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The effects of peer instruction on ninth grade students' conceptual understanding of forces and motion

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THE EFFECTS OF PEER INSTRUCTION ON NINTH GRADE STUDENTS' CONCEPTUAL UNDERSTANDING OF FORCES AND MOTION

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ABSTRACT

Because students are often taught physics in a traditional, lecture-based classroom, the present study was undertaken to test whether the use of peer instruction, specifically concept questions embedded within a PowerPoint that allows for students to interact throughout the lecture, affects learner outcomes in a classroom setting. The outcomes from classes taught using peer instruction were compared to classes taught with traditional, lecture-based teaching strategies. Students in five different sections of a 9th grade Physical Science class were given pre-tests and post-tests to determine their learning gains on the topics of motion and forces. In the first unit of instruction, three of the five classes were given peer instruction throughout each class lecture while the other two classes received a traditional, lecture based approach to each class. In the second unit, classes that had not used peer instruction previously received the peer instruction treatment, while the other classes received traditional lecture. Overall, the peer instruction technique showed a significant positive effect on learning gains compared to traditional teaching methods when used in a ninth grade Physical Science classroom. In each of the sections of students examined individually, peer instruction was as or more effective than traditional lecturing in improving student learning.

INTRODUCTION

The Need for Physics Education Reform

We live in a physical world and have observed and interpreted the world from birth. Because of this experience students develop an innate understanding of the world around them, based upon their observations (Trowbridge and McDermott, 1980, Crouch and Mazur, 2001). For example, they inherently learn patterns about forces and motion. Because they have made these observations they do not understand why in the classroom they should need to explain something that everybody already knows. Sometimes, though, their interpretations of the patterns they have observed do not always follow the common interpretations of physicists (Trowbridge and McDermott, 1980).

A number of studies have documented the prevalence of such misconceptions in a variety of populations of educators and students alike. A study asking participants to interpret motion in terms of kinematic concepts found that a significant number of those tested did not understand the concepts. Only 41% of elementary school teachers, 53% of college students placed in a special class for people interested in health careers, 59% of non-calculus based physics, and 68% of calculus-based physics students at the University of Washington were able to correctly compare speeds of two different objects. Furthermore, at least 30% of all the individuals confused the concepts of speed and position. In a second study, involving over 200 introductory physics students, over 60% of individuals confused the concepts of velocity and acceleration in a pre-course interview (Trowbridge and McDermott, 1981). Students identified as honors also have strong misconceptions about basic physics concepts (Peters, 1981). After having been given a repeated demonstration of the motion of an object for twenty minutes, students were asked to draw a graph to represent what they had just seen. Only 30% of students were able to show the motion with reasonable accuracy. Pre-service teachers and college teaching assistants have misconceptions about fundamental physics concepts (Shaffer and McDermott, 2005). Given a picture of a child

on a swing (pre-service teachers) or a bob on a pendulum (teaching assistants), less than 5% of teachers and only 15% of teaching assistants were able to correctly identify the direction of acceleration for the diagrams.

Peer Instruction in the Classroom

Students have misconceptions because their understanding of physics is mostly based on personal observations of events: each student brings a different level of understanding to class (Trowbridge and McDermott, 1980, Crouch and Mazur, 2001). Some students would understand, for example, that part of the reason for a feather taking a longer time to hit the ground than a bowling ball is air resistance, while others could never have made the same connection. Students interacting with one another through peer instruction were able to connect with each other and share experiences and observations allowing them the chance to teach each other while increasing their conceptual knowledge of physics as a whole. Peer instruction is a technique in which students interact in small groups developing answers to lecture embedded questions and validating these answers in their group discussions (Mazur, 1997). The peer instruction approach poses concept-based questions after a short lecture. Each student then records individual answers to the questions, through a clicker system, before turning to a neighbor and discussing what the possible correct answer may be. Each student will take one to two minutes to convince their neighbor what the right answer is and why before being given the opportunity to revise their answer if needed. After the chance to re-answer the question, the instructor will then show what the correct answer is and explain why it is correct (Mazur, 1997).

In the classroom physics concepts are commonly taught through a series of calculations, using mathematics to drive instruction. Students gain very little conceptual understanding from this approach (Crouch and Mazur, 2001). This traditional instructional method uses mathematical equations to validate procedures (Peters, 1981), rather than using physics concepts to drive a lesson and allowing the mathematics to complement the concept. An alternative approach, peer instruction, allows for a deeper understanding of conceptual physics (Mazur, 1997). Peer instruction, which was first developed and tested in college level

introductory physics courses resulted in dramatic differences in achievement on concept tests compared to traditional teaching methods. Students in introductory calculus based physics from fall 1990 to fall 1997, and introductory algebra based physics from fall 1998 to fall 2000 at Harvard University were given the Force Concept Inventory (FCI) and the Mechanics Baseline Test (MBT) at the beginning and end of each term. Gains in the FCI, a thirty-question concept inventory, were only 25% for the traditionally taught calculus based class in 1990 and up to 74% in the peer instruction taught calculus based class in 1997. The algebra based class showed an improvement from a 40% gain in the traditional style class in 1999 to a 63% gain in the peer instruction class in 2000. An improvement was even seen in the mathematical based MBT, showing scores ranging from 66% in the traditional style calculus based class in 1990 to 79% in the peer instruction calculus based class in 1997 without working any additional mathematical problems in class lectures (Crouch and Mazur, 2001). Providing concept questions throughout a class breaks up a lecture into smaller, more manageable chunks, as well as an opportunity for students to practice problem solving (Smith, et al., 2009).

Peer instruction, as implemented in this study, is an active learning strategy designed to increase student engagement in a traditionally passive classroom setting. In a traditional setting, a teacher will commonly ask various questions throughout the lesson. When this occurs, only a few of the highly motivated students will be engaged (Crouch and Mazur, 2001). By having all students vote to answer questions through a clicker system, each student is actively participating for the duration of a lesson. Peer instruction also works on the premise that each student brings a different understanding of a concept to class, and acquires new levels of understanding from the short lectures before each concept question and can then share their different knowledge levels to arrive at complete understanding of the concepts presented. Peer instruction causes students to learn through having to explain, as if they were the teacher. Because peer instruction is a form of cooperative learning groups, there are different interpretations of how to implement it. In one method, called peer discussion, students discuss their rationale for answering a question with peers before being allowed to re-answer the same question.

Once the original question is re-answered, a second similar question is presented without any explanation from the instructor. In the second mode, called teacher explanation, students simply answer a question before a teacher explains the correct answer. There is no peer discussion before the students are allowed to re-answer the original question before moving on to the second, similar question. The third mode, called combination mode, allows students to discuss the answer to a question before re-answering it. The instructor then explains what the rationale is behind the correct answer before allowing the students to answer the second, similar question (Smith, et al., 2009).

Which peer instruction approach is most effective in student understanding of biology concepts was tested in classes of biology students at the University of Colorado (Smith, et al., 2009). The approaches examined were peer discussion between questions embedded in the lecture, only teacher explanation of embedded conceptual questions, or a combination of both peer discussion and teacher explanation. Previous studies of the effects of peer instruction on student learning (Mazur, 1997; Crouch and Mazur, 2001; Smith et al., 2009), suggested that an increase in correct answers resulted from students increasing their conceptual understanding through active discussion. These studies did not, however, address the added component of teacher explanation. Smith et al. (2009) embedded an average of four conceptual questions per class session, including matched-pair questions that were graded for participation points into each of the three peer instruction approaches that they tested. Matched pair questions allowed the students to answer the first question (Q1) of a pair and then after either peer discussion or the teacher's explanation answer a second (Q2); the second question was similar but not identical to the first question and covered the same concept (Smith, et al, 2009). The greatest gains were achieved with the combination mode of instruction.

Rationale for this Study

These studies of the effectiveness of peer instruction were performed in college level courses in genetics (Smith, et al, 2009) and physics (Mazur, 1997). The effectiveness of the peer instruction strategy in the college

classroom suggests that this approach may have value in the high school science classroom as well. It is in the high school science classroom where many students' pre- and misconceptions are first challenged. There is little information available on the efficacy of such an approach in high school. The current study was undertaken to assess the effectiveness of the combination mode of peer instruction compared to the traditional teaching mode in the high school physical science classroom.

In order to assess the effectiveness of peer instruction in high school physics two populations of high school students, those identified as honors and those characterized as regular will be taught basic lessons in force and motion using peer instruction and the more commonly used mathematics-based approach.

In high school physical science classes, over the period of time in which two units, motion (kinematics) and forces, are studied, lessons were presented both with and without the combination peer instruction mode. Students took notes from a traditional PowerPoint note format, but were provided with "clickers" that allowed them to answer concept-based questions periodically throughout the lessons. Students were given concept questions and at instructed times, the students were allowed to collaborate with their neighbors over what the correct answers were and why the answers were correct. Students were then allowed to re-answer the same question that had been posed before discussions in groups before being shown the correct answer. The instructor then reinforced what the right answer was and why it was correct before students individually answered a similar question to reinforce concept knowledge.

