A Comparison of the Effects of Laboratory Method and Computer Simulations to Avoid Misconceptions in Physics Education [*]

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Abstract

This study seeks the answer to the question "Is computer assisted physics education as effective as laboratory assisted physics education in overcoming students' misconceptions?" "Force and motion" is chosen to be issued in the study. 48 students studying sciences in the 10th grade of Ankara-Altındag Esenevler Anatolian High School constitute the sample group of the study. Pre-test/Post-test group design is used in the study. The study is carried on by experimental and control groups from random classes. Survey data is derived from pre and post misconception tests. In data analysis, arithmetic mean, standard deviation and t-test were used. As a result of the study, it was concluded that there is significant difference between the effects of laboratory assisted and computer assisted education in overcoming misconceptions for the good of computer assisted education.

Introduction

As physics has been perceived as a quantitative subject so far, it is thought to be difficult to both understand and teach. However, according to the studies (Clement, 1982; Halloun & Hestenes, 1985) the reason for this is neither teachers nor students but it is the fact that methods and technologies necessary in physics education cannot be used properly due to impossibility or lack of information. Although physics is a conceptual based broad-spectrum branch of sciences, it has usually been thought to be highly related with formulas, and it is still taught in this manner. This makes physics lessons difficult, and cause students to deal with numerical operations rather than concepts. The students, hence, try to create those concepts and situations by themselves in their minds and this causes misconceptions. However, physics subject is so intertwined with visual matters that it is not different to teach students physical rules and concepts visually. In this manner, the importance of teaching physics via experimental methods has been proved by studies (Ergin, Akgun, Kucukozer & Yakalı, 2001; Council for Research and Development, 1995).

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The laboratory in which experimental method is applied is an environment where the subject or concept wanted to be taught is transferred to the student artificially via first-hand experience or demonstration (The Council of Higher Education/World Bank, 1996). Laboratory method, having been frequently applied in teaching sciences and physics and ensuring permanent learning, gives high importance to mentation and it is a way for students to learn subjects through practice and experience individually or in small groups in laboratories or special classes (Algan, 1999).There are two main purposes of laboratory studies. First one is the demonstration of some evidence supporting the concepts. The other one is supporting student project studies related to research, supplying the students with skills, proving the truth of theoretical knowledge by working on real items (Sonmez, 1994). Laboratory studies affect reasoning, critical thinking, understanding of science, process capability and manual skills and enable the students to use the knowledge, develop a general concept, define a new problem, explain an observation and make decisions (Ayas, Akdeniz & Cepni, 1994a; 1994b; 1995). For this reason, laboratory is the focal point of science education (Kocacınar, 1969). As the students can actively participate in the studies, observe and evaluate the results in laboratory environment, they can also create environments for themselves and this makes learning permanent and persistent (Gumus, 1999:16). Though laboratory is so crucial in science education, it is seen that there are also some complications in experimental applications. Some of the main reasons for these problems can be regarded as the fact that the schools do not have sufficient test equipment; it takes a long time to teach a lesson with experimental methods; the students lose time while collecting data; and the teachers' concern to complete the subjects on the curriculum. In a study of Halloun (1997) on schematic modeling, it is stated that when a teacher is teaching a physics subject, students start to envision the situation. If the teacher cannot help his students enough on this phase, the students may configure the situation incorrectly and this lays the foundation of misconceptions. In their study, Akdeniz, Cepni and Azar (1998), reported that laboratories usually lack the necessary environmental conditions and equipments and for this reason, the teachers either do not carry out experiments or they perform the experiments as demonstration in classes or laboratories. As the teachers cannot get enough information, skills and attitudes during their pre-service training, when come across with insufficiently equipped environments, they do not put in effort to carry out experiments with available sources. Alternative teaching methods have been developed in order to overcome such problems and to raise students' success in physics education. Computer assisted education, which is based on Thorndike and Skinner and which has survived to these days by being impressed by constructivist approach, has a crucial role. Computer systems, providing wide opportunities in modeling and simulation, have been indispensible tools in education as they demonstrate motions and sounds of situations interactively (Akkoyunlu, 1995). As computer software used in computer assisted education are similar to other education materials in terms of content (Yalın, 1996: 5-7), various learning environments aimed at teaching physics can be created by computer assisted learning techniques.

The effect of computer simulations on physics teaching was analyzed in various studies (Andoloro, Bellamonte & Sperandeo-Mineo, 1997; Rodrigues, 1997; Calverley, Fincham & Bacon, 1998; Jimoyiannis & Komis 2001; Yigit & Akdeniz, 2003; Ayvacı, Ozsevgec & Aydın, 2004; Dancy & Beichner, 2006; Karamustafaoglu, 2012). In these studies, generally, it was emphasized that computer assisted Physics education is more successful in conceptual understanding compared to conventional teaching methods, and it suppresses problems related to comprehension. In his study, Christian (2001) introduces *Physlet's* software package which consists of physics simulations made with *ava* software to be used in physics education. Physlet's advantages and its importance in physics education research were mentioned in the study and it was concluded that Physlet can be a rewarding tool to ease students' learning physics and to form an interactive curriculum material. Alessi and Trollip (2001) categorize simulations in four parts:

1. **Physical simulations**: A physical item or situation is shown on a computer screen. The user learns by analyzing it.

2. **Repetitive simulations**: These are similar to physical simulations as they also teach an item or a situation. However, in repetitive simulations, the case is analyzed by shifting the parameters and this is repeated until the desired result is achieved. Cases which are too slow or too fast can be analyzed via this type of simulation.

3. **Procedural simulations**: Its aim is to teach the necessary steps to reach a goal.

