred to calculation during teaching which may result in better grasp of vector nature of momentum and a meaningful learning of two dimensional impulse and momentum for students.

In his study entitled "Misconceptions in mechanics and how to avoid them" McClelland (1985) mentions about misconceptions concerning the concept of momentum. He emphasized the relationship between Newton's Laws of Motion and the change in momentum and also outlined the students' ideas about the concept of work.

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 real situation about the conservation of momentum and approximately half of the sample gave in correct 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.

Raven (1968), on the other hand, aimed to define the elements necessary in understanding of momentum by primary students in order to change itself. In designing his study Raven (1968) used 160 nursery and primary students at ages 5-8 and showed that students had intuitive ideas without understanding the elements (concepts of mass and velocity) involved in momentum and how those elements compose an interaction together (Güneş, İngeç & Taşar, 2001).

Güneş et. al. (2001) tried to define the students' level of ability to describe the concepts of impulse and momentum by asking 192 students in school of education directly to descriptions of some concepts related to the concept of momentum in their study, while only one third of the students were able to describe correctly the concept of momentum, the proportion of the sample reduces to 25 % in describing the concept of impulse correctly. Moreover, it was found that some students confused considerably the concept of momentum with moment. In addition, it was evident that there were qualitative differences in the explanations made in terms of the level of grades and primary education department students achieved lower than physics education department students who mostly responded to the questions by ignoring the vector property of momentum in their reasoning.

In the study of Singh and Rosengrant (2003), students' understandings of energy and momentum concepts in an introductory physics course were investigated. 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 and in employing them in physical situations.

Hein (1999) investigated a particular writing strategy which is called a folder activity and applied in a physics course at one of the American Universities. She argues that the folder activity used shows students' misconceptions about particular concept in physics course. Also, Kamela (2007), in his study, presented a class exercise for helping students to develop an intuitive grasp of the relations with velocity-acceleration and force-acceleration. Analyses of demonstrations were used to show the impulse-momentum relation and it was suggested that such a demonstration could be utilized as a starting point for the discussions concerning energy issues.

Ellis and Turner (2003) introduced a developed conceptual framework which was taught in secondary schools and administered to college students. In that framework, the causes of motion were showed graphically using Newton's laws and impulse-momentum relationship. They explained how it was used by teachers and students in the classroom as a part of a learner-centered method. They developed a curriculum of laboratories, activities and homework assignments and also investigated students' ideas about this approach in their research.

The purpose of this study was to outline the misconceptions of grade 10 students, who were enrolled in five secondary schools at the city centre of Balıkesir, about impulse and momentum. In order to achieve this aim the question of "What are the misconceptions that secondary school students have about impulse and momentum?" was tried to be answered.

This study was thought to be limited with;

- 139 students who were randomly selected from five secondary schools at the city centre of Balıkesir.
- The concepts of impulse and momentum,
- Interview questions and a conceptual understanding test which was designed to reveal students' misconceptions about impulse and momentum.

METHODOLOGY

The sample of this qualitative study, in which students' ideas about a certain topic were tried to be examined thoroughly, consisted of 139 grade 10 students who were randomly selected from classes of five secondary schools at the city centre of Balıkesir.

A conceptual understanding test was designed to determine 139 students' ideas about impulse and momentum after teaching. In addition, semi-structured interviews were conducted with 8 students about the concepts to integrate responses obtained from the conceptual understanding test and to produce more explanatory data.

The conceptual understanding test consisted of 8 open-ended questions while some of the questions in the test were selected from the study of Graham and Berry (1996), the rest of them were designed by the researchers.

The questions in the conceptual understanding test were selected to identify whether the students knew the physical meaning of the momentum, vector nature of the momentum, the conservation principle of the momentum, impulse in one dimension and the rule that the change in momentum is equal to impulse in terms of scientifically acceptable point of view. Table 1 shows the concepts related to each conceptual understanding test question.

Table 1. *Concepts Related to The Questions in The Conceptual Understanding Test.*

Concept/s related to each question	Question number
Momentum is equal to the product of mass and velocity.	1, 5, 7
Vector nature of momentum	3, 6, 8
Conservation of momentum	2, 6
Impulse in one direction	1, 4 and 6

A pilot study was carried out with 30 grade 10 students before the administration of the final form of the test to the selected secondary schools. All questions were reviewed after pilot study completion and to prepare the final form of the test.

