

# Use of concept cartoons as an assessment tool in physics education\*

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**Abstract:** There are numerous studies in literature related to the use of cartoons in physics, chemistry and mathematics education. However the studies on the use of cartoons as an alternative assessment tool are highly limited. This study was concerned with the use of cartoons as an alternative assessment method. There were five cartoons prepared related to impulse, momentum, impulse-momentum equation, conservation of momentum and vector property of momentum. The study revealed that physics pre-service teachers failed to emphasize the fact that momentum is vector quantity. Also the fact that only 15% of the participants scored a full point for the caricature related to the conservation of momentum is an issue which should seriously be considered. This shows us that there are some problems in the application of the conservation of momentum to everyday examples.

**Key words:** concept cartoons; impulse; momentum; physics education

## 1. Introduction

There are numerous studies in literature related to the use of cartoons in physics, chemistry and mathematics education (Keogh & Naylor, 1999; Chambers & Andre, 1997; Keogh, et al., 2000; Uğurel & Moralı, 2006; Kabapınar, 2005; İncec, et al., 2006). However the studies on the use of cartoons as an alternative assessment tool are highly limited. This study is concerned with the use of cartoons as an alternative assessment method. The topic chosen for this purpose are momentum and impulse which are thought to be easy to conceive but involves some difficulties in explanation. This study which aims at introducing cartoons as an alternative assessment tool in physics education is expected to fill an important gap in literature.

## 2. Concept cartoons

There are numerous methods being developed in order to promote the construction of knowledge. One of these methods is concept cartoons (Keogh & Naylor, 1999). Cartoons are visual tools which combines exaggeratedly drawn characters with dialogues related to everyday events in a humorous and satirical fashion (Keogh & Naylor, 2000; Naylor, Downing & Keogh, 2001; Stephenson & Warwick, 2002; Coll, 2005).

Concept cartoons are related to a special topic in science. There are three, four or five students stating different opinions about a specific topic. The opinions are mainly misconceptions however one of them is scientifically acceptable. The others are not illogical and based upon the experiences of the students (Stephenson, 2002).

The fact that people realized the effectiveness of the use of characters in dialogue with each other in

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education purposes was an important mile-stone in the development of concept cartoons. Cartoons enable the presentation of an example of a misconception in classroom atmosphere by illustrating the misconceptions of the students in their minds at a much wider perspective (İngeç, et al., 2006). In concept cartoons, the opinions taken from everyday life related to the topic are presented in an argumentative manner. The learners are then asked to argue with the characters (Kabapınar, 2005).

According to Dabell (2004) concept cartoons help the students to question their thoughts, solve the problem they encounter in their everyday lives, broaden their horizons and provide different perspectives for the events.

This technique which was developed in 1990s did not receive the interest it deserves in our country until recent times. The studies carried out in recent times revealed the fact that the use of concept caricature would have a very positive effect on science education. Concept caricature may conveniently be used in classroom in order to promote the participation of the students and create a motivating atmosphere (Keogh & Naylor, 1999; Chambers & Andre, 1997; Keogh, et al., 2000).

### **3. Method**

In this study concept cartoons and achievement test were used. There were five cartoons prepared related to impulse, momentum, impulse-momentum equation, conservation of momentum and vector property of momentum. Characters used in the cartoons were found on Internet and physics books. There were three experts consulted in the preparation of the cartoons. An example can be seen in Appendix A. The participants were also subjected to 21—true or false question test prepared by H. Ş. Kızılcık (Kızılcık & Tan, 2007). The test was analyzed using a classical item analysis approach. The reliability of the test was estimated by the use of Kuder-Richardson Formula 20 and the reliability coefficient was found as 0.53. The validity of test was verified by at least four experts in the field of physics.

A total of 52 teacher candidates participated in the study. The concept cartoons which contained five study sheets were distributed one by one and they were collected in the same order without allowing the participants to go back to their previous answers. The participants were then subjected to an achievement test.