4. **Situational simulations**: It deals with the behaviors of people or institutions in different situations and circumstances. Here, the students are aimed to present alternative solutions in different situations and see the results.

The main reason in using simulation is to provide students with real like studying possibilities which are hard, dangerous and expensive to have in real environments (İpek, 2001; Usun, 2004; Arıcı & Dalkılıc, 2006).

Method

Research Design

"Pre-test/post-test control group design" was used in the study. Test models dealing with experimental methods are widely used in education research, and the mistakes or variables stemming from the dates, testing and tools that may threaten internal validity can be effectively controlled as they would have the same effect on experimental and control groups (Kaptan, 1995: 85). Experimental methods are widely used in studies in which quantitative results are wanted especially about the effectiveness of experimental intervention because in those kinds of studies, statistical operations are applied on pre-test/post-test outcomes, and by this way, whether there are significant differences between the groups or not is tried to be detected. The process of this quasi-experimental study is shown in Table 1.

Table 1. Experimental design of the study

Group	Pre-test	Implementation	Post-test
EG	MT	CAE	MT
CG	MT	CTM	MT

EG: Experimental Group; CG: Control Group; CTM: Conventional Testing Method;
CAE: Computer Assisted Experiments; MT: Misconception Test

Participants

The setting of this research is all 10th grade science students in Ankara Altındag Esenevler High School. The sample group is 48 10th grade science students in Ankara Altındag Esenevler High School. The control group consists of 24 students from class 10 Science A, and the experimental group consists of 24 students from class 10 Science B. Pre-test result equation for both groups has been proved via hypothesis testing.

Research Question

"Is computer assisted Physics teaching as effective a laboratory assisted pyhsics teaching to overcome students' misconceptions?"

Sub-problems

1. Is there a significant difference between experimental and control groups according to Misconception Test (MT) pre-test results?
2. Do conventional experimental methods have an effect on teaching 10th grade students concepts about force and motion and overcoming their misconceptions?
3. Do computer assisted experimental methods have an effect on teaching 10th grade students concepts about force and motion and overcoming their misconceptions?

4. Is there a significant difference between conventional and computer assisted experimental methods in teaching 10th grade students concepts about force and motion and overcoming their misconceptions?

Research Instrument

A Misconception Test (MT) of 30 questions with three stages was developed in order to be able to detect students' misconceptions about the subject of force and motion. A section of this test can be found in APPENDIX-1. The first stage of the test consists of multiple choice questions and each question has 5 options. In the second stage, the student is asked if he is sure about his answer. In the third stage of the questions, the student is asked to write a brief explanation for his answer.

The misconception test developed was implemented to groups of 40 12th grade science students studying in Ankara Altındag Esenevler High School in order to measure its item difficulty and reliability. As a result of this piloting study, each item was analyzed in terms of item difficulty and the KR-20 (Kuder-Richardson 20) reliability coefficient of the test was figured as 0.81. While analyzing item difficulty and KR-20 reliability, each correct answer of the students was given 1 point, and incorrect or unmarked questions were given 0 point. In accordance with the result of this analysis, questions 9, 12, 13, 14, 16, 17, 20, 21, 25 and 26 were removed as they had negative effect on the reliability of the test. In the test, average item difficulty value is 0.49 and average item discrimination value is 0.53. The KR-20 reliability coefficient of the test was measured as 0.78. Recommended KR-20 reliability co-efficient for multiple choice tests of about 10-15 questions is at least 0.50, and that of the tests of more than 50 questions is at least 0.80. Misconceptions detected after the literature review on the subject of force and motion (Kuru & Gunes, 2005) and their matching items and options in the misconception test can be seen in APPENDIX-2.

Data Collection

In order to conduct it in a healthy way, the research was limited to the subject of force and motion, which is one of the Physics course subjects high school students have highly rated misconceptions about. A misconception pre-test study defining students' prejudice on the subject was carried out and the students' success rate before the study was specified. After the control and experimental groups on which conventional and computer assisted experimental designs would be applied were chosen randomly, the experiments were carried out within the frame of curriculum. While conventional experiments were carried out by the class teacher in the control group; computer assisted experiments were carried out in the experimental group by the class teacher with the assistance of the researcher. At the end of the experiments, the misconception test implemented as a pre-test was implemented as a post-test to be able to measure changing misconceptions, and the success rate of overcoming students' misconceptions after experiments was defined.

Most of the computer software that can be used for computer assisted experiments is Flash or Java simulations which are distributed for free and which can be run online via an Internet browser. There are many such simulations developed by schools or instructors available on the Internet. As a result of the study, the following software is approved to possess the desired features about force and motion subject.

1) Yenka Motion, Crocodile Clips Ltd, UK.
2) PhET interactivesimulations, Colorado University, USA.
3) Absorb Physics interactivelessons, David Fairhurst.

Yenka Motion is a part of the new version of an education simulation formerly called *Crocodile Physics*. Being only interested in force and motion, Yenka Motion is now marketed as a separate product. There are licenses unlimited for home use by students and teachers and 15-day trial for using at schools. The program, being in English, requires being online for installation and licencing check.

PhET interactive simulations are education simulations developed by Colorado University and distributed for free. As they are developed by Java and Adobe Flash, an Internet browser

supporting Java and Flash is enough to run the simulations. The simulations can be copied to work offline and they can be translated into Turkish with the help of plug-ins. Most simulations are in English but some have been translated into Turkish.

Absorb Physics interactive lessons are simulations developed by Adobe Flash and are distributed for free. As they are developed by Flash, any Internet browser supporting Flash is enough to run the simulations. Simulations can be copied to work offline. Screenshots of these software can be seen in APPENDIX-3 (URL-1; (URL-2; (URL-3).In this study, all simulations related to 10th grade force and motion subject were used.

