A STUDY ABOUT STUDENTS' MISCONCEPTIONS IN FORCE AND MOTION CONCEPTS BY INCORPORATING A WEB-ASSISTED PHYSICS PROGRAM

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ABSTRACT
The aim of this study was to incorporate a web-assisted program to normal traditional classroom instruction and study about students' misconceptions in force and motion concepts in physics. The Web-based physics program was incorporated with the traditional lecture. Specifically, 30% of class time was allocated for using this tutorial program, and 70 % of class time was used for normal lecture. The Force Concept Inventory (FCI) was used as pre- and posttest. Although there were not any significant results between FCI post test scores and group memberships, and gain scores and group memberships ($F_{1,123} = 2.023$, $p > 0.05$); relative to FCI pre-and post test mean difference scores, group membership (being control and treatment groups) was statistically significant at .05 ($F_{1,123} = 4.307$, $p < 0.05$).

Key words: Science Education, Physics Education, Web-assisted Instruction, Misconception, and Computer-based Instruction.

I. INTRODUCTION

During the last two decades, physics education research has shown the difficulties introductory university students have had because they lack the ability to perform formal operations inherent to learning physics. This suggested a need for a more interactive and problem-solving teaching methodology in introductory physics. At the same time, the ongoing revolution in information technology has led to new tools for creating innovative educational environments. In response to these two developments, a wide variety of new models of physics instruction are beginning to appear and have potential for challenging the way physics has been taught traditionally.

It is evident from the literature that students of different educational backgrounds and different ages have basic preconceptions or misconceptions about force and motion concepts that affect student' further learning or achievements (Clement, 1982; Eckstein & Shemesh, 1993a and 1993b; Halloun & Hestenes 1985; Maloney, 1984; Palmer, 1997; Poon, 1993; Thijs, 1992, Bransford et al., 1999; Demirci, 2001).

So far, much of the research carried out that examines computer use and student achievement, seems to emphasize that there is a positive correlation between these variables. There is plenty of evidence to indicate a positive relationship between technology and student achievement (James and Lamb, 2000; Weaver, 2000; Wenglinsky, 1998), although most of these studies emphasize that for technology to have an effect on student achievement it must be challenging, focused on higher-order thinking skills, the teachers must be capable of using and teaching it and have the appropriate support. In other words, examining computer use or technology, by itself is not enough to determine its effects on student achievement.

Purpose

The aim of this study was to incorporate a web-based program to normal traditional classroom instruction and study about students' misconceptions in force and motion concepts in physics.

Hypothesis

The null hypothesis that corresponds to this study is as follows:
Incorporating the web-assisted physics program with traditional lecturing will have no effect on high school students' Force Concept Inventor (FCI) pre-and post test mean difference scores as compared to traditional lecturing alone.

II. LITERATURE REVIEW

Misconceptions in Physics Education

During the past two decades, many studies have shown that students enter physics classes with many preconceived ideas. These preconceptions are often misconceptions in which students do not provide a correct description of the behavior of the physical world that is consistent with the laws of physics.

Misconceptions can be classified in the following areas: preconceived notions, nonscientific beliefs, conceptual misunderstandings, vernacular misconceptions, and factual misconceptions (Committee on Undergraduate Science Education, 1997). Preconceived notions make it difficult to learn about heat, energy, and gravity. Many scientists see these misconceptions as superfluous, but students often prefer them because they make more sense. Even after the lesson, these beliefs can linger thereby hindering the learning process Nonscientific beliefs are all views learned by students from sources different than scientific education. One way they can emerge is from religious or mythical teachings "Conceptual misunderstandings arise when students are taught scientific information in a way that does not provoke them to confront paradoxes and conflicts resulting from their own preconceived notions and nonscientific beliefs" (CUSE, 1997, p2). Vernacular misconceptions arise from the use of words that mean one thing to laymen but something totally different when you are talking about science (CUSE, 1997).