Students' understanding was measured with matching pre- and post-tests that were solely used for evaluating the effectiveness of the teaching method and were not used in the calculation of the overall grade for the class. Two different pre- and post-tests were used so that each class of students served as their own control to lessen outside factors, such as honors versus regular classes or morning versus afternoon classes which potentially could have affected the outcomes. The simplified Force Concept Inventory (FCI), obtained from Dr. David Koch at Arizona State University, served as both the pre- and post-test for the unit on Motion, because it

contains most kinematic based questions (Halloun, et al. 1995)... The Simplified FCI was also chosen because it was written for middle school reading levels, and would therefore test students' understanding of motion without their reading ability hindering results. To create the Simplified FCI, the original test was modified and evaluated by a reading expert, as indicated by Dr. David Koch at Arizona State University. To test the unit on forces the Force Motion Concept Evaluation (FMCE), obtained from Priscilla Laws at Dickinson College, was used because it contains primarily force-based concept questions and is a written for the high school level (Thornton and Sokolov, 1998).

MATERIALS AND METHODS

Definition of the Study Population

A total of 139 students participated in the study, with ages ranging from thirteen to fifteen. The entire population is divided into five sub-groups that have different class hours. Of these students four classes are identified as honors students, which totals 119 students. One class period is identified as regular students, totaling 20 students. The students in the regular class do, however, take other honors courses such as honors math, English, or World Geography. The students are in a school system that is a small district, with four elementary schools, each housing two different grade levels, one middle school and a single high school. Student cohorts travel between each of the schools without being divided because each elementary school only houses two grade levels; preschool and kindergarten, first and second, third and fourth, fifth and sixth. The district has been ranked as the highest performing district in the state for the past eight years, which means the students in this study have been in the highest performing school district for the entirety of their academic careers. The students who participated in the study were representative of the population of honors students of the whole school (Table 1). While these numbers do represent the whole school, 9^{th} through 12^{th} grade, the students participating were a majority honors level 9^{th} grade. To be considered for the honors program, past student standardized test scores, overall grades in previous science classes, and teacher recommendations are used for admittance. Of the four classes of Honors Physical Science students in this study, approximately half will continue in the honors science program at the school. The school's population was 1402 students at the time of the study.

Table 1: Numbers of students in various categories for the school and study population. These numbers were taken from JGradebook or provided by the administration.

Demographics for Zachary High School in Zachary, Louisiana		
	Whole School	**Study Population**
White	51%	65%
Black	46%	33%
Hispanic	1%	0%
Asian	1%	1%
Other	1%	1%
Free/Reduced Lunch	38%	0.7%
504	5%	1%
Special Ed.	13%	1%

The Pre- and Post-Tests

To assess student learning, pre- and post-tests for both motion and forces were used. The simplified Force Concept Inventory (FCI) was used as both the pre- and post-test for the motion unit. The FCI was chosen for the motion unit because approximately half of the questions on the inventory dealt more with the motions caused by forces, rather than the forces themselves. The test was designed to be used in its entirety (Hestenes, et al., 1992), therefore the questions dealing strictly with motion were not parsed out for a shortened, motion only version of the inventory. The FCI is an instrument designed to probe student understanding of force concepts and how they compare to Newtonian concepts (Hestenes, et al., 1992). Each question in the FCI is designed to make students choose between the correct Newtonian answer and common sense beliefs that are not correct. Developed in 1992 to improve the Mechanics Diagnostics, the FCI has been used by instructors across the country with thousands of students and results in nearly identical scores each time the test is administered to over 6,000 students in a wide range of instructional settings (Hestenes, et al., 1992, Thornton, et al., 2009). The FCI was designed with three specific uses in mind; as a diagnostic tool, as a placement exam, and for evaluating instruction (Hestenes, et al., 1992, Huffman and Heller, 1995). For the purposes of this study, the FCI was used as a diagnostic tool. The Force-Motion Concept Evaluation (FMCE) was a second concept inventory used as the

pre- and post-test for the force unit. The FMCE is a 45 multiple-choice question concept inventory designed to test students' conceptual knowledge of both motion, and the forces behind the motion, presented in graphical and story problem context. The FMCE was used in the second unit of study, forces, because 67% (30/45) of the questions focus more on the forces causing motion, rather than strictly motion itself. Validated through factor analysis, the FMCE is considered reliable as a diagnostic tool (Ramlos, 2008). The two concept inventories were chosen for this study because each class of students would receive peer instruction for one unit and traditional class for the other unit, so inventories were needed to compare results of classes against themselves. Since the force unit is taught second, the pre-test score on the FMCE could conceivably be altered by knowledge gained from the previous instruction in the motion unit, but the gains in knowledge should still be apparent. While both inventories test one dimensional kinematics and Newton's Laws, the FCI also covers the topics of acceleration and two dimensional motion (Thornton, et al., 2009), which are both topics in the motion unit of instruction. The two concept inventories were chosen because, despite their differences, there is a consistent pattern of responses on the exams independent of instructor given the same instructional methods, with normalized gains dependent on instructor and instructional methods (Thornton, et al., 2009). Examples of the questions are shown in Appendix A.

Administering the Tests

All students agreed to participate by having a parent or guardian sign a letter of consent (Appendix B) and each participating student signing a student assent form (Appendix C). The Institutional Review Board at Louisiana State University approved this research project, the parent consent form, and student assent form (LSU IRB #E6006).

On the first day of each unit the respective pre-test, FCI for motion and FMCE for forces, was given to the students. Not reviewing the answers, along with collecting the pre-tests without handing them back, helped to keep the students from memorizing correct answers to questions. The first unit studied was motion, so the FCI

was the first pre-test administered, in which 145 students participated. In this unit, 83 students were taught using peer instruction and 62 were taught with a traditional style. The unit took approximately four weeks, and 147 students completed the FCI post-test (Table 2). In the second unit, forces, 141 students completed the FMCE pre-test, with 62 taught with peer instruction and 80 with the traditional style. At the end of the unit, 142 students completed the FMCE post-test (Table 3).

Table 2: Number of students in each class who took the FCI for the motion unit. Number of students refers to the number that took both the pre-test and post-test for each class hour. PI is Peer Instruction; T is the traditional teaching style. These methods of teaching are described below.

Class	**Number of students Pre-test**	**Number of students Post-test**	**Teaching Method**
1	30	32	PI
2	31	31	T
3	21	22	PI
6	31	31	T
7	32	31	PI

Table 3: Number of students in each class that took the FMCE for the force unit. Number of students refers to the number that took both the pre-test and post-test for each class hour. PI is Peer Instruction; T is the traditional teaching style. These methods of teaching are described below.

Class	**Number of students Pre-test**	**Number of students Post-test**	**Teaching Method**
1	29	28	T
2	30	31	PI
3	20	22	T
6	31	31	PI
7	31	30	T

Traditional Versus Peer Instruction Teaching Methods

Students in the traditional style class were presented lessons in mini-concepts. The motion unit was broken down into eight different concepts and the force unit was broken into six concepts; each concept was also associated with student learning objectives (Table 4). While the motion unit contained two more concepts, they were presented to lay the foundation to understand the other six concepts associated with the motion unit. Also, because the two topics, motion and forces, are connected, there were times when forces would have been mentioned in the motion unit and vice versa. The instructor then delivered content via PowerPoint notes, in which students took notes during a lecture-based class. While being lecture-based, questions by the instructor were still asked orally throughout the lecture, but no formal answering process was used. The questions were meant to reinforce previous content and help students make connections to other topics in the class. Some of the questions asked were rhetorical in nature; while individual students were randomly called on to answer others. Upon completion of lecture for concepts in each unit, various reinforcement activities were completed. A laboratory activity that gathered data on acceleration, for example, was used after the completion of concept six, acceleration, in the motion unit.

Table 4: Concepts and Learning Objectives for Motion and Forces Units

Unit	**Concept**
Motion (FCI)	Distance, Displacement, and Position
	Speed
	Velocity
	Position vs. Time Graphs for Uniform Motion
	Position vs. Time Graphs for Non-Uniform Motion
	Acceleration
	Speed vs. Time Graphs for Uniform Motion
	Curved (Non Linear) Motion
Force (FMCE)	Newton's 1st Law and Inertia
	Types of Forces
	Free Body Diagrams
	Newton's 2nd Law
	Newton's 3rd Law
	Momentum

Classes taught with the peer instruction method received identical class PowerPoint lectures and reinforcement activities, but with the addition of clicker questions embedded into each concept lecture. The clicker question design was based on Mazur's (1997) Concept-Test questions. Concept-Test questions are conceptual questions, with little to no math, created to stimulate understanding of basic physics concepts. The Concept-Test questions were inserted into the traditional PowerPoint notes, with a matched pair question (Smith, et al., 2009) directly behind it. Matched pair questions were used to limit memorization of correct answers for the original Concept-Test question and were created with the help of senior physics teachers at the school before the implementation of each lesson. The format for how peer instruction was implemented in this study is seen in Table 5. During collaboration time, students were instructed to not only explain what answer they chose, but why they chose it as well. Peer groups were chosen haphazardly based on the seating arrangement in class, with peer groups limited to the one or two students seated near each other. Each lesson in a unit was limited to two or three concept embedded questions to keep pace with the traditional style classes.