Conventional experiments applied to the control group consist of example activities demonstrated in Turkish Ministry of National Education Board of Education and Discipline's grade physics lesson curriculum.

Data Analysis

Pre-tests and post-tests used in the study were graded in accordance with the key and "Yes, I'm sure" and "No, I'm not" options students marked. Data analysis was based on the questions that the students were sure about, and unmarked questions or the questions marked as "No, I'm not sure" were not included in the analysis..

In order to determine the error rate about the misconceptions, APPENDIX-2 was used and how many times the questions and option combinations related to each misconception was marked was detected. The proportion of the sum of the answers given to the options about misconception to the sum of the answers given to all questions about related misconception gives the rate of misconception. Misconception points were figured by calculating these rates for each student to test the hypothesis. Hypotheses were also tested by the sum of given correct answers (success rate) by the students for the pre-test and the post-test. Hypotheses developed were tested by *Dependent Sample T-test* in control and experimental groups and by *Independent Sample T-test* between the groups. These tests are a kind of parametric analysis widely used in normally distributed situations when the sample magnitude is small (smaller than 30) and the standard deviation of the nature is unknown (Ural & Kılıç, 2005). *SPSS-16* (Statistical Package for Social Sciences) and *Microsoft Excel 2007* programs were used in data analysis.

Results

In this section, data gathered from the tests implemented to the experimental and control groups during the study was analyzed and compared in order to compare conventional and computer assisted methods in teaching physics subject to high school students.

The sum of the correct answers (success rate) by control group students in pre-test and post-test in accordance with "Yes, I'm sure" answers to the misconception test is given in Table 2.

Table 2. Pre-test/Post-test Success Rate for the Control Group

Item Number	Pre-test	Post-test	Item Number	Pre-test	Post-test
1	3	6	13	6	11
2	3	3	14	2	7
3	5	6	15	4	9
4	4	5	16	5	9
5	5	8	17	3	2
6	1	6	18	3	6
7	2	6	19	2	4
8	7	5	20	1	6
9	3	5	21	3	6
10	2	5	22	1	9
11	3	2	23	0	9
12	5	3	24	5	3
Mean				3.25	5.88
Standard deviation				1.75	2.40

When Table 2 is analyzed, it can be seen that mean of the success rate for the control group in pre-test is 3.25, and that in post-test is 5.88.

The sum of the correct answers (success rate) by experimental group students in pre-test and post-test in accordance with "Yes, I'm sure" answers to the misconception test is given in Table 3.

Table 3. Pre-test/Post-test Success Rate for the Experimental Group

Item Number	Pre-test	Post-test	Item Number	Pre-test	Post-test
1	5	18	13	3	4
2	0	16	14	3	9
3	5	17	15	1	14
4	2	16	16	1	9
5	1	9	17	1	8
6	3	18	18	2	12
7	2	13	19	2	13
8	2	18	20	1	1
9	1	15	21	6	4
10	1	12	22	3	0
11	2	7	23	6	6
12	3	13	24	3	2
Mean				2.46	10.58
Standard deviation				1.64	5.63

When Table 3 is analyzed, it can be seen that mean of the success rate for the experimental group in pre-test is 2.46, and that in post-test 10.58.

In the first sub problem of the study, an answer to the question "*Is there a significant difference between experimental and control groups according to Misconception Test (MT) pre-test results?*" is sought, and for this, a dependent sample t-test analysis was made by developing a hypothesis like "*According to misconception test (MT) pre-test results, statistically there is no significant difference between control and experimental groups.*"(Table 4).

Table 4. Independent Sample T-Test Results of Pre-test Scores for Experimental and Control Group Students (MT)

Group	n	$\bar{x}$	s	df	t	p
Control	24	3,25	1,75	43	1,832	0,074
Experimental	24	2,46	1,64			

p>0, 05

According to Table 4, on 0,05 relevance level, there is not a meaningful difference between the (MT) pre-test results of experimental and control groups (t$_{(43)}$=1,832, p=0,074). In accordance with this result, it can be said that pre-test grades of experimental and control groups are equivalent to each other and in the light of this result, Hypothesis-1 was accepted.

The percentage distribution of misconception of control and experimental groups according to pre-test results is given in Figure 1.
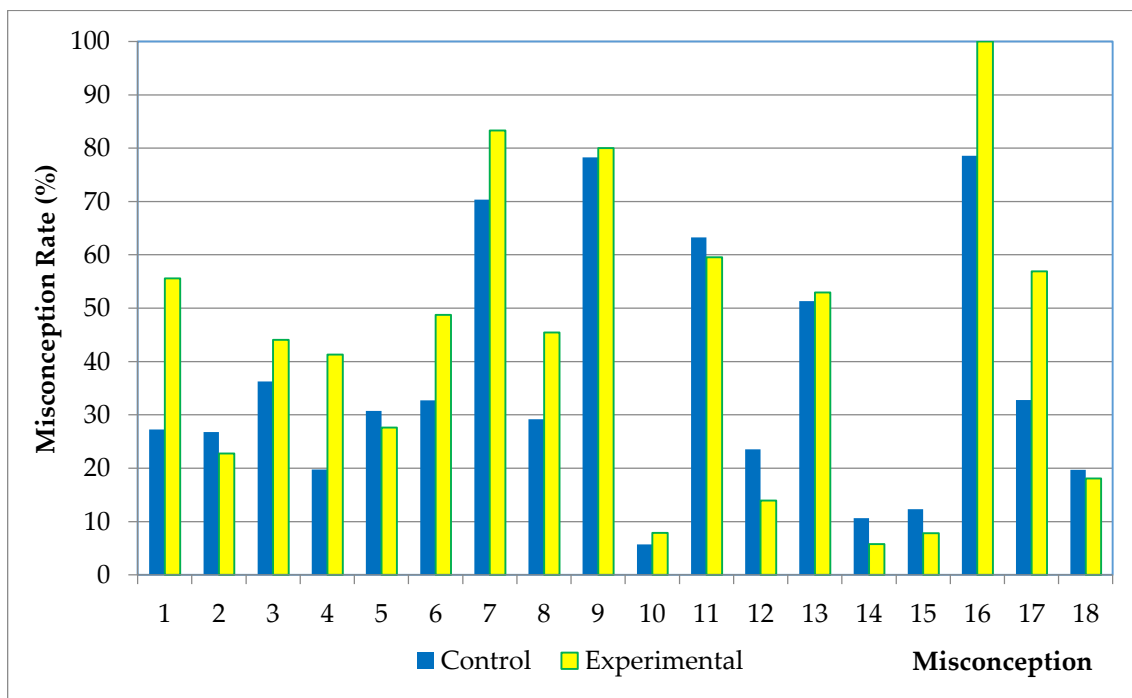