Analysis of the conceptual understanding test was performed at two stages by taking into account the responses given to the first and open ended part of the questions. The first parts of the questions were in one of the forms of multiple-choice, the selection of a phenomenon between two events or requiring yes-no type responses from the students. The second part of the questions composed the actual sections where the responses examined using qualitative analysis methods.

Scientifically complete response of each question was defined by considering the consent of experts in physics education before starting the analysis of the qualitative data and there after the responses were grouped by diagnosing whether they were scientifically acceptable or not. If a response was scientifically acceptable then it was reconsidered to decide whether it was a full response or a partial response, which includes components of the full response in terms of the elements involved in itself.

On the other hand, scientifically unacceptable responses were gathered in five categories entitled "scientifically unacceptable responses related to momentum", "scientifically unacceptable responses unrelated to momentum", "intuitive responses", "uncodeable responses" and "no response" and the analyses of data was carried out on the basis of this categorization. Table 2 shows the analyses structure of qualitative responses given to the conceptual understanding test.

Table 2. *Categories of Responses in The Coding System*

Category	Response Types
	A. Scientifically Acceptable Responses
3	A1.Full response
2	A2. Partial response
	B. Scientifically Unacceptable Responses
1	B1. Responses Related to Momentum
1	B2. Responses Unrelated to Momentum
1	B3. Intuitive Responses
0	C. Uncodeable
0	D. No response

The data were analyzed by the researchers, 20 randomly selected conceptual understanding tests were given to an expert in the area of physics education to be analyzed again so as to measure the reliability of coding during the analysis of the test. Here, the consistency between the analyses of the researcher's and the expert's coding of the categories was investigated. Since the researchers' ways of perception and interpretation are valid in the qualitative research, the errors originating from perception and interpretation have to be kept to a minimum. Therefore, coefficient of concurrence for response categories of each question was calculated and those coefficients in percentages were presented in Table 3 to indicate the degree of concurrence between two coders. As can be seen in Table 3, the average coefficient of concurrence was found to be 91.25% which highlights the fact that the coding system can be regarded as reliable.

Table 3. *Coefficient of Concurrence for Each Question*

Question number	**Coefficient of concurrence (p)**	**Average ($\overline{P}$)**
1	0.90	0.9125
2	0.90	
3	1.00	
4	0.85	

FINDINGS

In this part of the study, analysis results of 4 questions in the conceptual understanding test were presented.

The findings obtained from the analysis result of the first question which investigates the ideas of students about the relationship between momentum and the concepts of mass and velocity and how the change in momentum depends on impulse were given below.

Table 4.*Percentage of The Responses Given to The First Part of Question 1*

Responses	**N**	**Frequency (%)**
A) It is harder to stop the car than the lorry	33	23,7
B) It is harder to stop the lorry than the car	**100**	**71,9**
C) Both have equal difficulty to be stopped	6	4,3

As can be seen it Table 4, 71.9% of the students gave the correct response to the first part of this question. According to the results shown in Table 4, the rate of correct response given to the first part of the question 1, which is related to the notion that momentum is equal to the product of mass and velocity is considerably high.

Table 5. *Analysis Results of The Responses Given to The Second Part of Question 1*

Level	**Response Types**		
	A. Scientifically Acceptable Responses	Num. of resp. **(N)**	Per. of resp.**%**
3	**A1.Full response**		
	Change in the momentum of an object gives the impulse exerted on that object. Since the change in the momentum of lorry is bigger than the car's momentum change, it is harder to stop the lorry than the car.	2	1,4
2	**A2.Partial response**		
	Responses Related Only to The Change in Momentum *"Since the momentums of the lorry and the car are* P_L*=3000(0-30)=-90000 ,* P_C*=1000(0-80)=-80000 respectively, it is harder to stop the lorry than the car.*"	3	2,2
	Responses Related Only to The Change in Momentum *"It is hard to stop an object which has a bigger momentum than the other."*	40	28,8
	Total	**45**	**32,4**

Table 5. Continued..