#### **3.1 Scoring concept cartoons**

The participants were asked to write down the character that they agree together with the reasons. In two of the cartoons the answer was not given in the choices and it was left to the participants to write it down. The concept cartoons were scored on three categories as:

- (1) [0]—Ones agree with the wrong character or left the box empty.
- (2) [1]—The ones agree with the right character but failed to state the exact reasons.
- (3) [2]—The ones agree with the right character and provide the answers which match with the physical descriptions.

### **4. Results**

#### **4.1 The findings from concept cartoon assessment**

Analysis of responses to cartoons related to the description of impulse is given in Table 1. It is seen that 65% of the students gave the right and 31% of the student gave the wrong answer. The students have the opinion that

the impulse is described by short term interactions.

**Table 1 The number of students in each code and percentages for cartoons related to the description of impulse**

Codes	Number of students	Percentages in codes
[0]	16	<p><b>Description of Impulse</b></p> <p>65% 31% 4%</p> <p>■ [0] ■ [1] ■ [2]</p>
[1]	2	
[2]	34	

Table 2 shows that 67% of the participants scored two, 12% scored one and 21% of the participants scored zero points for the cartoons related to the description of momentum. The participants thought that the speed would be independent of the mass in projectile based on the conservation of energy and neglected the fact that the process was a problem of momentum.

**Table 2 The number of students in each code and percentages for cartoons related to the description of momentum**

Codes	Number of students	Percentages in codes
[0]	11	<p><b>Description of Momentum</b></p> <p>67% 21% 12%</p> <p>■ [0] ■ [1] ■ [2]</p>
[1]	6	
[2]	35	

Percentage and the number of students in each code for the cartoons related to the vector property of momentum represented in Table 3. It is seen that 58 % of the participants scored full two points. The ratios of the ones who scored one and zero points were 2% and 40%. The participants thought that momentum is preserved in non elastic collisions. It was also observed that the participants took momentum as a scalar quantity and failed to take its vector property into account.

**Table 3 The number of students in each code and percentages for cartoons related to the vector property of momentum**

Codes	Number of students	Percentages in codes
[0]	30	<p><b>Vector Property of Momentum</b></p> <p>40% 58% 2%</p> <p>■ [0] ■ [1] ■ [2]</p>
[1]	1	
[2]	21	

84% of the participants scored full two points for the cartoons related to impulse-momentum equation. 10% of the participants scored one and 6 of them scored zero points. Most of the participants explained the phenomenon giving example from the everyday life.

**Table 4** The number of students in each code and percentages for cartoons related to the impulse-momentum equation vector property of momentum

Codes	Number of students	Percentages in codes
[0]	3	<p style="text-align: center;"><b>Impulse-Momentum Equation</b></p> <p style="text-align: center;">6% 10% 84%</p> <p style="text-align: right;">■ [0] ■ [1] ■ [2]</p>
[1]	5	
[2]	44	

The ratios of the participants who scored full, one and zero points for the cartoons related to the conservation of momentum were 15%, 14% and 71% respectively as seen in Table 5. It was apparent that the participants had the misconception that the momentum is preserved in all types of collisions and neglected the internal and external forces.

**Table 5** The number of students in each code and percentages for cartoons related to the conservation of momentum

Codes	Number of students	Percentages in codes
[0]	37	<p style="text-align: center;"><b>Conservation of Momentum</b></p> <p style="text-align: center;">15% 14% 71%</p> <p style="text-align: right;">■ [0] ■ [1] ■ [2]</p>
[1]	7	
[2]	8	

#### 4.2 The findings from achievement test assessment

The mean total test score of the participants related to impulse, momentum, impulse-momentum equation, vector property of momentum and conservation of momentum was 76.8. The corresponding value obtained from the cartoons was 58.7. It is interesting that the mean of teacher candidates' concept cartoons scores is fairly low when compared with the scores of the achievement test. The correlation coefficient between the cartoon and test scores was 0.14 indicating a positive and weak relation. The value of Cohen effect was calculated as 0.83. This shows that there is a highly significant difference between two scores showing that there is not a significant correlation between them.