Figure 1. Percentage Distribution of Misconception of Control and Experimental Groups according to Pre-test Results

When we look at the misconception rate of control and experimental groups in Figure 1, it can be said that, according to pre-test results, both groups have similar misconception percentage for the same misconceptions.

In the second sub problem of the study, an answer to the question "*Do conventional experimental methods have an effect on teaching 10th grade students concepts about force and motion and overcoming their misconceptions?*" is sought, and for this, a dependent sample t-test analysis was made by developing a hypothesis like *"Conventional experimental methods have no effect on reaching 10th grade students concepts about force and motion and overcoming their misconceptions."*(Table 5).

Table 5. Dependent Sample T-Test Results of Pre-test/Post-test Scores for Control Group Students (MT)

Group	Test	n	$\overline{x}$	s	df	t	p
Control	Pre-test	24	3,25	1,75	22	-4.094	0.000
	Post-test	24	5,88	2,40			

p<0, 05

According to Table 5, on 0, 05 relevance level, there is a meaningful difference between the mean of (MT) pre-test and post-test grades of the control group ($t_{(22)}$=-4,094, p=0,00). Also, it was found that while the mean of pre-test grade of the control group is $\overline{x}$=3, 25, the mean of post-test grade is $\overline{x}$=5,88. This shows that conventional experimental methods have a significant effect on raising students' (MT) test success.

The percentage distribution of misconception of the control group according to pre-test and post-test results is given in Figure 2.
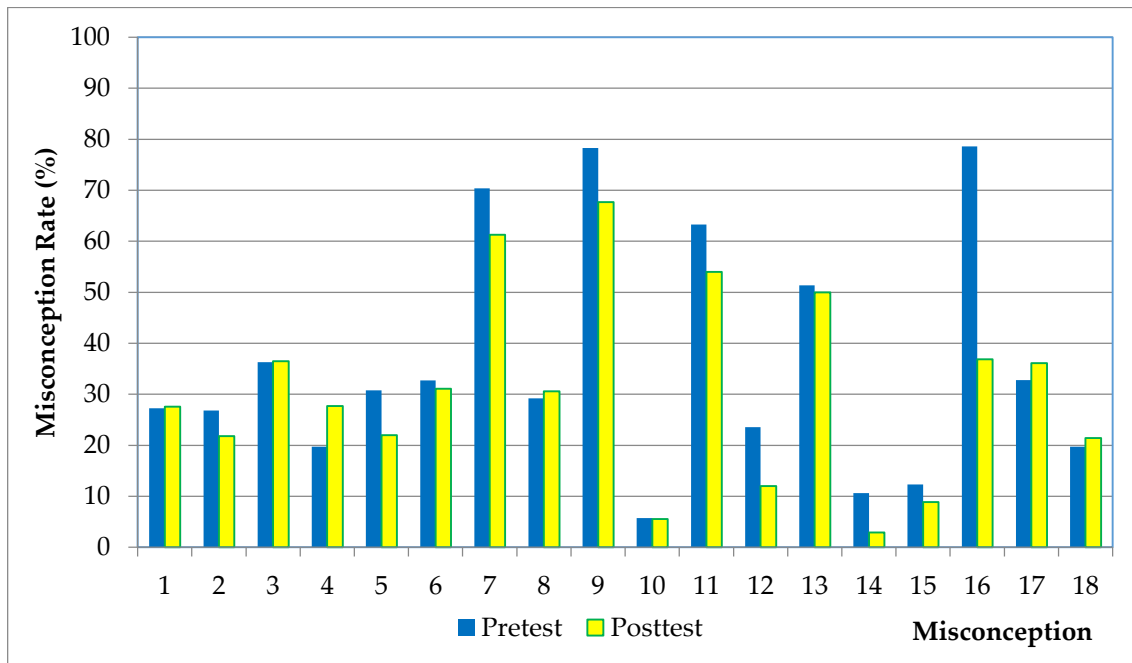

Figure 2. Percentage Distribution of Misconception of the Control Group according to Pre-test/Post-test Results

When we look at the misconception rate of the control group according to pre-test and post-test results given in Figure 2, it can be said that the rates of some misconceptions decreased after the post-test.