Table 5: General Format for Peer Instruction Method (Mazur, 1997 and Smith, et.al, 2009)

Direct instruction by instructor	5-10 min.
Concept-Test Question answered individually	1-2 min.
Collaboration with peers	3-5 min.
Re-answer original Question	1-2 min.
Instructor reveals and explains correct answer	2-3 min.
Answer matched pair question individually	1-2 min.
Instructor reveals and explains correct answer	1-2 min.

Analysis of the Pre- and Post-Test

The FCI test had thirty questions, each counted as one point, and the FMCE had 45 total questions. Because of the difference in number of questions, the FMCE score was normalized to the FCI by multiplying the number of correct questions by 2/3. A student that earned a 40/45 on the FMCE would be normalized to a 27/30 to allow for matching pre-test and post-test scores on both the FCI and FMCE. Data from this study were compared in three different ways; comparing overall scores on pre-test and post-tests and overall normalized gains, individual class pre-test and post-test scores and normalized gains by class, and pre-test and post-test scores and normalized gains based on concept inventories. All comparisons used a form of a nonparametric statistical analysis because the scatter in the data did not indicate normality (Figure 1), nor did the data pass the Kolmogorov-Smirnov normality test. In a preliminary examination of the data, excluding outlier test scores did not normalize the data, thus the outliers were kept in the statistical analysis of this study and nonparametric tests were used. Paired statistical analyses were also chosen because test scores and learning gains were compared to each individual student.

Upon completion of both the pre-test and post-test for each unit of study, data from each class were pooled to determine the overall pre-test and post-test scores, and overall normalized learning gains. To calculate the normalized learning gain, Hake's (2002) formula was used, where learning gain = (post-test score % - pre-test score %)/(100– pre-test score %). For example, a student who earned a 10/30, or 33%, on the pre-test and then a 12/30, or 40%, showed a 0.1, or 10%, learning gain. (0.1 = [12– 10] ÷ [30 – 10]×100). Learning gains were calculated to compare the different teaching methods from this study, and with data from other studies. A nonparametric, paired test called a Wilcoxon matched pairs test was used to determine the overall viability of peer instruction as compared to traditional teaching methods in regard to overall normalized learning gains The Wilcoxon matched pairs test was used in lieu of a basic t-test due to the pairing nature of the data. A nonparametric, paired test analogous to a repeated measure ANOVA, the Friedman test, with Dunn post-tests

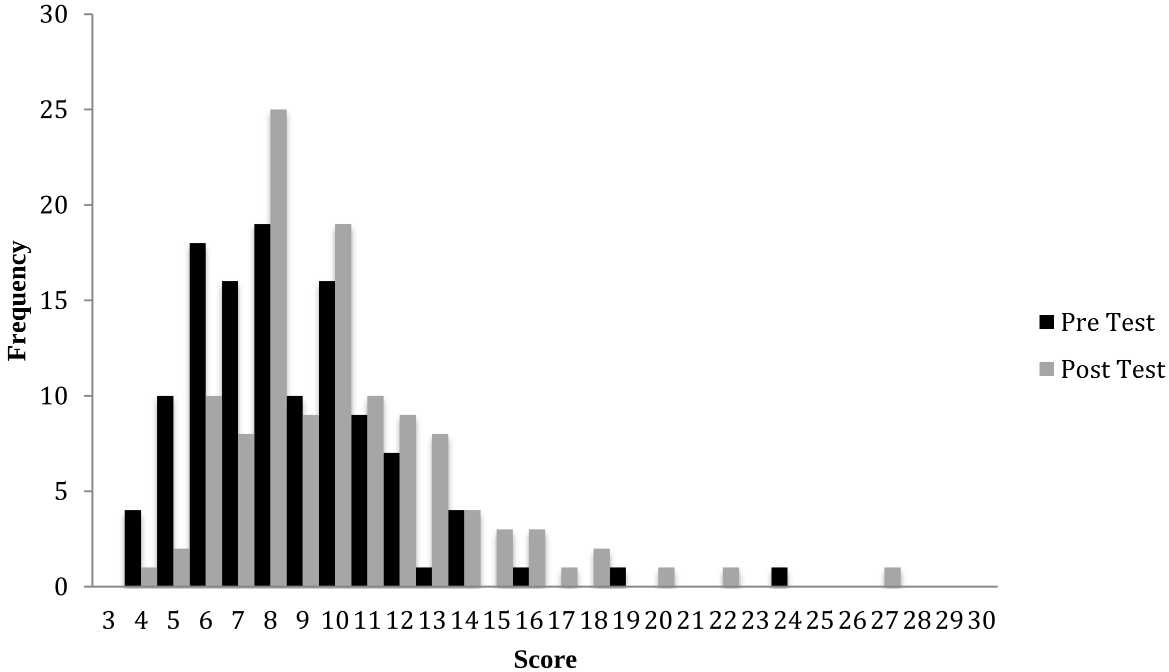
where appropriate, the average raw scores on both sets of pre and post-tests. The pre-test score for each test was also compared to the respective post-test to see if there was significant difference in raw test scores of the two teaching methods studied.

Average raw test scores by class also used a Friedman test to compare pre-test and post-test scores. This was run to determine whether any individual class period showed any significant difference in scores based on teaching methods. The Wilcoxon matched pairs test was also used when comparing the average normalized learning gains by individual class.

To compare the raw test scores of the two concept tests, the FCI and FMCE, data were pooled into experimental and control data sets based on how they were utilized in the different class periods. Because of this, there was not an equal number of data points in each data set, so a Kruskal-Wallis was used to compare the pre-test and post-test scores by concept test. A Kruskal-Wallis statistical analysis is a nonparametric, unpaired test used when comparing three of more sets of data, as was the case in comparing pre-test and post-test scores of both the experimental and control groups for each concept test. Again, because of the unequal data sets the pairing of data was not appropriate, so a Mann-Whitney test was used to compare the learning gains of the different teaching methods by concept test. This set of data was run to determine if the use of either concept inventory would affect learning gains, in addition to the teaching methods tested.

All forms of statistical analyses were compared in GraphPad InStat version 3.00 for Windows 95, GraphPad Software, San Diego California USA, www.graphpad.com.

Control Raw Test Scores



Experimental Raw Test Scores

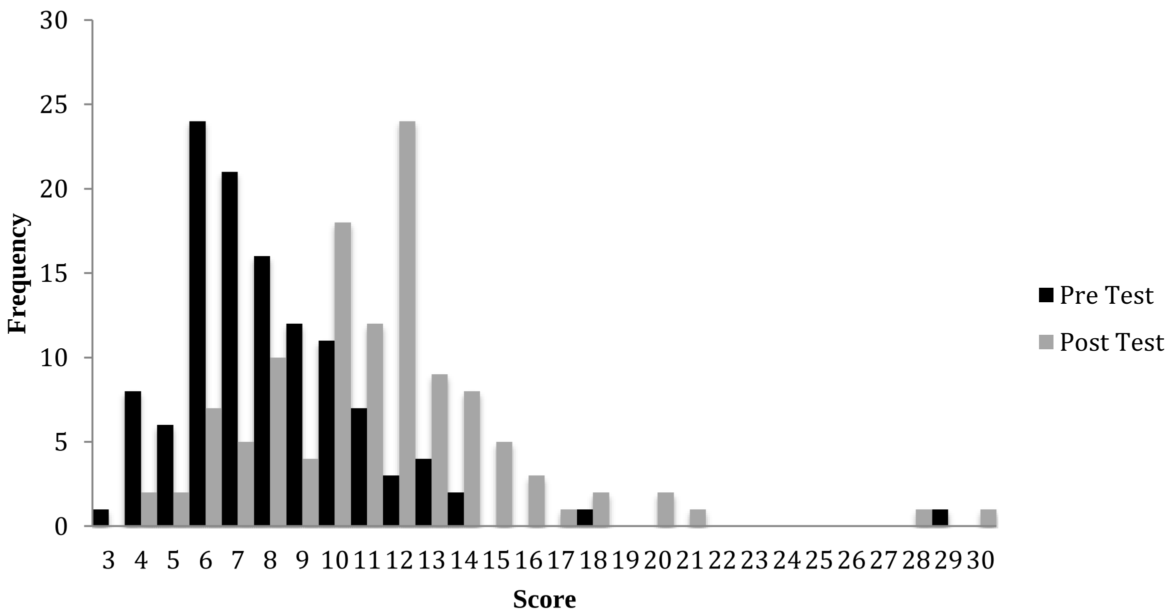


Figure 1: Control and experimental pre-test and post-test raw score frequencies.

RESULTS

Overall Raw Test Scores

The average performance on the pre- and post-tests varied with values ranging from 3% to 97% (Table 6). There were some negative mean learning gains in this study because several students scored higher on the pre-test than on the post-test. This could cause a problem when calculating learning gains. For example, one student scored a 96% (43/45) on the experimental pre-test and then scored a 93% (42/45) on the matching post-test. The learning gain for this student was a -50%, even though there was only one question difference in the actual test score. This student was atypical in scores on both the FCI and FMCE, scoring significantly higher than peers on both tests, thus the data point was a large outlier. Outliers in this study were not excluded, because they did not affect the significance of the comparison when not used in the various analyses. The large negative learning gain of this student would cancel out the positive learning gains of the majority of students tested and for this reason the data were analyzed excluding this student.

Table 6: Pre- and post-test results for peer instruction and traditional learning styles for FCI and FMCE units.