##### 4.2.1 Description of impulse

The Pearson correlation coefficient between the achievement test scores and concept cartoon about description of impulse scores were found 0.58 indicating positive and moderate relations. Distribution of the description of impulse scores presented in Figure 1.

##### 4.2.2 Description of momentum

The Pearson correlation coefficient between the achievement test scores and concept cartoon about description of momentum scores were found -0.12 indicating negative and weak relations. Distribution of the scores can be seen in Figure 2.

##### 4.2.3 Impulse-momentum equation

The Pearson correlation coefficient between the achievement test scores and concept cartoon about impulse-momentum equation scores were found -0.11 indicating negative and weak relations. Distributions of

scores were indicated in Figure 3.

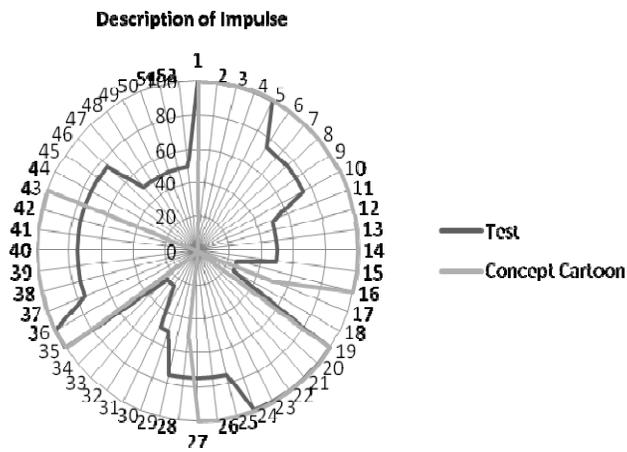


Figure 1 Distribution of the achievement test scores and concept cartoon about description of impulse scores

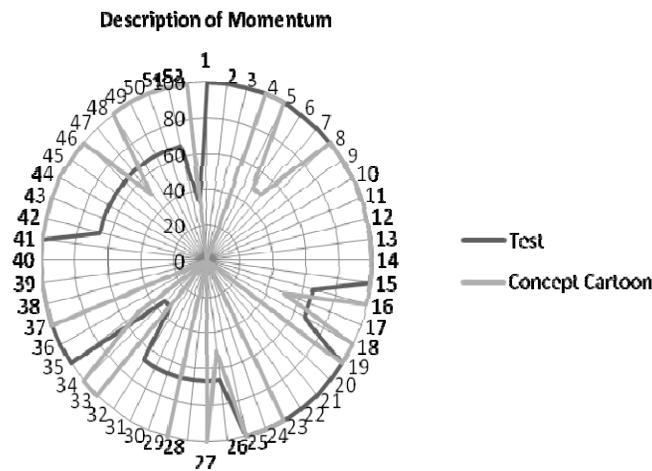


Figure 2 Distribution of the scores the achievement test scores and concept cartoon about description of momentum scores

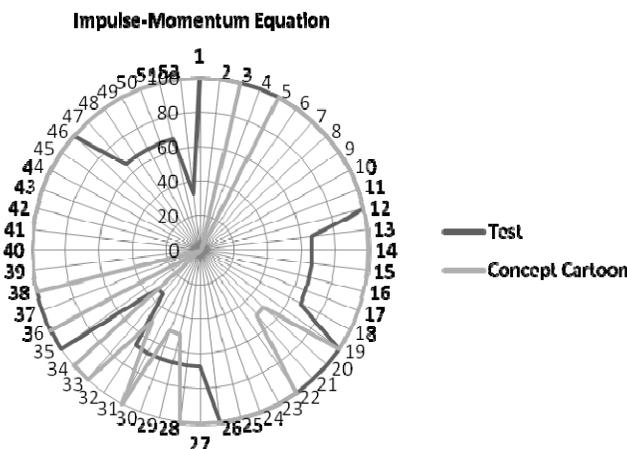


Figure 3 Distribution of the scores the achievement test scores and concept cartoon about impulse-momentum equation scores

4.2.4 Conservation of momentum

The Pearson correlation coefficient between the achievement test scores and concept cartoon about conservation of momentum scores were found -0.06 indicating negative and weak relations between them. Distribution of the scores was shown in Figure 4.