In the third sub problem of the study, an answer to the question "*Do computer assisted experimental methods have an effect on teaching 10th grade students concepts about force and motion and overcoming their misconceptions?*" is sought, and for this, a dependent sample t-test analysis was made by developing a hypothesis like *"Computer assisted experimental methods have no effect on teaching 10th grade students concepts about force and motion and overcoming their misconceptions."*(Table 6).

Table 6. Dependent Sample T-Test Results of Pre-test/Post-test Scores for Experimental Group Students (MT 1)

Group	Test	n	$\bar{x}$	s	df	t	p
Experimental	Pre-test	24	2,46	1,64	22	-6,224	0.000
	Post-test	24	10,58	5,63			

p<0, 05

According to Table 6, on 0, 05 relevance level, there is a meaningful difference between the mean of (MT) pre-test and post-test grades of the experimental group (t$_{(22)}$=-6,224, p=0,00). Also, it was found that while the mean of pre-test grade of the experimental group is $\bar{x}$=2,46, the mean of post-test grade is $\bar{x}$=10,58. This shows that computer assisted experimental methods have a significant effect on raising students' (MT) test success.

The percentage distribution of misconception of the experimental group according to pre-test and post-test results is given in Figure 3.
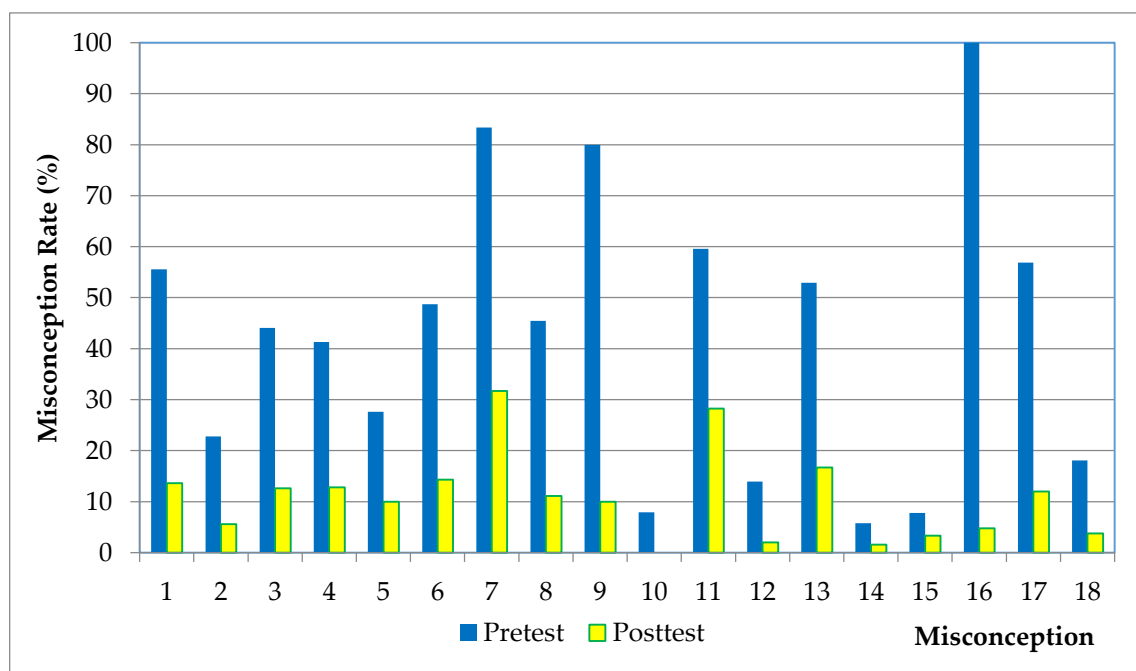

Figure 3. Percentage Distribution of Misconception of the Experimental Group according to Pre-test/Post-test Results

When we look at the misconception rate of the experimental group according to pre-test and post-test results given in Figure 3, it can be said that the rates of most misconceptions decreased after the post-test.

In the fourth sub-problem of the study, an answer to the question *"Is there a significant difference between conventional and computer assisted experimental methods in teaching 10th grade students concepts about force and motion and overcoming their misconceptions?"* is sought, and for this, a dependent sample t-test analysis was made by developing a hypothesis like *"There is no significant difference between conventional and computer assisted experimental methods in teaching 10th grade students concepts about force and motion and overcoming their misconceptions."*(Table 7).

Table 7. Independent Sample T-Test Results of Post-test Scores for Experimental and Control Group Students (MT)

Group	n	$\overline{x}$	s	df	t	p
Control	24	5,88	2,40	30	-3,481	0,002
Experimental	24	10,58	5,63			

p<0, 05

According to Table 7, on 0, 05 relevance level, there is a meaningful difference in the benefit of the experimental group between the mean of (MT) post-test grades of control and experimental group ($t_{(30)}$=-3,481, p=0,002).