Pre- and Post-Test Results				
	Peer Instruction		Traditional	
	Pre-Test	Post-Test	Pre-Test	Post-Test
Range	10% - 97%	13% - 97%	13% - 80%	3% - 90%
Mean	26.22%	37.28%	27.87%	32.94%
Standard Error	0.2971	0.3671	0.2793	0.3470

The average raw test scores of students taught by the two teaching strategies were compared pre-test and post-test (Figure 2). The pre-test raw scores for students taught using peer instruction (7.92± 0.30, mean ± SE) versus traditional methods (8.37 ± 0.28) was not significantly different (Table 7). The post-test scores for peer instruction (11.1 ±0.37) versus traditional methods (9.9 ± 0.5) were significantly different (Table 7).

Table 7: Summary of the overall comparisons made for the peer instruction (PI) vs. traditional instruction (T) and probabilities (P).

Comparison	P value
PI pre-test vs. T pre-test	> 0.05
PI post-test vs. T post-test	< 0.005

Figure 2: Average raw pre and post-test scores in relation to lessons using peer instruction (experimental group) and traditional (control group) methods of teaching. The scores were compared using a paired non-parametric ANOVA called the Wilcoxon matched pairs test. For the pre-test, there was no statistical difference between raw scores for the experimental and control groups ($P>0.05$, $n = 117$). For the post-test, there was a significant difference between peer instruction (experimental group) and traditional (control group) methods ($P<0.005$, $n = 117$). Means and standard errors are shown.

Overall Mean Learning Gain

The learning gains of students on the pre-test and post-tests were compared based on teaching styles (Figure 3). The percent mean learning gain for students taught using peer instruction (12.3 ± 1.36) was significantly different from the mean for students taught using traditional learning (6.97 ± 1.20) (Wilcoxon matched-pairs signed ranks test, $P = 0.0012$).

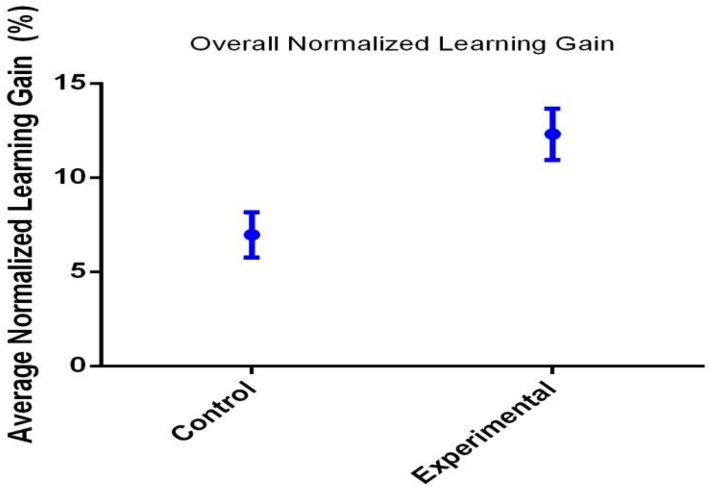


Figure 3: Overall mean learning gains in relation to lessons using peer instruction (experimental group) and traditional (control group) methods of teaching. The scores were compared using a paired non-parametric ANOVA called the Wilcoxon matched pairs test. There is a significant difference in the learning gains for classes taught with peer instruction and those taught inn a traditional setting ($p=0.0012$, $n = 117$). Means and standard errors are shown.

Individual Class Raw Test Scores

The average raw test scores by class period on pre-tests and post-tests, comparing peer instruction and traditional teaching methods were compared using Friedman's test with an aposteriori comparison using a Dunn's test. In the first period class, the pre-test from the experimental group, peer instruction (7.19 ± 0.52), was not significantly different than the average pre-test score from the control group, traditional instruction (8.29 ± 0.78). There was a significant difference (Table 8) in the first hour post-test score for the peer instruction technique (12.86 ± 0.71) and the post-test score for the traditional teaching method (8.27 ± 0.78). The pre-test scores in the second period class for peer instruction (7.40 ± 0.49) and traditional teaching method (9.08 ± 0.55) were significantly different (Table 8). The post-test scores for peer instruction (9.92 ± 0.79) and traditional teaching (11 ± 0.74) were not significantly different (Table 8). For the third hour class, the pre-test scores for peer instruction (8.00 ± 0.61) and traditional teaching methods (7.35 ± 0.54) were not significantly different (Table 8). The post-test scores for peer instruction (10.24 ± 0.57) and traditional teaching methods

(8.53 ± 0.54) were not significantly different (Table 8). The pre-test scores for peer instruction (8.22 ± 0.96) and traditional teaching (8.59 ± 0.71) in the sixth hour class were not significantly different (Table 8). The post-test scores for peer instruction (12.04 ± 1.07) and traditional teaching (11.85 ± 0.82) were also not significantly different (Table 8). In the seventh hour class, the pre-test scores for peer instruction (8.59 ± 0.52) and traditional teaching (8.22 ± 0.52) were not significantly different (Table 8). The post-test scores for peer instruction (10.93 ± 0.59) and traditional teaching (9.07 ± 0.57) were significantly different (Table 8).

Table 8: Summary of the comparisons made for the peer instruction (PI) vs. traditional instruction (T), and probabilities (P) by individual class.

Hour	Comparison	P value
1	PI pre-test vs. T pre-test	> 0.05
	PI post-test vs. T post-test	< 0.001
2	PI pre-test vs. T pre-test	< 0.05
	PI post-test vs. T post-test	> 0.05
3	PI pre-test vs. T pre-test	> 0.05
	PI post-test vs. T post-test	> 0.05
6	PI pre-test vs. T pre-test	> 0.05
	PI post-test vs. T post-test	> 0.05
7	PI pre-test vs. T pre-test	> 0.05
	PI post-test vs. T post-test	< 0.05

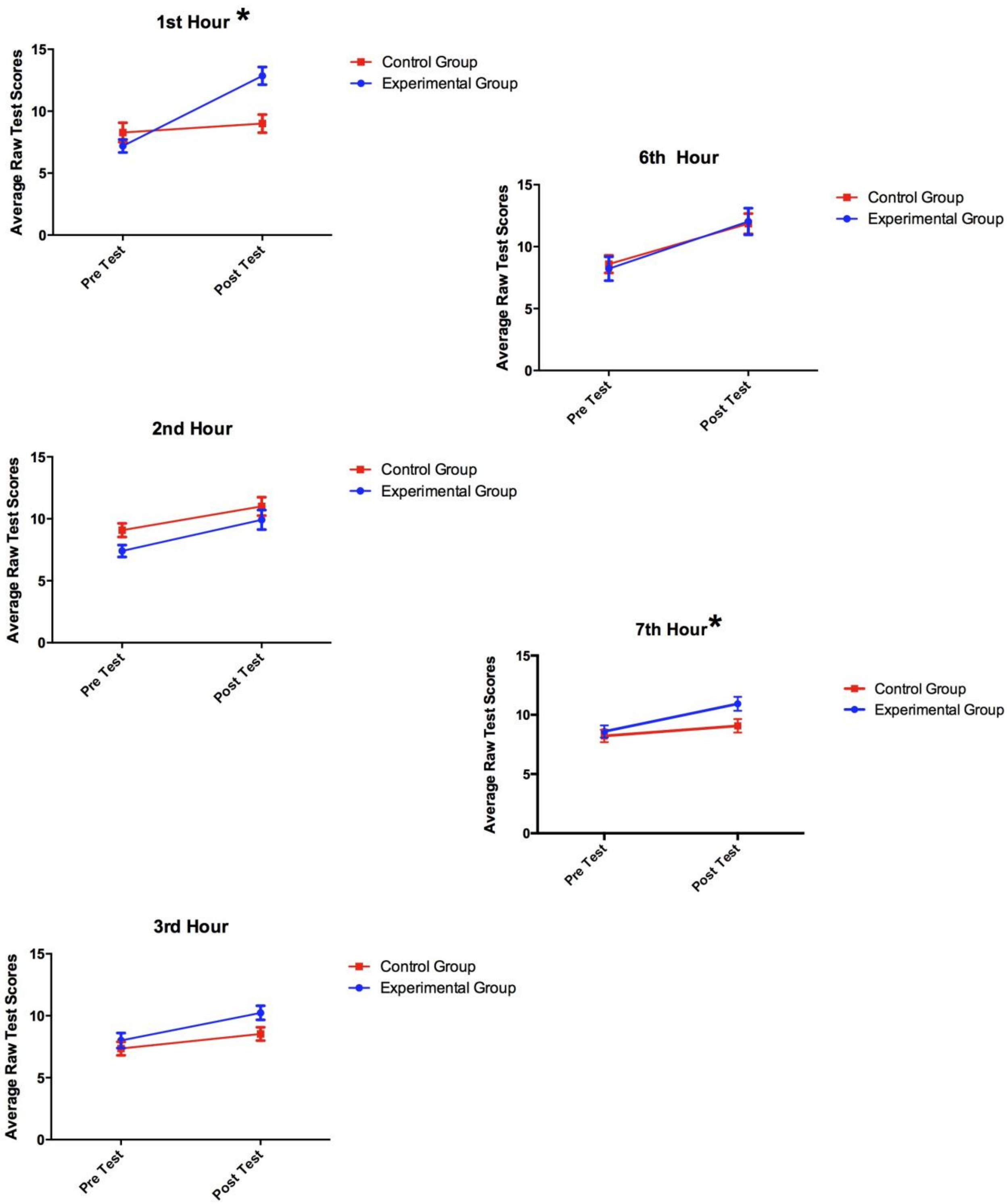


Figure 4: Average raw pre-test and post-test scores by individual class. First hour and seventh hour classes show a significant difference in post-test scores. Second, third, and sixth hour classes show no significant difference in post-test scores. Means and standard errors are shown.

