CONCEPTUAL LEARNING OF SELECTED PHYSICAL TOPICS THROUGH INTERACTIVE MULTIMEDIA

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ABSTRACT
In the contribution there is the importance of selected physical phenomena regarding to the physical thinking of students presented. The results of pedagogical research show limited understanding of selected physical concepts using traditional methods of teaching. In order to improve students understanding interactive multimedial instructional materials and instructional technique were developed. The effectiveness of the use of these multimedia tools in understanding of selected physical phenomena was examined by the pedagogical experiment. Experimental teaching and its results show the key role of a teacher in learning and systematization of knowledge. There was a positive impact of teaching with the use of interactive multimedial hypertexts in the field of the level of students understanding of selected physical problems proved.

KEYWORDS
multimedia, hypertext, inertia, mass, pedagogical experiment

INTRODUCTION

One of the key goals of physics teaching is to achieve the certain level of student's knowledge in physics. The educational norms determine the extent of knowledge that must be learn by student at high school. But in spite of the effort of teachers as well as students to master the content of physical education, it is proved by several researches that in many cases the traditional methods used in teaching are not effective enough to gain appropriate level of understanding the certain physical concepts (Haertel, 2001, 2003; White,1983). Researchers and working in the field of education in physics try to find and implement modern and innovative teaching methods that could help in better understanding and eliminate the student's misconceptions and misunderstandings of physical concepts.

PEDAGOGICAL EXPERIMENT AND ITS CHARACTERISTICS

In order to test the effectiveness of teaching with a help of modern multimedia tool we designed a pedagogical research in cooperation with Dr. Hermann Haertel from Institute of Pedagogy of Science, Kiel, Germany. The pedagogical experiment itself, i.e. its proposal, realization and evaluation was realized under an international project DAAD. The testing itself was aimed at student's knowledge of rather difficult physical concepts of mass and inertia. There was a teaching material in the form of hypertext prepared using interactive applets and videoclips. This material was translated into 4 languages of European countries and it was implemented into teaching respecting equal conditions.

At the experiment small groups of high school students took part that have already been learning about the mentioned physical concepts. There were three experimental groups of 12 high school students participating. The teaching itself was realized in a computer room where students worked in pairs with a computer studying the teaching material in the form of hypertext on the web. The printed version of a teaching material was also available. Two groups realized the experiment as an ordinary lab activity

during the physics lesson while the meetings of the rest of students were in the afternoon as an optional additional activity. Two weeks before the experiment started the students filled in two pre-tests.

Teaching itself was divided into two two-hours and one one-hour lesson. The first meeting was dealing with a problem of inertia and behaviour of objects under influence of different forces. The second included the problem of free fall and satellite movement. The teaching material contained questions for students to answer during learning. They could ask a teacher for help or they could use the appendix with more detailed explanation of certain concepts. They were asked to write down their assumptions about the behaviour of the object. The teaching material was supported by interactive applets where students could change initial conditions, set the parameters and they could see how the changing parameter influences the behaviour of the object. This was used to compare and check the student's assumptions and correct their original opinion. There were also videoclips of certain situations concerning the influence of forces on the object presented. At the end of each lesson the teacher with a help of the students revised the discussed physical problems making the most important conclusions. The students working sheets with their answers were collected and checked by the teacher. The web page with a hypertext was accessible for the students. The last lesson was devoted to revision and it was lead by the teacher in the class with one computer only. The teacher went through the most important conclusions of the previous two lessons discussing the most important results together with the students. The testing that should show the level of understanding after experimental teaching was realized two weeks after the experiment itself. The questions of the post-test were identical with those of the pre-test.

RESULTS OF THE PEDAGOGICAL EXPERIMENT

One of the goals of testing of the concepts of mass and inertia understanding was to show if the Aristotelian view of the world (uniform motion needs constant force) that is deeply rooted in student's thinking could be changed with a help of multimedia tools. That's why the percentage of Newtonian answers (uniform motion needs no force, constant force causes uniformly accelerated motion) comparing the percentage of Aristotelian answers to the selected questions was monitored. The results of pre-test showed the high percentage of Aristotelian answers. In the post-test we expected the shift towards the Newtonian thinking. But, as the results of testing shows (table 1) this is not such a simple task. The shift towards the Newtonian thinking is only 17,76% and the Aristotelian answers decrease was about 25%.