The percentage distribution of misconception of control and experimental groups according to post-test results is given in Figure 4.
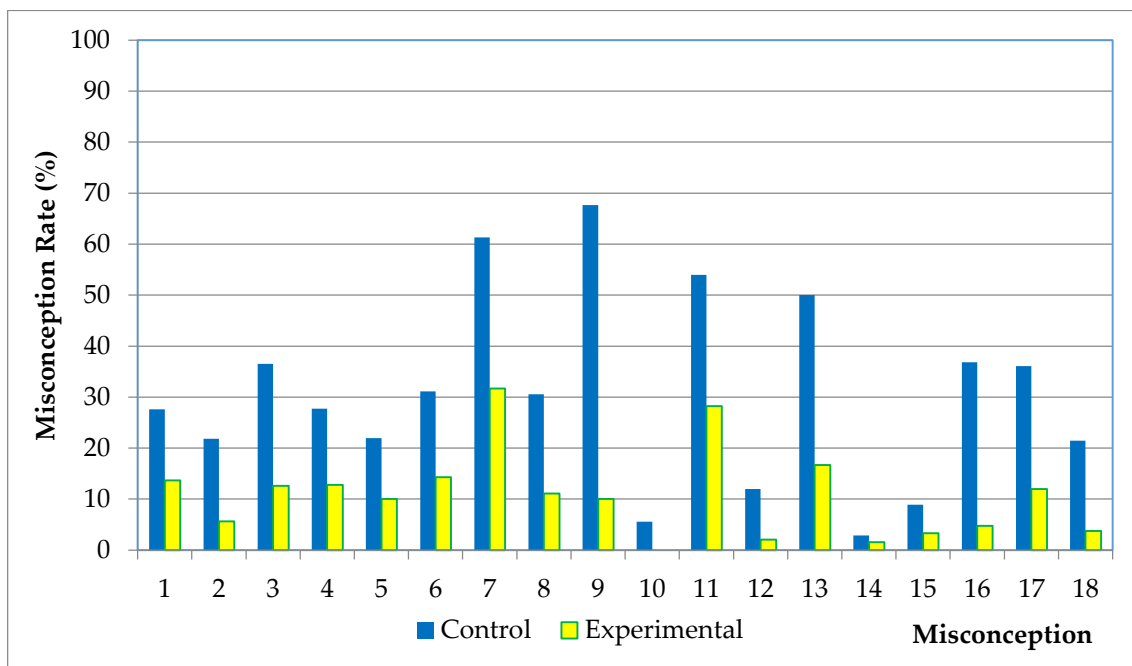

Figure 4. Percentage Distribution of Misconception of Control and Experimental Groups according to Post-test Results

When we look at the misconception rate of control and experimental groups according to post-test results given in Figure 4, it can be said that the experimental group have less misconception rate in all misconceptions when compared to the control group.

Discussion, Conclusion and Suggestions

In this study, the effects of laboratory assisted experimental method and computer assisted experimental method on overcoming the misconceptions of 10th grade science students studying in high school about force and motion were compared. Before the study, with the help of the results a pre-test implemented to students, it was seen that the students have a great deal of misconceptions about force and motion. It is concluded that the experiment group, who was taught using computer assisted experimental method, is more successful than the control group, who was taught using laboratory assisted conventional experimental method, in reducing students' misconceptions about force and motion.

Percentages of increase and decrease according to control group pre-test/post-test analysis are given below:

1. There is 1.17% increase in the following misconception: "*If an object is moving, there are forces affecting this object in the direction of the motion.*"
2. There is 18.58% decrease in the following misconception: "*If an object is moving, there are forces affecting this object in the opposite direction of the motion.*"
3. There is 0.60% increase in the following misconception: "*An object under a stable force moves in a stable speed.*"
4. There is 40.35% increase in the following misconception: "*Although an object moves in a stable speed, there is a net force in the direction of its motion.*"
5. There is 28.56% decrease in the following misconception: "*When the total force affecting an object is zero, the speed of the object decreases.*"
6. There is 4.97% decrease in the following misconception: "*Quantity of motion is in direct proportion to quantity of force.*"
7. There is 12.90% decrease in the following misconception: "*The magnitude of an object's speed is in direct proportion to the magnitude of force applied to it.*"
8. There is 4.76% increase in the following misconception: "*When an object is thrown, the force causing the motion affects the object throughout its movement.*"
9. There is 13.55% decrease in the following misconception: "*In the fall of an object with a horizantal initial speed, there is a force affecting it in the direction of its movement (initial speed direction).*"
10. There is 2.62% decrease in the following misconception:".*If an object is stable, no force affects it.*"
11. There is 14.65% decrease in the following misconception: "*In action-reaction forces, the object with a bigger mass applies more force the the other one.*"
12. There is 49.00% decrease in the following misconception: "*In action-reaction forces, there exists a net force in the direction of objects' motion.*"
13. There is 2.62% decrease in the following misconception: "*In action-reaction forces, the object moving faster applies more force.*"
14. There is 72.67% decrease in the following misconception: "*Only living objects apply force, passive ones (table, wall, floor, …) do not apply force.*"
15. There is 27.89% decrease in the following misconception: "*Gravity is ineffective on objects moving up vertically, and also on stable and falling objects.*"
16. There is 53.11% decrease in the following misconception: "*Concepts of pressure, momentum, motion and energy are confused with concept of force.*"
17. There is 10.12% increase in the following misconception: "*Speed and net force vectors are in the same direction.*"
18. There is 8.67% increase in the following misconception: "*Net force doesn't constitute acceleration.*"

In correspondence with these results, percentages of increase and decrease according to experimental group pre-test/post-test analysis are given below:

1. There is 75.44% decrease in the following misconception: *"If an object is moving, there are forces affecting this object in the direction of the motion."*
2. There is 75.36% decrease in the following misconception: *"If an object is moving, there are forces affecting this object in the opposite direction of the motion."*
3. There is 71.36% decrease in the following misconception: *"An object under a stable force moves in a stable speed."*
4. There is 68.98% decrease in the following misconception: *"Although an object moves in a stable speed, there is a net force in the direction of its motion."*
5. There is 63.80% decrease in the following misconception: *"When the total force affecting an object is zero, the speed of the object decreases."*
6. There is 70.68% decrease in the following misconception: *"Quantity of motion is in direct proportion to quantity of force."*
7. There is 61.98% decrease in the following misconception: *"The magnitude of an object's speed is in direct proportion to the magnitude of force applied to it."*
8. There is 75.55% decrease in the following misconception: *"When an object is thrown, the force causing the motion affects the object throughout its movement."*
9. There is 87.5% decrease in the following misconception: *"In the fall of an object with a horizantal initial speed, there is a force affecting it in the direction of its movement (initial speed direction)."*
10. There is 100% decrease in the following misconception: *"If an object is stable, no force affects it."*
11. There is 52.56% decrease in the following misconception: *"In action-reaction forces, the object with a bigger mass applies more force the the other one."*
12. There is 85.37% decrease in the following misconception: *"In action-reaction forces, there exists a net force in the direction of objects' motion."*
13. There is 68.51% decrease in the following misconception: *"In action-reaction forces, the object moving faster applies more force."*
14. There is 72.96% decrease in the following misconception: *"Only living objects apply force, passive ones (table, wall, floor, …) do not apply force."*
15. There is 57.63% decrease in the following misconception: *"Gravity is ineffective on objects moving up vertically, and also on stable and falling objects."*
16. There is 95.24% decrease in the following misconception: *"Concepts of pressure, momentum, motion and energy are confused with concept of force."*
17. There is 78.91% decrease in the following misconception: *"Speed and net force vectors are in the same direction."*
18. There is 79.23% decrease in the following misconception: *"Net force doesn't constitude acceleration."*

When the results of the pre-tests for control and experimental groups are analyzed, it was seen that *"Concepts of pressure, momentum, motion and energy are confused with concept of force."* is the most mistaken conception for both groups. This misconception was found with a percentage of 78.57% in pre-test results for the control group and with a percentage of 100.00% in that for the experimental group.

When the results of the post-test were analyzed, it was seen that laboratory assisted conventional experimental methods were able to overcome the misconception *"Only living objects apply force, passive ones (table, wall, floor, …) do not apply force."* the most successfully (72.67% decrease) while computer assisted experimental methods were able to overcome the misconception *"If an object is stable, no force affects it."* The most successfully (100.00% decrease). Additionally, it was also concluded that laboratory assisted conventional experimental methods were able to overcome the

misconception"*Although an object moves in a stable speed, there is a net force in the direction of its motion.*"The least successfully (40.35% increase) while computer assisted experimental methods were able to overcome the misconception"*In action-reaction forces, the object with a bigger mass applies more force the the other one.*"The least successfully (52.56% decrease). According to the post-test results, when the means of misconception rate for both groups were taken into consideration, it can be said that the misconception that "*The magnitude of an object's speed is in direct proportion to the magnitude of force applied to it.*"was the most frequently seen one.

As a general result of the study, it was concluded computer assisted education has a bigger effect on overcoming misconceptions than laboratory assisted education. This conclusion is parallel to the results of many national and international studies (Andoloro et. al, 1997; Rodrigues, 1997; Calverley et. al, 1998; Jimoyiannis & Komis, 2001; Yigit & Akdeniz, 2003; Ayvacı et. al, 2004; Dancy & Beichner, 2006; Karamustafaoglu, 2012).

Following suggestions can be made in accordance with the results of the study:

1. This study has shown that computer assisted education has a stronger effect on conceptual meaning than laboratory assisted education. This means that placing computers in physics laboratories at schools may positively affect student success.

2. This study can also be repeated on other Physics subjects separated from "Force and Motion" and the results can be compared and contrasted.

3. It is known that all the experiments cannot be carried out by the teacher due to the limited amount of time allocated to physics and the intensity of the curriculum. In such circumstances, using physical simulation to fill in this gap may increase students' success.

4. Class Materials Development Center (CMDC) may prepare these simulations for the sake of easier reach of the teachers.

5. In a study carried out by Kazu and Yavuzalp (2008) with 471 teachers in 17 primary schools that has science and technology classes in the cities of Elazig and Malatya, when the awareness of the teachers about education software at schools and their situation about checking out the education software in their own fields, it was seen that a considerable amount of the teachers were not aware of the software (26.8%) and had not checked out the software in their own fields (27.6%), although their schools possess education software and there are software prepared in every field. In this regard, teachers can be integrated into in service training about school subject software.

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APPENDIX-1: A SECTION FROM MT (MISCONCEPTION TEST)

Name	
Surname	
Age	
Class and School	

In the following questions;

- Do not regard force resulting from air friction or air pressure.
- Accept the moving objects as solid and inelastic.
- Briefly explain why you chose that answer in the explanation part.

1) Which of the following can be used as an exact force expression?

A) Push, Pressureand Pull
B) Energy, Momentum and Motion
C) Push and Pull
D) Push and Motion
E) Push, Pressure, Pull, Energy, Momentum and Motion

Explanation:

Are you sure about your answer?	○Yes, I am.	○No, I'm not.

The following questions (2-6) are about a sled moved on ice with use of force. Ignore friction.


2) When the sled is stable, which force makes it speed up to the right with a stable acceleration?
A) A stable force to the right
B) An increasing force to the right
C) A decreasing force to the right
D) A first increasing, then decreasing force to the right
E) There is no need to use force.