	B. Scientifically Unacceptable Responses B1. Responses related to the concept of momentum	Num. of resp. (N)	Per. of resp.%
1	Situation in which the change in momentum and momentum itself is confused. *"It is harder to stop an object which has a bigger momentum and thus it also has a bigger impulse..*	22	15,8
	Explanations involving the equality of impulse and momentum *"Because momentum is equal to F.Δt, a bigger force is exerted on the object which has a bigger momentum to stop it."*	13	9,4
	Responses involving incorrect use of momentum equation *"Stopping an object depends on its velocity. An object, which has the highest momentum, is always faster than the others."*	5	3,6
	Explanations concerning the concepts of momentum and force *"As the momentum of an object increases a bigger force is needed to stop that object."*	1	0,7
	Responses involving confusion between the concepts of moment and momentum *"It is harder to stop because it has a higher moment."*	4	2,9
	Responses based on the concept of velocity *"Since the object with a bigger momentum will have a higher velocity, it is harder to stop an object with a bigger mass."*	15	10,8
	Responses related to the frictional force *"In order to stop an object frictional force should be bigger than its momentum."*	1	0,7
	Responses related to the concepts of mass-weight *"According to momentum equation, it is harder to stop an object with a bigger mass."*	2	1,4
	Total	**63**	**45,3**
	B2. Responses unrelated to the concept of momentum	Num. of resp. (N)	Per. of resp.%
	Explanations based on the concept of acceleration *"As can be seen in the equation V=a.t if the acceleration reduces with time it is not depend upon the mass."*	2	1,4
	Responses concerned with the concept of velocity *"It is important that the velocity of the object should be low to stop it."*	19	13,7
	Responses Related to the Frictional Force *"Because the frictional force acting on the lorry is higher it is harder to stop it than to stop the car"*	1	0,7
1	Responses Related to the concepts of mass-weight *"It is hard to stop the vehicle with a bigger mass."*	5	3,6
	Total	**27**	**19,4**
0	C. Uncodeable	4	2,9
	Total	**139**	**100**

Students were asked to explain the reason(s) of the response given to the first part of the question in the second part of question 1. It can be seen in Table 5 that the group of scientifically acceptable responses compose 32.4% of the whole responses. While the rate of full responses is 1.4%, the rate of partial responses is 31% in this group. 28.8% of the students reasoned that "it is hard to stop an object which has a bigger momentum than the other." Although this kind of responses did not mention about the change in momentum, they were put into the category of partial responses since they involved the explanations based on the acceptable ideas about the concept of momentum.

In this group, scientifically unacceptable answers' ratio is very high, the 15.8 percent of students are confused with concepts "momentum change" and "momentum". Simply, in their explanations students used momentum concept instead of momentum change concept. It is established that students try to answer question with the fact that momentum is equal to mass multiplied with velocity.

If continued with looking up the analysis table of answers given to the second part of the question, another noticeable situation is that 24.5% of the students have scientifically unacceptable knowledge of velocity concept. 10.8 percent of those who did explanation based on velocity concept used scientifically unacceptable expressions about momentum in their explanations. On the other hand, other student group of 13.7 percent also used velocity concept and made a scientifically unacceptable statement with no momentum concept in it. Those made explanation only depending on velocity and not related with momentum. Briefly, students think that to stop truck is more difficult because it has higher velocity instead it has higher momentum change.

The second question used in conception test is about the law “conservation of momentum”. To learn conception of students about conservation of momentum, the question, astronaut in the space, is asked. Analyzing this question gave the findings below.

Table 6. *Analysis of Answers Given to the 1st Part of the Question about Conservation of Momentum.*

Answers	N	Conceptual Test Frequency (%)
Astronaut moves together with ball.	**95**	**68**
The ball does not affect astronaut, he catches the ball and stops.	25	17,3
In space you can’t throw ball to astronaut.	8	5,8
He goes down because of ball’s mass.	5	3,6
The volume of astronaut increases.	1	0,7
Inappropriate coding	3	2,2
Unanswered	3	2,2

As it is seen on Table 6, 68 percent of students pointed out that astronaut would move together with ball, 17.3 percent pointed that ball does not affect astronaut, he would catch the ball and stop, 5.8 percent pointed out that in space you could not throw ball to astronaut. It is noted that ratio of students gave correct answer to the first part of the question is 68 percent.