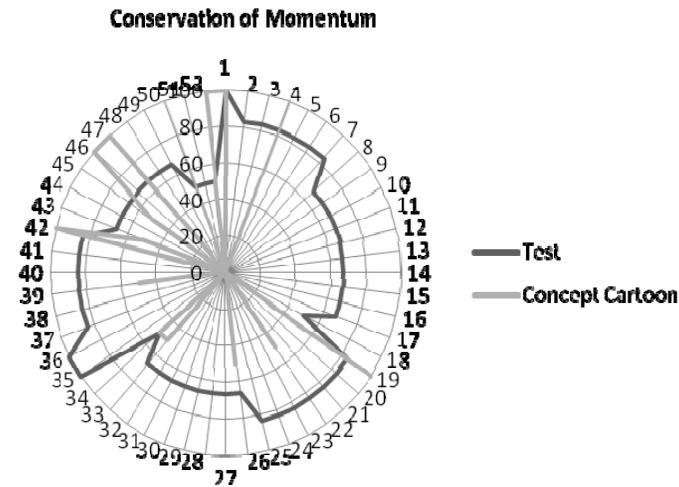


Figure 4 Distribution of the scores the achievement test scores and concept cartoon about conservation of momentum scores

#### 4.2.5 Vector property of momentum

The Pearson correlation coefficient between the achievement test scores and concept cartoon about vector property of momentum scores were found 0.20 indicating positive and weak relations. Distribution of the scores presented in Figure 5.

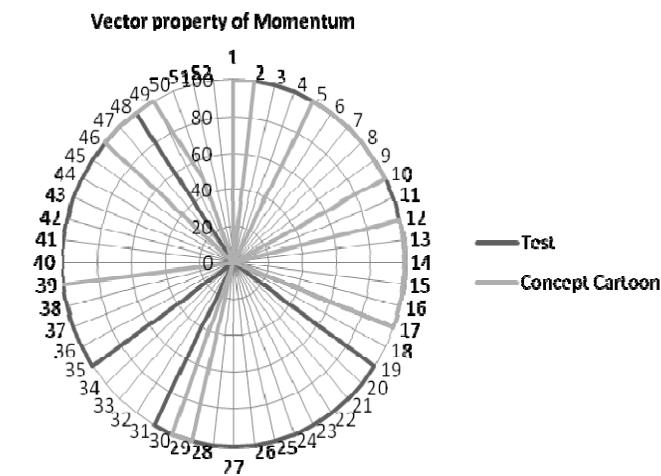


Figure 5 Distribution of the scores the achievement test scores and concept cartoon about vector property of momentum scores

### 5. Discussion

The study revealed that participants' initial knowledge state is not adequate. Physics pre-service teachers failed to emphasize the fact that momentum is vector quantity. Also the fact that only 15% of the participants scored a full point for the caricature related to the conservation of momentum is an issue which should seriously

be considered. This shows us that there are some problems in the application of the conservation of momentum to everyday examples.

As determined by Graham and Berry (1996) there are two possible reasons for this outcome. The first is that some textbooks and teachers do not emphasize on and provide into two dimensions sufficiently. So, some students do not recognize momentum as a vector quantity. They therefore are not able to explain the conservation of momentum. The second is that this is an area of considerable difficulty. Another reason for ignoring the vector aspects of momentum is that some textbooks and teachers do not give sufficient examples for the cases where momentum is conserved or not conserved. The students are unable to perceive the vector property of momentum since the text books in Turkey contain only examples where the momentum is conserved. It is necessary that the role and importance of internal/external forces in collisions should be underlined in teaching conservation of momentum and examples should be given for both cases where momentum is conserved or not conserved.