Ezplanation:

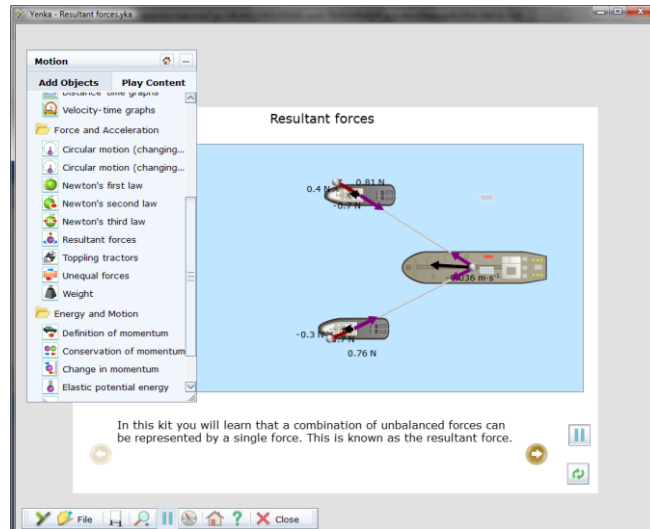| *Are you sure aboutyour answer?*	○Yes, I am.	○No, I'm not.

APPENDIX-2: MISCONCEPTIONS ABOUT FORCE AND MOTION AND QUESTION OPTIONS THEY MATCH WITH

#	Misconceptions	Matching Question Items
1	*If an object is moving, there are forces affecting this object in the direction of the motion.*	3) A, B, C, D; 4) A, D; 5) A, C, D; 6) C, D; 7) A, C; 18) B
2	*If an object is moving, there are forces affecting this object in the opposite direction of the motion.*	4) C, D; 5) B; 6) A; 8) A, C; 11) A, D; 18) C
3	*An object under a stable force moves in a stable speed.*	3) A; 5) A, B; 8) A, C; 9) B, C; 13) B, D, E; 18) B, C 20) B, E
4	*Although an object moves in a stable speed, there is a net force in the direction of its motion.*	3) A; 5) A; 9) B, C; 13) B, D; 18) B
5	*When the total force affecting an object is zero, the speed of the object decreases.*	4) E; 6) E; 7) E; 19) A, D, E; 20) A, D, E
6	*Quantity of motion is in direct proportion to quantity of force.*	3.B, C, D; 5.C, D; 7)C, D; 8) C, D; 9)D, E; 11) C, D; 18) D
7	*The magnitude of an object's speed is in direct proportion to the magnitude of force applied to it.*	2) B, C, D; 4)A, C, D; 6) A, C; 7) C, D; 8) C, D
8	*When an object is thrown, the force causing the motion affects the object throughout its movement.*	10) B, D; 19) B
9	*In the fall of an object with a horizantal initial speed, there is a force affecting it in the direction of its movement (initial speed direction).*	7) A, C; 10) B, D
10	*If an object is stable, no force affects it.*	15) D; 16) A
11	*In action-reaction forces, the object with a bigger mass applies more force the the other one.*	15) A, B; 16) A, E; 17) A, B
12	*In action-reaction forces, there exists a net force in the direction of objects' motion.*	14) D; 16) B, E; 17) D
13	*In action-reaction forces, the object moving faster applies more force.*	14) A, B; 16) B, E
14	*Only living objects apply force, passive ones (table, wall, floor, …) do not apply force.*	14) C; 16) B; 17) E; 18) E
15	*Gravity is ineffective on objects moving up vertically, and also on stable and falling objects.*	7) E; 8) E; 10) C, E; 11) E; 12) E
16	*Concepts of pressure, momentum, motion and energy are confused with concept of force.*	1) A, B, D, E
17	*Speed and net force vectors are in the same direction.*	4) A, D; 6) C, D; 7) A, C; 18) B, D
18	*Net force doesn't constitude acceleration.*	2) E; 4)E; 6)E; 12) D, E

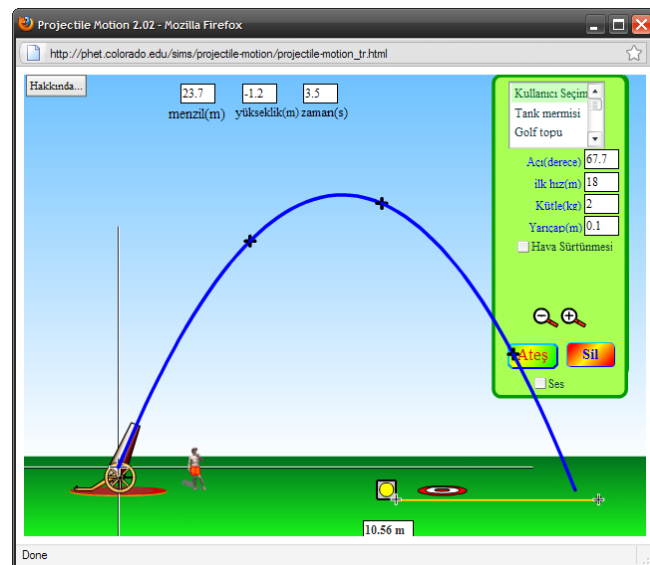**APPENDIX-3:** SCREENSHOTS OF SOFTWARES USED FOR COMPUTER ASSISTED EXPERIMENTS
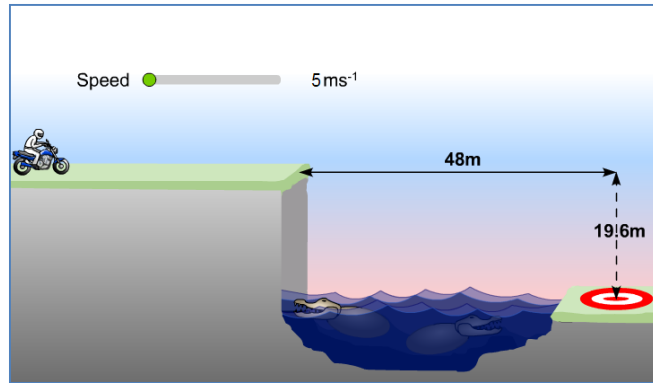
AbsorbPhysics

Yenka Motion

PhET