The other part of the test was devoted to basic knowledge of mechanics concerning the differences between the gravitational and inertial mass. The percentage of correct answers to the selected questions 2, 3, 7 and 8 in pre and post-test is presented in table 2. As the table shows, there is a positive shift for each of the questions (but very little in question 8) with average shift of 37,07% as well as for the whole test.

Table 1. Results of pre-test and post-test for questions about forces and motion

	Selected question	3	6	10	12	total	difference
Aristotelian answers	Pre-test	56,76%	72,97%	86,78%	75,68%	**66,02%**	**-25,1%**
	Post-test	27,03%	21,62%	40,54%	43,24%	**40,93%**	
	difference	**-29,73%**	**-51,35%**	**-43,24%**	**-32,43%**		
	Selected question	1	4	7	13		
Newtonian answers	Pre-test	21,62%	21,62%	8,11%	2,7%	**13,32%**	**17,76%**
	Post-test	72,97%	51,35%	27,03%	16,22%	**31,08%**	
	difference	**51,35%**	**29,73%**	**18,92%**	**13,51%**		

Table 2. Results of pre-test and post-test for the part testing Basic knowledge of mechanics

Selected question	2	3	7	8	total	Difference
Pre-test	5,41%	8,11%	5,41%	78,38%	**43,63%**	**37,07%**
Post-test	67,57%	83,78%	78.,38%	86,49%	**80,69%**	
Difference	**62,16%**	**75,68%**	**72,97%**	**8,11%**		

To summarize the test results, considering the effort of the teacher, small number of participating students, individual approach to students, extra lessons devoted to the already known topic, innovative methods used in the experiment the difference between pre and post-test does not reach the expected value. On the other hand, the results for separate parts (-25,1%, 17,76%, 37,07%) shows that the active learning with modern multimedia combined with the teacher as a key person in teaching can bring better understanding than traditional methods.

EXAMPLES OF QUESTIONS ABOUT FORCES AND MOTION

Situation:
A space shuttle is moving on a straight path from the earth to the moon or in the opposite direction. The shuttle is jet-propelled and can be controlled from the earth.

Assignment:
In the following 7 possibilities (A to G) are presented for the sum of all forces, acting on the shuttle. They differ in respect to direction and time dependence. Furthermore 6 situations are described. Please choose for each situation one of the offered possibilities (A to G), which you think is correct.

Remark:
You may choose each possibility more than once for the situation 1 to 6. But please, choose only 1 answer for each situation. If you think that no possibility is correct, please choose K as answer.

The sum of all applied forces, acting on the shuttle is directed towards the moon and
- A is constant
- B is increasing in magnitude
- C is decreasing in magnitude

The sum of all applied forces on the shuttle is directed towards the earth and
- D is constant
- E is increasing in magnitude
- F is decreasing in magnitude
- G in total no force is needed
- K no answer is valid

1. The shuttle is moving towards the moon. Its velocity is increasing linearly (constant acceleration). Which of the choices given above is correct?
3. The shuttle is moving towards the moon. Its velocity is decreasing linearly (constant acceleration). Which of the choices given above is correct?
4. The shuttle is moving towards the earth. Its velocity is decreasing linearly (constant acceleration). Which of the choices given above is correct?
6. The shuttle is moving towards the earth. Its velocity is increasing linearly (constant acceleration). Which of the choices given above is correct?

Situation:
A slider is moving on an air cushion track, either to the right or to the left. Since the slider is hovering and takes on only small velocities, all effects due to friction forces and air resistances can be neglected. A force can be applied to the slider in horizontal direction.

Assignment:
In the following, 9 different force/time diagrams (A to I) are given, where the applied force is drawn on the vertical axis (positive = to the right, negative = to the left). The time is displayed on the horizontal axis. Furthermore 8 situations are described. Please choose for each situation one of the offered graphs (A to I), which you think will correspond to the situation.

Remark:
Each of the graphs can be chosen more than once or not at all. If you think that none of the graphs is correct please chose K as answer.