Table 7. *Analysis of Answers Given to The 2nd Question Which is about Conservation of Momentum*

<table>
<tr><th>Level</th><th>Response Types</th><th>Num. of resp. (N)</th><th>Per. of resp.%</th></tr>
<tr><td></td><td>A. Scientifically Acceptable Answers</td><td></td><td></td></tr>
<tr><td rowspan="2">3</td><td>A1.Full response</td><td></td><td></td></tr>
<tr><td>“After astronaut caught the ball, because of no friction in space and because of the initial momentum of the ball, he moves with ball at the same velocity. (Momentum’s preservation law) But their last velocity is under the ball’s initial velocity.”</td><td>10</td><td>7,2</td></tr>
<tr><td>2</td><td>A2.Partial response</td><td>0</td><td>0</td></tr>
<tr><td colspan="2" align="right">Total</td><td>10</td><td>7,2</td></tr>
<tr><td rowspan="6">1</td><td colspan="3">B. Scientifically Unacceptable Responses
B1. Responses related to the concept of momentum</td></tr>
<tr><td>Explanations concerning the concept of momentum
“Momentum of ball does not change. Because m.V is constant. Astronaut falls back”</td><td>23</td><td>16,6</td></tr>
<tr><td>Explanations concerning the concept of impulse
“The object may fell down the vacuum with its impulse.”</td><td>10</td><td>7,2</td></tr>
<tr><td>Explanations concerning the concept of collision
“Both of them fly. Because they collide inelastic.”</td><td>1</td><td>0,7</td></tr>
<tr><td>Explanations concerning the concepts of mass and velocity
“Ball has a mass. Ball goes on with constant velocity in the space. When astronaut catches the ball, both of them go on with low velocity. Because ball’s mass is added astronaut mass.”</td><td>2</td><td>1,4</td></tr>
<tr><td align="right">Total</td><td>36</td><td>25,9</td></tr>
</table>

Table 7. Continued..

	B2. Responses unrelated to the concept of momentum	Num. of resp. (N)	Per. of resp.%
	Explanations concerning the concept of velocity *"Astronaut rises because of ball's velocity. They go on together for a distance and then they stop."*	26	18,7
	Explanations Concerning the Concept of Energy *"Because of there is no resistance in the air, ball's energy transfer to astronaut so astronaut goes with low velocity to ball's direction."*	5	3,6
	Explanations Concerning the Concepts of Force-Frictional Force *"Both of them goes balls direction because of ball applies a force to astronaut."*	9	6,5
	Explanations Concerning the Concept of Gravity *Ball can not impact to the astronaut because there is not gravity in the space."*	23	16,6
	Explanations Concerning the Concepts of Mass and Weight *"Because of ball's mass, astronaut fells down a little in the space."*	3	2,2
	B3 Intuitive Responses *"Astronaut moves with ball."*	22	15,8
	Total	**88**	**63,3**
0	**C. Uncodeable**	2	1,4
	D. No response	1	0,7
	Total	**139**	**100**

68% of the students, gave correct responses to the first part of second question (Momentum conservation principle-MCP), but, only 7.2% of them gave scientifically acceptable responses for the second part of this question. For this reason, students have problems about momentum conservation principle (MCP). Scientifically unaccepted part of the Table 7 shows students misconceptions about MCP.

The analyses result of the question about vector nature of momentum is shown below.

Table 8. *Percentage of the Responses Given To the First Part of the Question about Vector Nature of Momentum*

Responses	N	Frequency (%)
A) Momentum does not change since the magnitude of the velocity is constant.	**74**	**53,2**
B) Value of the velocity does not change but momentum changes due to the vectorial change in the velocity.	**45**	**32,4**
C) Momentum changes since the value of the velocity changes.	**20**	**14,4**

As it seen on Table 8, 32.4% of the students gave the correct response to this question after teaching. Another 68% of students have not got enough knowledge about vector nature of momentum. 53.2% of students, who did not know that momentum is vectorial or cannot learn of this property of momentum, assume that the velocity does not change because the magnitude of velocity is constant. Other 14.4% of students suppose that velocity change, so momentum must change. In the light of these findings, it can be said that big amount of students have not learn the vector nature of momentum completely.