Individual Class Mean Learning Gain

The average learning gains by percent of each class period were compared based on teaching styles (Figure 5). The percent mean learning gain for students in the first period class taught using peer instruction (24.79 ± 2.79) versus traditional teaching methods (1.38 ± 2.11) was extremely significantly different. The results of the paired non-parametric ANOVA, called the Wilcoxon matched pairs test, show a p value less than 0.001 (Figure 5). In the second class period, there was no significant difference between the percent learning gains between peer instruction (7.68 ± 1.93) and traditional teaching methods (9.99 ± 2.43), as shown with a p value of 0.4475 (Figure 5). The percent learning gain for peer instruction (9.747 ± 2.24) was not shown to be significantly different from traditional teaching (3.00 ± 2.26) in the third period class (P =0.1046, Figure 5). There was no significant difference in the sixth period class taught with peer instruction (10.93 ± 3.18) and traditional methods (15.75 ± 3.03) (P= 0.2970, Figure 5). In the seventh period class, there was a significant difference between the peer instruction teaching method (9.87 ± 3.16) and traditional method (2.26 ± 1.88) (P= 0.0089, Figure 5).

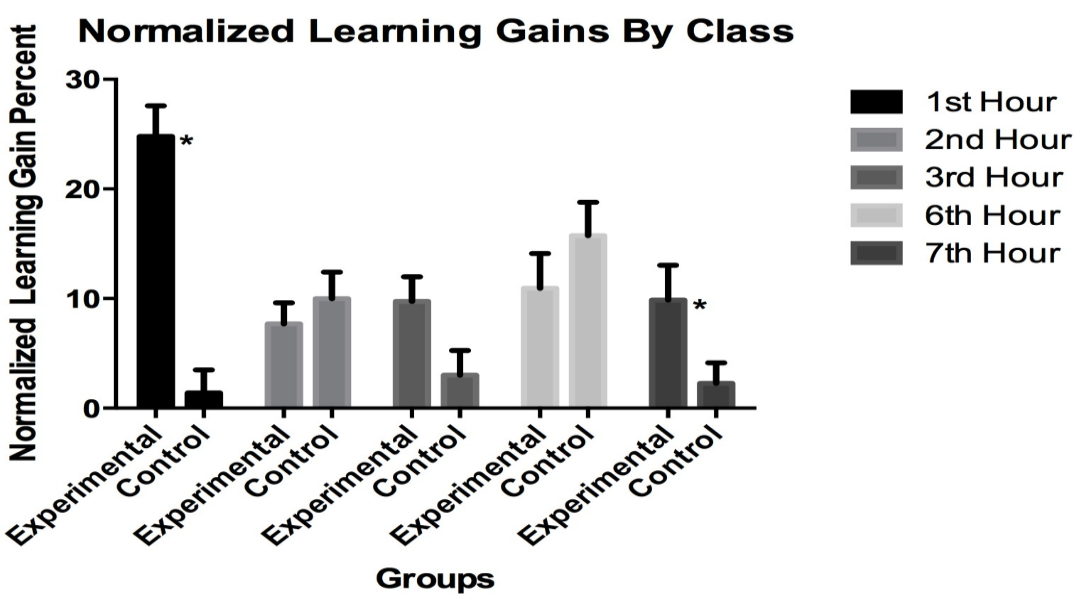


Figure 5: Normalized learning gains by class, as taught with peer instruction (experimental) and traditional (control) teaching methods.

Raw Test Scores by Concept Test

The average raw pre-test and post-test scores by concept test, using peer instruction and traditional teaching methods were compared using a Kruskal-Wallis test. There was no difference between the experimental pre-test score (7.98±0.32**)** and pre-test scores for the control group (8.83 ± 0.45) for the FCI (Table 9, Figure 6). There was also no difference between the experimental post-test score (11.37 ± 0.39) and the post-test score for the control group (11.44 ± 0.55) for the FCI (Table 9, Figure 6). Similarly, the experimental pre-test score (7.82 ± 0.55) did not differ from the pre-test score (8.02 ± 0.36) for the control group for the FMCE (Table 9, Figure 6). The experimental post-test score (11.02 ±0.68) was not different from the post-test score (8.91 ± 0.36) for the control group on the FMCE (Table 9, Figure 6).

Table 9: Summary of the comparisons made for the peer instruction (PI) vs. traditional instruction (T), and probabilities (P) by individual concept test.

Concept Test	Hours	Teaching Method	Comparisons	p value
FCI	1,3,7	PI	PI pre-test vs. T pre-test	> 0.05
	2,6	T	PI post-test vs. T post-test	> 0.05
FMCE	2,6	PI	PI pre-test vs. T pre-test	> 0.05
	1,3,7	T	PI post-test vs. T post-test	> 0.05

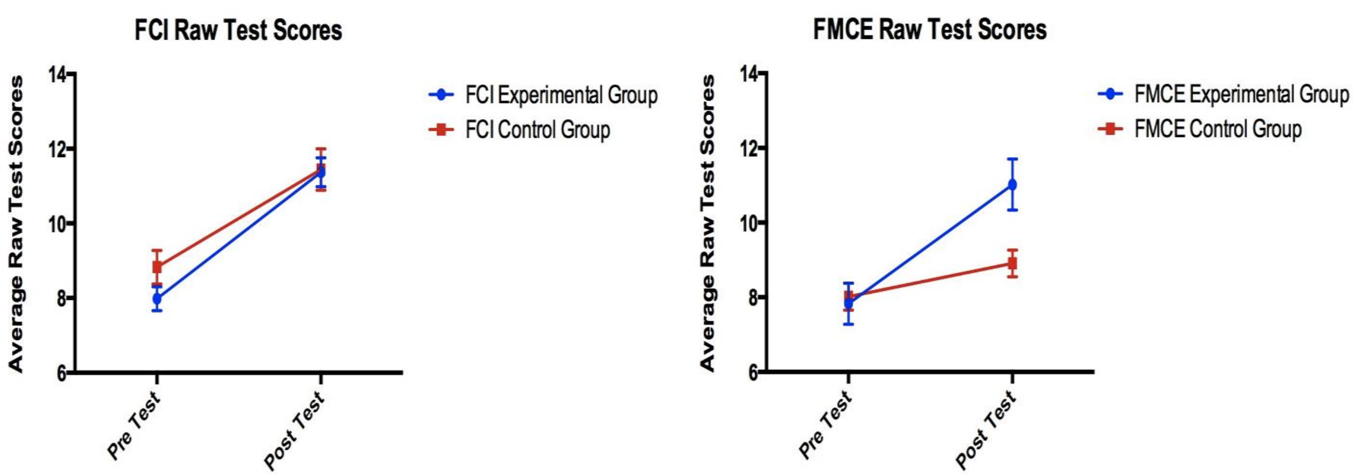


Figure 6: Average raw pre-test and post-test scores by concept test. No significant differences in test scores detected. Means and standard errors are shown.

Mean Learning Gain by Concept Test

The average learning gains by percent on each concept test were compared based on teaching styles (Figure 7). The percent mean learning gain for students on the FCI taught using peer instruction (14.66 ± 1.89) versus traditional teaching methods (12.81 ± 1.99) was not significantly different. The results of the unpaired non-parametric test, called the Mann-Whitney test, show a p value of 0.3356 (Figure 7). On the FMCE, normalized learning gains differed between peer instruction (9.33 ± 1.89) and traditional (2.17 ± 1.18) teaching methods, as shown with a p value of 0.0008, (Figure 7).