Tao and Gunstone (1999) investigated the process of students' conceptual change during computer supported physics units in a 10th-grade science class (N = 27). They found that many students vacillated between alternative and scientific conceptions from one context to another during the instruction, i.e., their conceptual change were context dependent and unstable.

Technology and Use of Web-assisted Instruction in Education

The computer's capacity which to interact with students and to react to their individual needs has the potential to provide a student-centered context that can assist students in learning. Papert (1993) discusses that computers offer progressive tools that can bring and shape qualitative changes in education for educators. Technological competence also requires a transition in the usage of computer: from the use of computer as an instructional delivery system to the use of computer as a learning tool (computer-supported instruction) (Lowther et al., 1998). The hypermedia format used by World Wide Web has received a wide acclaim and its potential as a learning tool derives from the nature of creating a motivating and active learning environment (Becker & Dwyer, 1994). It supports and encourages browsing and exploration, learner behaviors that are associated with higher-order learning (Thuring, Mannemann, & Haake, 1995). Hypermedia facilitates a very natural and efficient form for information retrieval. Although it has been argued that web technology has the potential to provide a unique environment for technology for teaching and learning, hypermedia materials themselves do not teach but provide a medium that in which learning is supported appropriately (Eklund, 1995; Alexander, 1995). In addition to this, according to Moore (1999), research on web-based instruction does not present much empirical evidence to validate the instructional applications of web-based technology.

Savelsberg, Jong, and Fergusson-Hessler (2000) used the computer algebra software as a tool for problem-solving visualization to compare an electrostatics course module with a usual paper-and pencil based one. Learning outcomes for both courses were not significantly different. Hargis (2001) designed an online instructional module to measure the effect of learning through the Internet. The result of the ANCOVA indicated no significant main effect with age or gender. Nevertheless, there was a significant interaction between age and treatment.

III. METHODOLOGY

The sample for this study was chosen from two public high school students enrolled in introductory physics in Brevard County, Florida. The Force Concept Inventory (FCI) test (Hestenes, Swackhamer, & Wells, 1992), which consists of 29 multiple-choice questions related to force and motion concepts, was used as a pre- and posttest in the study. In this study, internal reliabilities for the pre- and posttest (Kuder-Richardson 21) were calculated as .67 and .69, respectively. The reliability estimates for the FCI test imply that scores obtained on this test are reliable and valid in measuring students' understanding concepts of force and motion. According to the FCI test results obtained in the study there were 125 public high school students of 11th (93 % of the sample) and 12th (7 % of the sample) grades. The ages of students ranged from 15 to 18 years old (total distribution of students: 2.4 % of the students was 15 years old, 52.8 % of the students was 16 years old, 40 % of the students was 17 years old, and 4.8 % of the students was 18 years old or older). Also 54.4 % of students was female and 45.6 % of students was male.

The test was used to identify the following misconceptions (this table was given by Hestenes, Swackhamer, and Wells in1992), as presented in Table 1.

Table 1:
Misconceptions and their descriptions about force and motion concepts and related FCI test questions.