If Table 9 is examined, 2.9% of students' responses are scientifically accepted. There is misunderstanding about elastic collides in scientifically unaccepted part of questions' analysis (24.4% of). Students who have elastic collide explanation have scientifically unacceptable knowledge about elastic collides subject. The students who has elastically collide base explanations, have scientifically unacceptable responses. The rate of scientifically acceptable responses is very low. The students have very complex, weak, incomplete knowledge about impulse. And they have many misconceptions.

Table 9. *Analysis Results of the Responses Given to the Question about Impulse Concept*

Level	Response Types		
	A. Scientifically Acceptable Responses	Num. of resp **(N)**	Per. of resp.**%**
3	**A1.Full response**		
	Due to the equation I=F.Δt, much time is spent to change the shape of the easily-crushed car and this causes the force on the car to be reduced.	0	0
2	**A2.Partial response**		
	"Some portion of the opposite car's impulse is used to change the shape of the other car during the accident.''	4	2,9
	Total	**4**	**2,9**
	B. Scientifically Unacceptable Responses **B1. Responses Related to the Concept of Impulse**		
	Explanations Related to the Concept of Impulse *"Since the damaging power is lessened when the impulse created after collision damages the car and prevents the people to be injured during the accident."* *"Cars, which experience a change in their shape, are safer as the impulse is low when they hit somewhere."* *"Because the car decreases the repulsive force acting on itself as its bonnet is crushed. This results in less reaction to the passengers travelling inside the car."*	8	5,8
	Explanations Related to the Concept of Momentum *"The cars interact with each other considering their momentum during the collision. The cars that are easier to damage have less mass and velocity. So they have less suffered damage in a collision."* *"The people more injury in the cars that aren't easier to damage than the other cars. Because momentum is transformed to people directly."*	16	11,5
	Explanations Related to the Concept of Elastic Collision *"If the cars damage in a collision, this collision is elastic. If not this collision is inelastic. Elastic collides are more safety than inelastic collides."*	34	24,4
1	**Total**	**58**	**41,7**
	B2. Responses unrelated to the concept of momentum		
	Responses based on the concept of velocity *"In the cars that are easier to damage, cars' velocity is not reduced suddenly so people in the car fly out to the car."*	9	6,5
	Responses related to the concepts of Force and Action-Reaction *"The cars that are easier to damage have less effect so reaction force is less."*	23	16,6
	Responses related to the concept of Energy *"The cars that are easier to damage take to all kinetic energy in a collision and this energy transforms to thermal energy. For this reason this type cars are more safety than another.."*	8	5,8
	Responses related to the concept of Pressure *"The cars that are easier to damage in a collision are more defensive because the opposite car applies little pressure to these cars."*	3	2,2
	Responses related to the concepts of mass-weight *"The cars that are easier to damage in a collision have also lighter body weight. So, the lighter cars' collisions are not very intensive."*	4	2,9
	B3. Intuitive Responses	27	21,8
	Total	**74**	**53,2**
0	**C. Uncodeable**	2	1,4
	D. No response	1	0,7
	Total	**139**	**100**

In addition, the students were asked the question of "what is momentum?" and 46 % of subject answered the question by means of applying the momentum equation ( ), 30% of them misused the concepts of momentum and impulse, and 24% of them used concept of energy, power, force, acceleration to answer the question these responses are not scientifically acceptable.

DISCUSSION

In this research with high school students 71.9% of them answered the first part of questions ("what is the relation between concept of mass and velocity?" and how is the change of momentum depended on impulse), but most of them did not answer the question scientifically acceptable. Only 32.4% of them answered scientifically acceptable.

The results show that 15.8% of students misused momentum and change of momentum. 9.4 % of them misused impulse and momentum.

The given answers to the first part of the second question concerning the momentum conservation principle were 68 percent. That's 32% of them have wrong conceptions about impulse and momentum conservation. The students gave correct responses to the first part of this question (68 percent). Only 7.2% of them gave scientifically acceptable responses for the second part of this question. In the second part, 92.8% of students did not explain the momentum conservation principle (MCP) in scientifically acceptable level. Students were asked to find the expression that explain the momentum conservation principle correctly in Ivowi's (1984) and Helm's (1980) work which was conduction on secondary school pupil and approximately 50% of the students did not give correct responses. In the light of these works, it can be argued that students have problems with the momentum conservation principle.