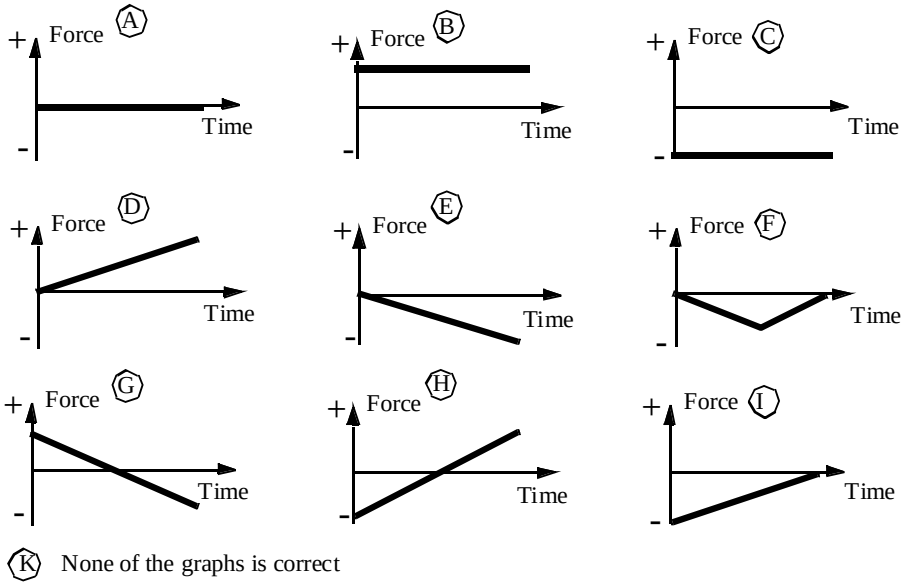

Figure 1. Force vs. time diagrams

Situations:
7. The slider moves to the right (in the positive direction) with a fixed (constant) velocity.
10. The slider moves to the right and its velocity is decreasing linearly (constant acceleration)
12. The slider moves to the right and its velocity is first increasing and then decreasing.
13. The slider was first pushed to the right and then left alone. Which diagram describes the applied force after this moment?

EXAMPLES OF TEST QUESTIONS AIMED AT THE BASIC KNOWLEDGE OF MECHANICS (GRAVITATIONAL/INERTIAL MASS)

Assignment 2:
Comparison Between Earth and Moon
Two objects are dropped from a height of 10 m, one here on earth and one on the moon. The object on the moon is 6 times as massive as the one on earth. The constant g on the moon is 6 times smaller than on the earth. Which of the following statements is correct:

a) The falling time on the moon is shorter
b) The falling time on the moon is longer
c) The falling times are equal

Please explain your answer briefly.

Assignment 3:
Free Fall in Vacuum
If friction can be neglected, all objects drop to the earth with the same acceleration, independent of their mass. What is, in a nutshell, the main reason for this fact?

Assignment 7:
Movement of a Satellite under Gravitational Forces
During one of the last CoLoS studies you have worked with a simulation where the circulating movement of a small object - a satellite - around a central body was simulated. Between both objects a gravitational force was acting, like in reality. What would happen, if the mass of the satellite would be increased? Please check the answer which you think is correct.
a) The satellite will move on an enlarged ellipse
b) The satellite will move on a narrower ellipse
c) The satellite will continue to move on the same circular path
Please write down an argument for your choice.

Assignment 8:
Movement of a Satellite under Coulomb Forces
During one of the last CoLoS studies you have worked with a simulation where the circulating movement of a small charged object A around a central body, charged oppositely, was simulated. The attracting force between both objects was based on Coulomb's law. A force due to gravity did not exist. What would happen, if in this artificial world the charge q of the little charged object would be increased? Please check the answer which you think is correct.
a) A will move on an enlarged ellipse
b) A will move on a narrower ellipse
c) A will continue to move on the same circular path
Please write down an argument for your choice.

CONCLUSIONS

In physics teaching the concepts of mass and inertia belong to the difficult ones causing a lot of misconceptions as the research in this field had already proved (Haertel, 2001, 2003; White,1983). That was the reason for designing an innovative way of teaching these concepts using modern multimedia tools. The experiment realized with small groups of students set the goal to prove better understanding of these concepts after the experimental teaching. As the results of research show the expectations were not completely fulfilled. There is a positive influence of new kind of teaching proved but as the research shows, the teacher will always play a key role in the process of learning.

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