Misconceptions	Descriptions	Related FCI questions and distractors
1.Kinematics a. Confusion between position and velocity	Confusion about an object's position or velocity. If two objects have the same position, they should have same velocity.	24- choices B, C, and D
b. Confusion between velocity and acceleration	Confusion about an object's velocity and acceleration. If the two objects have the same velocity, it is assumed that these two objects must have the same acceleration or vice versa.	24- choice A;25- choices B and C
c. Confusion between vector and non-vector velocity composition	Confusion about vector composition; for example, velocity composition.	11- choice C
2. Impetus view a. Impetus supplied by "hit"	If an object has a motion, it must have force acting upon this object. This is a contradiction with Newton's first law. Also, it is believed that if the object moves in the circular path, a circular (impetus) force tends to move this object in its path.	26-B, C, E; 13-B, C;33-D
b. Loss and recovery of original impetus		30- A, D, E; 8-D; 28-A;10- C, E 33A
c. Impetus dissipation		9- A, B, C; 12-C; 20-C, D; 27- E; 31-C, E; 33- B
d. Delayed impetus build-up		10-28- D; 12-B,D; 33- E
e. Circular Impetus		8- A and D; 14- A
3. Active Force Concept a. Only active agent exerts force	It is believed that an active force is necessary to continue an object's motion at constant velocity regardless of its medium. (Aristotelian view about maintaining an object in motion)	15-16- B; 17-18- D; 19-A, B;22- D; 26-A
b. Motion implies active force		33- A
c. No motion Implies No Force		16- E
d. Velocity proportional to applied force	It is assumed that there is a linear relationship between force and velocity instead of force and acceleration	29- A; 32- A
e. Acceleration implies increasing force		21- B
f. Force causes acceleration to terminal force		21- A; 29- D
g. Active force wears out		29- C and E
4. Action/Reaction Pairs a. A greater Mass Implies Greater Force	It is believed that greater mass implies greater force	6- A and D; 15- D; 17-18- B
b. Most Active Agent		17- C and D; 15- D

Misconceptions	Descriptions	Related FCI questions and distractors
Produce Greatest Force		
5.Concatenation of Influences		
a. Largest Force Determine the Motion	It is believed that motion of any object is determined by the largest force or compromise of force or last force	22- A and E; 23- A
b. Force Compromise Determine the Motion		8-C; 14-D; 20- A; 27-28- C; 23- C and D
c. Last Force to Act Determine the Motion		10- A; 11-28- B; 30- C
6. Other Influence of Motion		
a. Centrifugal Force	It is assumed that centrifugal force is a distinct kind of force. Some textbooks and instructors suggest (centrifugal) fictitious force to teach to students this force more easily	8-14- C, D, and E
b. Obstacles		13- A and B; 6- C;16- A; 17-18- E
7. Resistance		
a. Mass makes things stop	Mass is regarded as a kind of resistance. Motion occurs only when the active force "overcomes" the resistance, and it cases when the force becomes "too weak"	27-33- A and B
b. Motion occurs when force overcomes resistance		32- B and D
c. Resistance opposes Force		32- E
8. Gravity		
a. Air Pressure-Assisted Gravity	It is assumed that the bigger acceleration will be caused by a heavier weight. Also there is believed that the air pressure contributes to gravity. In addition to these, it is believed that the gravity does not affect on any object until impetus force wears down this object.	13- A; 16- C; 21-22- E
b. Gravity Intrinsic to Mass		9-13- E; 21- D
c. Heavier Objects Fall Faster		5- A; 7- B and D
d. Gravity Increases as Objects Fall		9-21- B
e. Gravity Acts after Impetus "wears down"		9- B; 20- D; 27- E

When calculating the students' FCI misconceptions scores, their total correct answer percentage (number of correct answers was divided by total number of questions) was used.

Design and Procedures

All of the Brevard County public high school physics teachers were invited to participate in this study. Only two responded to the invitation. In school A, there were three physics classes. One class was used as a control group and the other two were used as treatment groups. In school B, there were two physics classes, one of which was used as a control and the other as a treatment group. All classes were selected randomly in forming control or treatment groups.

Teachers who participated in the study were trained one to two hours before the beginning of the semester to follow the same procedures (involved the following steps: 1. Accessing the computer lab, 2. Running the physics program, 3. Using the tutorial, multimedia and test sections). The teachers were also trained to standardize the administration procedures and the implementation of the treatment. The FCI test was administered to all groups during the third week-as a pretest- and 11th week-as a posttest- of the same semester.

Experimental Group

As a treatment group, there were a total of three classes. The treatment was administered starting the fourth week, and continued for eight weeks. Three classes used a web-based physics program as part of their instruction. As indicated earlier, a total of 30 % of the class time each week was spent in the computer lab using the web-based program and 70 % of the class time was spent in normal lecturing in the regular classroom.