Moment and momentum concepts were confused with each other by 2.9% of the students. This coincides with the results of the study of Güneş et.al. which were conducted in university students in 2001. Students from different departments confused moment and momentum concepts with each other. (The ratio of these students was 2.6%, 3.1%, 11.8% and 2.5% respectively.)

It shows that misconceptions gained the secondary school had been kept even during the through University education. In the present study 32.4% of the students were aware of the fact that momentum is a vector. This outcome also coincides with result of Güneş et al.'s (2001) study (32.2%). In Graham and Berry's 1996 work, it has been found out that almost half of the students identified momentum as a vector.

Mostly in literature studies and as reported in this study its obvious that students have conceptual problems about momentum subject. The determined conceptual mistakes are similar with those reported in literatures.

RESULTS

Students' misconceptions about impulse and momentum subject are summarized to follow after the teaching.

- Bigger mass has bigger momentum (impulse) than another.
- Momentum is pusher force.
- It is harder to stop an object which has a bigger velocity, mass is not important.
- It is harder to stop a car which has bigger moment.
- , It is harder to stop a car which has a bigger momentum.
- Momentum related to mass and velocity, and equal with impulse.

Misconceptions are seen below which get from momentum conservation question.

• If an object has a velocity, it has a force because of its velocity.

• A stationary object has a force and this force is not lost after collision.

• If soft objects collide each other, momentum does not conserve.

• For the momentum conservation, objects must collide elastically.

• If objects shape is spoilt momentum conserves, if not momentum does not conserve.

• Ball and astronaut have not got momentum because of have not got any masses (weigh).

As a result, students don't know or have misconceptions about which situation momentum conserve or not. Teachers should explain this point very clearly in the course of teaching.

And misconceptions are seen below which determined from the question of momentum's vector quantity.

• Momentum is equal to F.d.

• Momentum, does not change because of momentum is equal and velocity doesn't change.

• If velocity's greatness doesn't change, momentum doesn't change too.

Some students do not know that momentum is vector because they do not know that velocity is a vector quantity. Another glaringly obvious point is that momentum's formula is misunderstood. As a result of distortion in our education system 2 conclusions (one is that; before earlier subject is well understood passing to the latter one the other is that by formulizing conceptions instead of understanding what really it means focusing on which formula should be used in solving questions etc.) are obstructs on learning progress of students which are difficult to be overcome.

Students' misconceptions about impulse concept are summarized to follow.

• Impulse means applying a force to an object which cannot react to the power exerted on itself.

• Impulse is momentum.

• Impulse is applying a force to an object and speeding up of that object as a result of the force applied or changing its position.

• Impulse changes objects' position with applying force.

• Impulse is a force which transferred energy one form another form. (kinetic energy-potential energy)

• If an object changes its position there is impulse, if not there is not impulse.

When examine to misconceptions which related to the all titles of subjects, it is reported that almost all students know that momentum is equal to the product of mass and velocity. But unfortunately their conceptual learning level stays low, and they could not learn very well to "momentum conservation principle", "vector nature of momentum", and "impulse is equal to momentum change" knowledge. Even though students learn something about these, their learning level is low and they have lots of misconceptions about subject.

CONCLUSION

The main reason of misconceptions are; the problems that are plug and chug are, solved, conceptual knowledge is not enough included, and the time is not enough for this subject in the curriculum. Also, the text books only include exercises problem and solutions, teachers do not use physics labs for experiments, and Student Selection Examination "SSE" exam doesn't include questions related to the subject of momentum due to these constructions, teachers don't give importance to teach this subject, these constructions (limitations) can cause learning level of students.

To change of this situation and misconceptions, researchers have developed new teaching models, as using experimental and control groups. It can be contributed to improve the quality of education using these teaching models. New teaching models can enriched by employing computer based teaching and activities, concept maps, concept webs.

Likewise, conceptions in physics are generally abstract, so it is very important to learn with doing and experiencing. For this reason, MEB should reform both curriculum and course materials, students should do more laboratories experiments, and it is prevented teachers from spending too much time to get prepared for the experiments. To reach this goal, researchers should do some studies about that and science educators and MEB should work together.

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