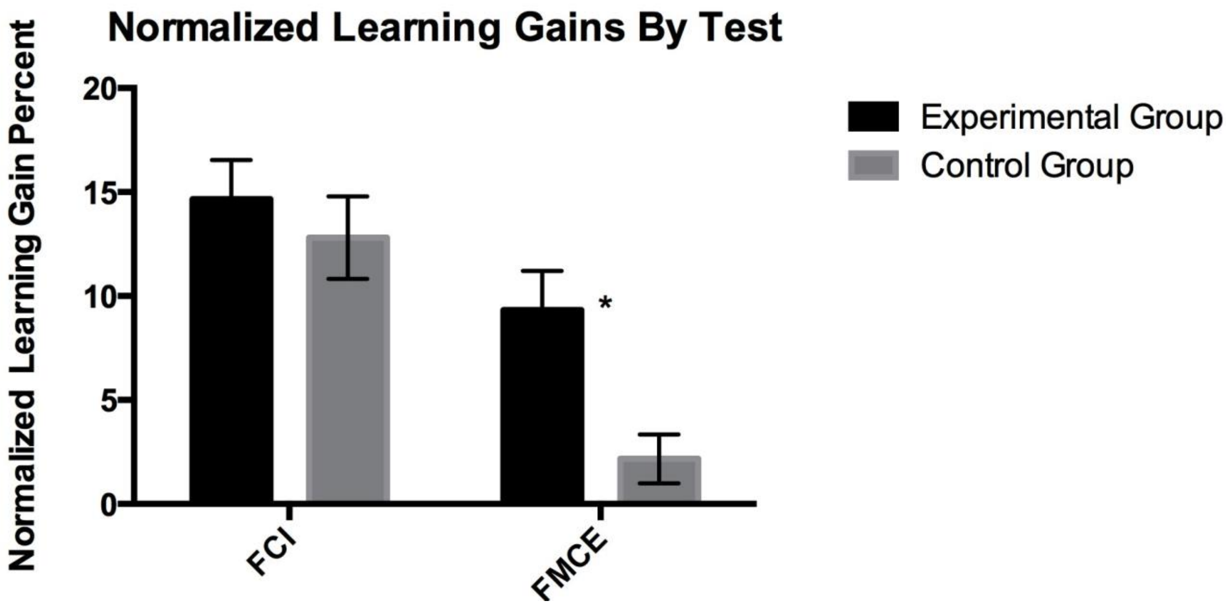


Figure 7: Normalized learning gains by concept test, as taught with peer instruction (experimental) and traditional (control) teaching methods.

Student Feedback

Of the 117 students whose data were included in this study, 93 students took a teacher made survey to determine student interest level of peer instruction versus traditional methods. Overwhelmingly, 92% of the students preferred peer instruction teaching methods to traditional teaching methods. More importantly, 88% also indicated that peer instruction made class more active and therefore more difficult to “zone out,” like in a traditionally taught lecture. Furthermore, when students were asked if they wanted more teachers to use peer instruction, 88% responded that they would prefer more peer instruction used in other classes, 1% said they did not wish it were used more, and 11% reported that it did not matter whether peer instruction was used by more teachers (Figure 8).

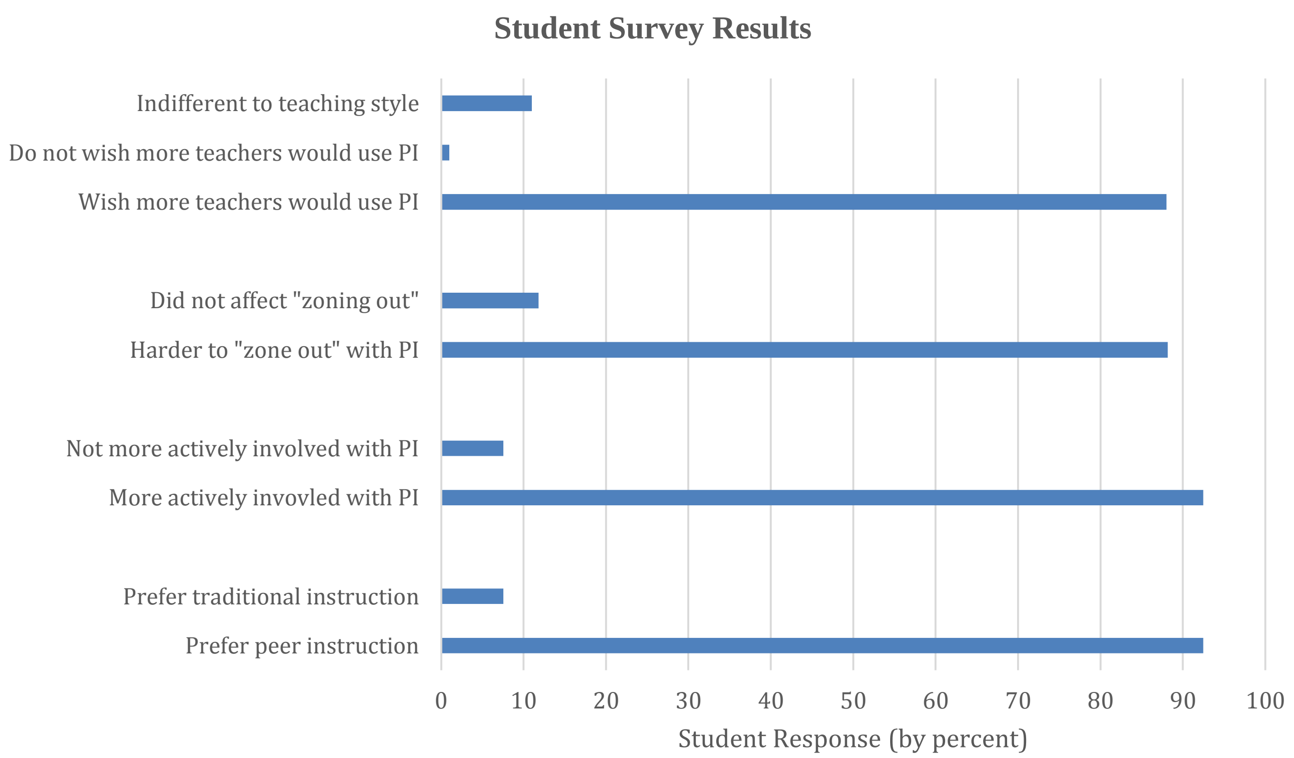


Figure 8: Student survey results of interest in peer instruction versus traditional teaching methods. Students were given the option of yes or no to each of the questions listed, with the exception of preference of more teachers using peer instruction. Response choice regarding preference of more teachers using peer instruction included “I wish more of my teachers would use peer instruction, I do not wish more of my teachers would use peer instruction, and it does not matter to me if more of my teachers use peer instruction.”

Students were also asked about which aspects of peer instruction they enjoyed. In this portion of the survey, students were allowed to choose more than one option for which portion of peer instruction they enjoyed. Of the students who took the survey, 94% reported that they enjoyed interacting with their classmates during peer instruction, 88% like having the teacher explain why each answer choice was correct or incorrect, and 86% of students liked being able to test their understanding of the topic right away. Interestingly, only 51% of students indicated that they liked that peer instruction was anonymous and 70% of students reported that they enjoyed using clickers (Figure 9).

Student Responses about Positive Aspects of Peer Instruction

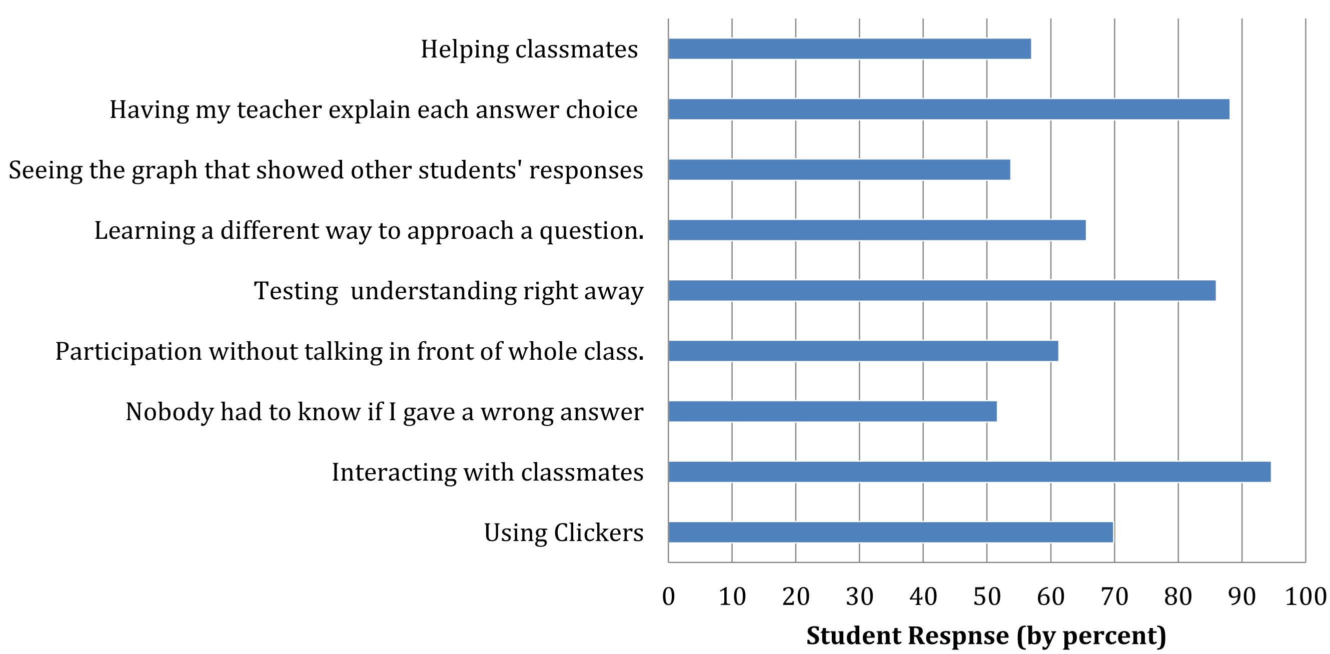


Figure 9: Student survey responses to the question of what they liked about peer instruction teaching methods. Students were able to select more than one preference. 93 students participated in this survey with 584 various choices indicated for this question.