The Treatment: Web-Based Physics Software Program

A web-based instruction program developed by Anderson (2003) was used in the study. Although the program includes many concepts and topics in physics, only the first three units (Kinematics, Force and Motion, and Vector and two-dimensional Kinematics) were chosen for our research purpose. The program is titled "The Physics Classroom," and consists of three modules or sections: Study topics, multimedia section, and quiz room. Study topics consist of the first three units of the physics-mechanics- concepts: a) One-dimensional Kinematics contains six lessons dealing with this concept, b) Force and Motion includes four lessons, and c) Two Dimensional Kinematics and Vectors contains four lessons. The multimedia section contains many animations related to study topics as indicated above. These animations visualize many ideas and misconceptions in order to make learning easy and dispel many preconceptions (as indicated in table 1) related to kinematics, and force and motion concepts. The quiz room contains many quizzes related to study topics and gives deep understanding of each lesson (detail of this program can be seen on the web).

The Web-based physics program was incorporated with the normal lecture in the treatment groups. Specifically, 30% of class time was allocated for using this tutorial program, and 70 % of class time was used for normal lecture. These percent allocations were aggregated on two-week schedule. The control groups used 100% normal lecturing only. There was a total of 250 minutes of physics instruction time per week. During the first week, the treatment groups received 200 minutes of lecture and 50 minutes of the web-based program and during the following week, they received 150 minutes of lecture and 100 minutes of web-based instruction. In that 30% of class time, the students in the experimental groups went to the computer lab and followed the instructional program under the guidance of their teacher. They reviewed the subjects covered in the classroom and followed multimedia and quiz sections related to those subjects. The control groups received a total of 250 minutes of lecture per week. Both groups were taught the same subject in the same week. As an instructional method, 30% of the class time in the computer lab was used as a supplement and complementary of the topics covered in the classroom.

Control Group

As a control group, there were a total of two classes. Students in these control groups were taught the same content as the students in the treatment groups, but did not use the web-based program. Instead, 100% of the instruction was delivered by traditional lecturing methods.

For the Hawthorne and John Henry effect, having eight-weeks between the pretest and posttest helped reduce the effect of these treats. Moreover, the study took place in regular classroom and computer lab. Computer use for students was not new issue and had no problem for that. Also there were two teachers and they followed the same standardize conditions under which the treatment and procedure implemented. Throughout the study period, the control and treatment classes were observed to ensure that all teachers followed the procedures exactly (e.g. accessing the computer lab, using program, preventing the control group from using physics program during the study period, etc). Finally, during the 11th week of the term, the teachers administered the FCI test as a posttest. Pre- and posttest misconception scores were calculated, reported, and analyzed as percentages: Number of correct answers was divided by total number of questions.

IV. RESULTS

Descriptive Statistics

Table 2 presents the descriptive statistics of the pre- and posttest and gain scores of all students from the Force Concept Inventory (FCI) Test. In the study there were two classes of control groups (as labeled control 1 and control 2) and three classes of experimental groups (as labeled experimental 1, experimental 2 and experimental 3). When we look at the control groups and experimental groups gain scores from table 2, we can see that overall gain scores for all control groups about 35 % and all treatment groups about 44 %.

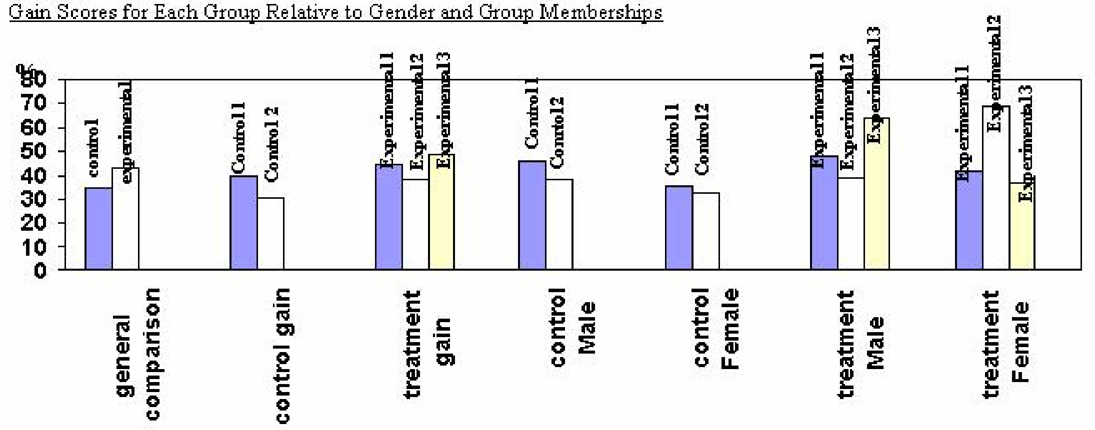
Table 2:
FCI Test Scores (in %), Means, Standard Deviation and Gain Scores for All Groups