It is also seen as a result of this study that there is a weak correlation between the achievement test and the concept cartoons. This may be attributed to the fact, the concept cartoons assesses the students' knowledge from a conceptual perspective while the achievement tests measure the level of students' knowledge on the topic and his/her ability to apply this knowledge at different occasions.

The use of concept cartoons as an alternative assessment tool will help the measurement of the academic achievements of the students and help them to become questioning individuals since they can easily utilize the concept cartoons in their everyday lives. Concept maps may also constitute an important step in the determination and elimination of misconceptions since they provide the opportunity to discuss the reasons behind these misconceptions. In conclusion, this paper showed that a concept cartoons can be used effectively to assess students' understanding.

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**Appendix A**

Example of the Concept Cartoon:

The work sheet about description of impulse

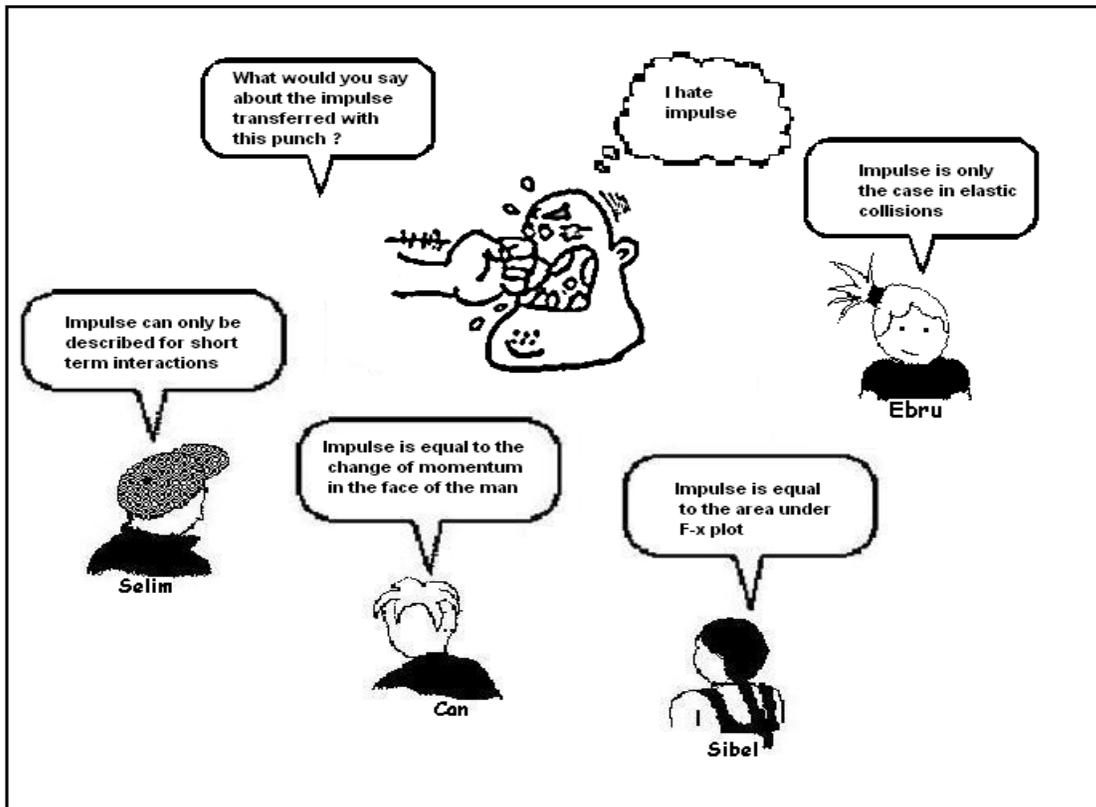
Name :.....

Department :.....

Surname :.....

Class :.....

**WHAT DO YOU THINK?**



I agree with..... Because.....