The 93 students who took the interest survey were also questioned about the perceived benefits of peer instruction. Students could choose more than one answer for this survey question. The list of perceived benefit choices were created based on informal feedback from students both in and out of class. If students did not

perceive a benefit, they did not have to answer the question. Students were able to make additional comments in a free response section of the survey. No negative comments regarding peer instruction made. Of the students, 92% said they were able to see if they understood the topic of discussion immediately, and 78% of students reported that peer instruction allowed them to gain confidence in their understanding of the lesson. Interestingly, while 73% of students indicated that peer instruction allowed them to see how questions could be asked on a topic, only 59% reported seeing better grades on quizzes and tests. The least chosen perceived benefit, making connections to other topics, was only indicated 48% of the time. Learning how to argue appropriately was selected 72% of the time, and the same percentage of students felt that they had better long-term retention of knowledge (Figure 10).

One student, from the third period class that showed no statistical difference in peer instruction and traditional teaching method, stated the following in the additional comments section of the survey;

> I would like to recommend other teachers to use peer instruction vs. traditional learning because there is an automatic difference in how students answer questions and grasp the information being taught to them. It helps students get involved in what they learn as well. Before peer instruction I would make low grades on test and quizzes, but as of today I am up to a C average due to peer instruction.

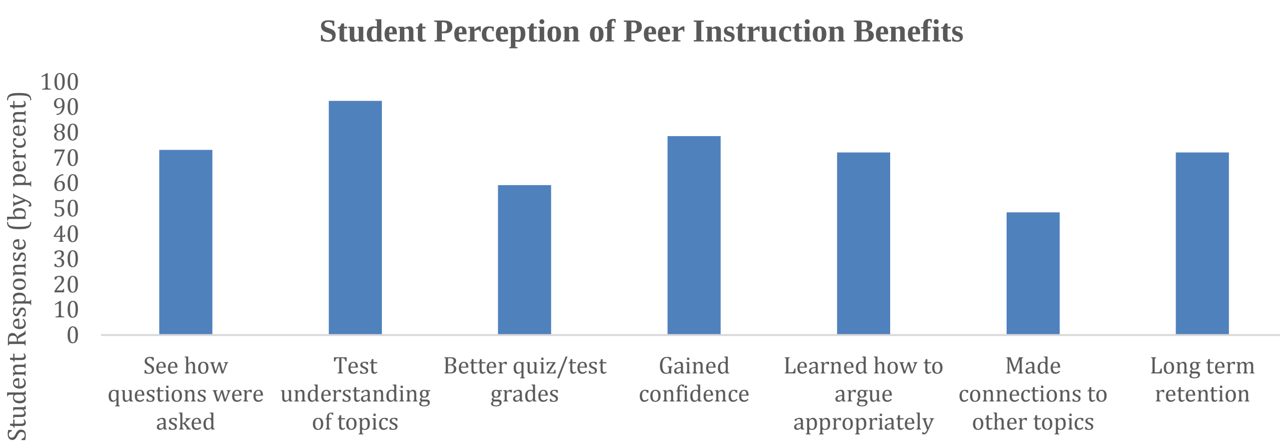


Figure 10: Student perceived benefit of peer instruction. In the survey, students were able to indicate more than one choice. 93 students participated in this portion of the survey and 461 choices were selected.

DISCUSSION

Physics education primarily uses lecture based teaching methods; yet physics is a course that many students struggle to succeed in. This study was performed to determine whether the instructional strategy of peer instruction affected learner outcomes more than traditional teaching methods in a 9^{th} grade physical science class. A comparison was made of the results obtained using traditional teaching methods and peer instruction in the physics topics of motion and forces.

Overall, there was a significant difference in the post-test scores between the peer instruction teaching method and traditional teaching method (Figure 2) and the normalized learning between the two teaching methods (Figure 3). In this study a 12.3 ± 1.36% learning gain occurred, which falls below the national average learning gains (39±9%) reported by Fagen, et al., 2002. Although the results from the current study are below the published national average of learning gains, it is important to note that instructors at 11 different colleges and universities provided the national average data. There was no high school data included. The difference in learning gains from the current study to the national average learning gains could be from a range of factors. That survey of peer instructors has quantitative responses only from post-secondary educators (Fagen, et al., 2002). The amounts of time spent on the topic by those instructors may differ significantly from the time available in the high school classroom. Students in college, and those entering into high school have different levels of knowledge and academic maturity and may not respond to peer instruction in the same manner. In addition, the college students represent a more select and perhaps more highly motivated group of students. Gains of 63% for algebra based physics students, and 74% for calculus based physics students on the FCI were reported in a similar study at Harvard University (Crouch and Mazur, 2001). While the Harvard study showed much greater gains than the present study, the instructors reporting such high learning gains had more practice utilizing the technique and refining their lessons to reflect the benefits of peer instruction. The assignments, along with peer instruction, have had the chance to adapt as students assimilate more information through class discussion (Crouch and Mazur, 2001).

Additionally the Harvard students were a highly selected population of students. Although the 9th grade students in the present study are in the honors science program, typically half of the students drop from this program as they transition to tenth grade. The students in the present study, while nominally honors students, were not truly as highly achieving a population as students at the collegiate level.

Interestingly, when the data were broken up to compare the effect of peer instruction on learning gains of the FCI and the FMCE, only the FMCE showed any significant difference in learning gain (Figure 7). This could have been due to the FMCE being used as the second concept test and, while it does focus more on the forces behind motion, students have naturally reviewed motion concepts from the first unit. Conceivably, students could have increased conceptual understanding of motion concepts because they better understood the cause of the motion, which would allow them to better understand motion concepts. For example, the graphing motion concepts that were present in the first unit of study may not have been mastered until a laboratory activity studying forces, the second unit of study. In the activity, students were required to draw graphs of motions based on differing forces, giving them a reinforcement of a motion concept in the forces unit. This means that prior to the second unit of instruction, when taking the FMCE pre-test students could have gotten motion specific FMCE test items incorrect and gotten the same questions correct on the FMCE post-test, thus showing a great increase in knowledge. It would be interesting to repeat this study, but switch which concept test is used for the motion and then force unit to see if similar results were achieved. Also, because this was the second unit of instruction, the teacher may have been more skilled at using the peer instruction technique, allowing for greater gains with the second concept test used, the FMCE.

While the pre-test and post-test scores and learning gains did not differ between traditional and peer instruction methods for the second, third and sixth hour classes, there were significant differences in the outcomes of these teaching methods for the first and seventh hour classes (Figure 4). Nonetheless, students overwhelmingly indicated a preference for peer instruction in comparison with traditional teaching methods

(Figure 8). The lack of a detectable effect of peer instruction for the second and sixth hour classes may be attributed to several factors. Factors such as school calendar, absenteeism, and make up classes could have affected the overall test scores and learning gains. Two of the class periods in which there was no difference were in the control group for the first unit of instruction, kinematics. These classes received the peer instruction method in the second unit of study, which was later in the school year. Due to the necessity to complete the state prescribe curriculum to prepare students to take a standardized End of Course test, limited the time spent on topic overall and the time spent in peer discussion each day. The students would be tested and expected to achieve a certain level of performance on the non-teacher created End of Course test, so the time available to truly complete peer instruction in the same manner as the first unit was severely limited. Secondly, the second and sixth hour classes were comprised of the top students in the science program. Of the total students (23) who made a 93% A or better in the class for a semester, 65% (15/23) came from two of the classes that did not show significant learning gain. Furthermore, 69% (9/13) students that earned a 95% A or higher without any bonus, which is the determining factor for final exam exemptions, also came from the second and sixth hour classes. It is plausible that students in these classes either passively deferred to a stronger students' answer choice, or responded with another student's answer choice (James and Willoughby, 2010). It is possible that students who were unsure of answer choices would defer to more confident students, or students they had deemed "the smart kids" on the in class clicker questions, but refer back to their original thought processes on the post-test. While no data

The lack of detectable differences in the scores for peer instruction and traditional instruction for the third hour science class could have been influenced by the same factors as the other two classes. In addition this was the only section of regular level students in the study. While fundamentally capable of making the same grades, and therefore the same learning gains as the honors classes, they are admittedly not as motivated to study and do well. A previous study in the different learning approaches of advanced and regular level

students gives credence to lower motivation levels, and therefore learning gains of regular level students (Knight and Smith, 2010). Regular level students are the high schools equivalent of non-majors students, and as such are less likely to listen to each other when in peer discussion (Smith, et al, 2010). In general, the overall attitude of the regular students in the third hour class and the honors students in the other four classes in this study even made a difference in students' approach to peer instruction during clicker questions (Knight and Smith, 2010). The regular students were more apt to simply find what they thought the right answer was, with little to no attention paid to the other answer choices or deeper discussion into why an answer was considered correct. The honors student, on the other hand, had a tendency to not only discuss why they felt an answer was correct, but why each choice was considered wrong as well.

Completing any form of educational research in an average high school setting makes finding discernable differences in teaching methods difficult. Factors, such as school calendar and standardized testing, are not factors that can be easily controlled for. Being cognizant of the school calendar when designing the study would certainly help to control time on topic for each unit of study. Also, running the study over more than two units of instruction would allow for more data points to be taken, thus decreasing factors that may have affected the study. More importantly, while the students are the focus of the study, they also add additional hurdles to completing a successful assessment of teaching methods. The most effective teachers understand that they teach students before they teach a subject, and as such need to be flexible in the lessons that they teach. Each year, a different set of students enters the classroom and with them comes a different level of understanding and achievement. Even within a set of students, different classes may have different needs that should be met. The regular class in this study, for example, had a much weaker mathematical background, which meant that more time needed to be taken on any concepts that required math skills. This meant understanding how to set up the embedded clicker questions so few math skills were required in order to truly test if the students understood the concepts, rather than getting stuck in trying to do math problems.