	FCI Pretest		FCI Posttest		Pre- Posttest	Gain scores
Group	Mean	SD	Mean	SD	Mean difference	
All	28.59	11.06	48.676	14.14	20.086	0.3914
All Control	31.585	10.27	49.22	13.54	17.635	0.3473
All Experimental	25.60	12.01	48.14	14.32	22.54	0.4346
Control 1	33.64	10.21	52.44	13.11	18.80	0.3953
Control 2	29.53	10.32	46.00	13.96	16.47	0.3050
Experimental 1	28.50	12.38	50.52	13.23	22.02	0.4450
Experimental 2	22.94	9.45	44.14	12.60	21.20	0.3795
Experimental 3	25.37	14.20	49.74	17.14	24.37	0.4849

Note: N = 125; SD = Standard Deviation; Gain score= ((posttest - pretest)/(100 - pretest))

Also table 2 gives some detail of pre- and post misconceptions scores and gain scores for each class; for example, female students from second treatment class achieved maximum gain scores with about 69 % and lowest achievement scores obtained from male students of second control class with about 32 %. In figure 1, you can see more detail of comparison between groups with respect to gain scores.

Figure1 :
Gain Scores for Each Group Relative to Gender and Group Memberships



Inferential Statistics

Although there was a significant result between group memberships (being control or treatment group) and FCI pre-and posttest mean difference results, it was not found any significant result difference between group memberships and gain scores. You can see these results in table 3 and 4.

Table 3:

Summary Table of Group Memberships and FCI Pre-and Post Test Mean Difference Results

Source	Sum of Squares	df	Mean Square	F	Sig.
Group memberships	727.017	1	727.017	4.30	.040*
Error	20764.295	123	168.815		
Total	72739.0	125			

*p< 0,05

Table 3 shows FCI pre-and posttest mean difference results. It can be seen that this difference relative to group membership is significant ($F_{1,123} = 4.307$, $p < 0.05$). When we looked at gain scores between control and experimental groups, as indicated in table 2, there were some differences in terms of test scores, however it could not find any significant result between these two groups ($F_{1,123} = 2.023$, $p > 0.05$). Summary table related to group memberships and gain scores is given in table 4.

Table 4:
Summary Table of Group Memberships and FCI Pre-and Post Test Gain Scores Results

Source	Sum of Squares	df	Mean Square	F	Sig.

Group memberships	0.07	1	0.070	2.023	.157
Error	4.26	123	0.034		
Total	14.18	125			

When we looked at FCI posttest scores and group memberships, it could not find any significant results between those variables ($F_{1,123} = 0.249$, $p > 0.05$). This result is given in table 5.

Table 5:
Summary Table of Group Memberships and FCI Post Test Scores Results

Source	Sum of Squares	df	Mean Square	F	Sig.
Group memberships	59.031	1	59.031	.294	.589
Error	24729.08	123	201.049		
Total	314615.00	125			

Analyses of the Null Hypothesis
As indicated before, the null hypothesis of this research was given as: "Incorporating the web-based physics program with traditional lecturing will have no effect on high school students' Force Concept Inventory (FCI) pre-and post test mean difference scores as compared to traditional lecturing alone".

Although there were not any significant results between FCI post test scores and group memberships, and gain scores and group memberships; relative to FCI pre-and post test mean difference misconception scores, as can be seen in Table 3, group memberships (being control and treatment group) was statistically significant at .05 ($F_{1,123} = 4.307$, $p < 0.05$). Based on data obtained from this study, it can be concluded that null hypothesis should be rejected for the FCI pre-and posttest mean difference scores. Incorporating the web-assisted physics program with traditional lecturing will have effect on high school students' Force Concept Inventory (FCI) pre-and posttest mean difference scores. It meant that web-assisted physics instruction program with supplemented to the traditional instruction, dispelled students' some misconceptions and increased their achievements.

V. DISSCUSSION AND CONCLUSIONS
Before taking the introductory physics course, students have many misconceptions related to their own previous experiences or knowledge, and normal traditional lecturing fails to overcome those difficulties. Based on the data obtained in this study, it was observed that incorporating the web-based physics program decreased students' some misconceptions, and increased their achievements. We can imply that using new instructional methods such as incorporating the web-assisted physics programs with the traditional lecturing can remediate students' misconception in force and motion concepts. A study from White (1993) on force and motion of sixth graders with computer based micro world for two months compared their science class with eighth graders who experienced more conventional instruction. He concluded that the computer-based micro world students performed better on a written posttest examining their ability to transfer the underlying Newtonian principles to real-world context. With respect to this study, Clark (1994) stated that one must assume that the study's comparison confounds instructional "method and content in the same way that many previous studies in this area fail to control for important alternative hypotheses" (p. 27). However, a meta-analysis study, which compared Cooperative Computer-Based Instruction and Individual-Computer-Based Instruction, conducted by Susman (1998) showed that studies that included these elements had greater mean effect sizes (Es =0 .413) than the mean of all studies (Es = 0.251).

The result from this study showed that the use of Computer Based Instruction dispels students' misconception about force and motion as Hicks and Laue (1989); Finegold and Grosky (1988); and Scott et al. (1992) concluded. Based on the data from this study, incorporating the web-assisted physics program was significantly effective on high school students' Force Concept Inventory (FCI) pre-and posttest mean difference scores, and increased their achievements in force and motion concepts in physics.
This study has reemphasized that there is a need for a teacher to probe the understanding of his/her students before, during, and after their instruction (White & Gunstone, 1992).

RECOMMENDATIONS
For those considering similar studies, several factors should be considered to improve or strengthen such research.
In this study, it was hypothesized that incorporating the web-assisted physics program with traditional lecturing will have no effect on high school students' Force Concept Inventory (FCI) pre-and post test mean difference scores as compared to traditional lecturing alone. For readers who are interested in conducting further research on determining the effects of constructivist teaching methods with incorporating web-assisted physics program

in their instruction, the following recommendations, based on this study's limitations, are offered so that significance may be improved.

Using intact groups appeared to limit research findings; more diverse random samples could remedial their misconceptions significantly. In this study, the accessible population was public high school students enrolled in introductory physics courses in Brevard County, Florida. The subjects were not randomly selected from the accessible population. Subjects who volunteered for this study were chosen as a sample of convenience, and the use of non-random samples of convenience limits the generalizability of the study findings.

RECOMMENDATIONS FOR FUTURE RESEARCHES

The information obtained from future studies within this area may determine more details whether web-assisted programs dispel high school students' misconceptions and increased their achievements, not just in physics but within the sciences and other discipline areas as well. As a conclusion of this section, I have several recommendations:

1. The replication studies are needed to investigate how web-assisted programs can be designed effectively to support learning and remedial misconceptions.
2. More random samples, long-term studies, different effect sizes and power levels of using these kinds of web-assisted programs are needed to study of misconceptions and achievements in any physics concepts.
3. Further studies should focus on, for example, using the web-assisted program only vs. lecture to compare students' misconceptions about force and motion concepts in greater details.

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