While there are many minor variations in which peer instruction can take place, the teacher needs to ensure consistency across class periods by pre-determining certain factors. For example, the teacher should look at each clicker question to decide exactly what teacher explanation or example would be used to describe the correct answer, or which questions, if any, could be used to call upon student groups to explain. Setting a time limit and using a visible timer for peer discussion would also assist in consistency for the study. Each clicker question would need to be studied prior to instruction to determine the length of time required for discussion. By using a countdown timer, the students would have a visual cue to know when to end discussion, providing a smooth transition and less loss of instructional time overall. The timer also serves the purpose of making students feel pressured to stay on task, with less off topic discussion occurring. Additionally, taking the time to teach the students how to complete peer discussion in a time efficient manner by practicing peer instruction prior to actual data collection would decrease the chances of students deferring to others. By practicing, the students have learned the ability to critically analyze the clicker questions presented and become more likely to actively participate in discussion and defend their choice. Also, the teacher should monitor the class discussions and be aware of which group to call on, if any, to share how the correct answer was arrived at. In doing so, the teacher should also ensure that the group called upon fully describes the correct answer in a method called "right is right" (Lemov, 2010). In this method, the students are required to not only say what answer they chose, but explain why it is correct and why the other answer choices are wrong. Practicing these processes serves the purpose of maintaining time management, but also gives the students a chance to practice the critical thinking skills that should be used on pre-test and post-tests used for data collection. Having students who are adept at critical thinking while test taking would mean that the test scores recorded are more likely to be a representation of knowledge, and less that of guessing the right answer.

A variety of useful topics arose for further study because of the results of this study. With male students showing a greater achievement in physics course (Cavallo, et al., 2010), a study into the efficacy of peer instruction between genders could be done. While previously shown to have no effect on closing the achievement gap between genders at the collegiate level (Pollack, et al., 2007), a study into the effects of peer instruction at the high school level may yield different results. Similarly, with an achievement gap existing between students of different races (Ball and Alvarez, 2004), a further study could focus on the effects of peer instruction on students of different races. While the size of a class has not been shown to have an impact on student test scores (Kennedy and Siegfried, 1997), many teachers will say that managing a smaller class is easier. Because of the ability to better manage a smaller class, the peer instruction technique may show a larger impact on students of smaller class sizes due to the teacher being better able to facilitate peer instruction. Furthermore, peer instruction is a very specific form of cooperative learning, and as such should be compared to other forms of cooperative learning to determine if the learning gains achieved are due to peer instruction itself, or to other aspects of cooperative learning. There have been studies comparing other cooperative learning strategies (Johnson, et al., 2000), but little research exists comparing peer instruction and other aspects of cooperative learning.

In education, many factors can affect the learning gains of students, none, arguably, impact student achievement as greatly as interest and engagement in a lesson. When a student is disengaged from a lesson, they will have a more difficult time absorbing concepts and retaining them long term., let alone long enough to study the same night. Students in this study were given a student survey regarding their experience with peer instruction. A student in the regular level, third hour class had the following comments about peer instruction as a whole:

> I loved peer instructions because it allowed me to be more active in my class instead of just zoning out every 5 minutes. Peer instructions helped me learn topics faster than traditional learning. For example, my teacher for world geography does traditional learning and when I went home I never remembered what I learned that day. When I do peer instruction in

> science class I would remember everything and I also understood topics I would need more help on. Also, peer instruction allowed me to talk to my peers without being in trouble or taking my attention away from learning and to find ways on how to discuss topics without getting in arguments on who is right.

Despite being in a class that showed no detectable difference in post-test scores between peer instruction and traditional methods, the student quoted above clearly prefers peer instruction and understands the positive impact it has on the classroom environment. As reported in the interest survey, students from all classes reported more engagement in a lesson taught using peer instruction, as opposed to traditional teaching methods (Figure 8). The increase in student interest combined with the significant learning gains demonstrated in this study indicate that peer instruction is a viable tool in achieving learning gains with high school students.

SUMMARY AND CONCLUSION

The present study tested the effectiveness of peer instruction in comparison to traditional teaching methods in student understanding of motion (kinematics) and forces (dynamics). The results indicated a positive impact of peer instruction compared to traditional methods when overall post-test scores and normalized gains were compared (Table 7, Figure 2, 3). In examining individual classes, only two of the five classes had different post-test scores (Figure 4), and normalized gains (Figure 5) between the peer instruction and traditional instruction methods. Peer instruction was at least as effective traditional lecture instruction. Although there was not a clear positive advantage in learning outcomes of peer instruction over traditional teaching in all of the classes, the students self-reported a preference for peer instruction and a desire to see the method used in more classes. As the study progressed, the students showed more confidence in their knowledge and became better at using evidence to support their answer choices. This study should encourage more teachers to use peer instruction, in the form of lecture embedded clicker questions, as a tool for instruction. While clicker questions are not the only form of group learning, it allows a formerly boring lesson to become more alive and students more active in the learning process.

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APPENDIX A
EXAMPLE MATCHED PAIR CLICKER QUESTIONS

Original Question:

Supposing a snowmobile is equipped with a flare launcher that is capable of launching a sphere vertically (relative to the snowmobile). If the snowmobile is in motion and launches the flare and maintains a constant horizontal velocity after the launch, then where will the flare land (neglect air resistance)?

a. in front of the snowmobile

b. behind the snowmobile

c. in the snowmobile

Matched Pair Question:

Suppose a rescue airplane drops a relief package while it is moving with a constant horizontal speed at an elevated height. Assuming that air resistance is negligible, where will the relief package land relative to the plane?

a. below the plane and behind it.

b. directly below the plane

c. below the plane and ahead of it

APPENDIX B
GUARDIAN CONSENT FORM

Parental Permission Form

Project Title: The Effects of Peer Instruction on Students' Conceptual Understanding of Forces and Motion.

Performance Site: Zachary High School

Investigators: Nicole Harvey

Purpose of the Study: The purpose of this research project is to develop an effective active learning strategy that can be used, even in a lecture-based classroom.

Inclusion Criteria: Students in a basic Ninth Grade Physical Science classroom.

Exclusion Criteria: Students not in Physical Science

Description of the Study:

Over the period of time in which two units of study, Motion (Kinematics) and Forces, are studied, the instructor will present lesson based in concepts. Students understanding will be measured with matching pre and posttests that will be solely used for information purposes and will not be figured into the overall grade for the class. The students will take notes from a traditional PowerPoint note format, but will be provided with clickers that will allow them to answer concept-based questions periodically throughout the lessons. At instructed times, the students will be allowed to collaborate with their neighbors over what the correct answers are and why before being allowed to re-answer the same question, as well as individually answer a similar question to reinforce concept knowledge. Each concept will also have other various reinforcement activities in the forms of group work, laboratory activities, and projects, as the instructor sees fit.

The benefit of this study will be the immediate reinforcement of student understanding, along with the ability to earn daily participation points for effort in answering questions. This will allow both the student and instructor to immediately know if a misconception occurs to be fixed before actual grades are assigned.

There are no known risks to this study.

Right to Refuse: Participation is voluntary, and a child will become part of the study only if both child and parent agree to the child's participation. At any time, either the subject may withdraw from the study or the subject's parent may withdraw the subject from the study without penalty or loss of any benefit to which they might otherwise be entitled.

Privacy: Investigators may review the pre and posttest scores of participants in this study. Results of the study may be published, but no names or identifying information will be included for publication. Subject identity will remain confidential unless law requires disclosure.

Financial Information: There is no cost for participation in the study, nor is there any compensation to the subjects for participation.

Signatures:

The study has been discussed with me and all my questions have been answered. I may direct additional questions regarding study specifics to the investigator. If I have questions about subjects' rights or other concerns, I can contact Robert C. Mathews, Chairman, Institutional Review Board, (225) 578-8692, irb@lsu.edu, www.lsu.edu/irb.

I will allow my child to participate in the study described above and acknowledge the investigator's obligation to provide me with a signed copy of this consent form.

Parent's Signature:________________________________ Date:____________________

The parent/guardian has indicated to me that he/she is unable to read. I certify that I have read this consent from to the parent/guardian and explained that by completing the signature line above he/she has given permission for the child to participate in the study.

Signature of Reader:________________________________ Date:____________________

Nicole Harvey, Science Teacher
Zachary High School
Zachary, LA 70791
P: 225.654.2776

APPENDIX C
STUDENT ASSENT FORM

Student Assent Form

I,__________________________________, agree to be in a study to find ways to help students better learn and retain knowledge. I will have to do normal school work in my classroom, without extra outside work being added. I have to follow all the classroom rules, and will follow the instructions as outlined by my teacher. I can decide to stop being in the study at any time without getting in trouble.

Child's Signature:______________________________ Age:______ Date:_____________

Witness* ____________________________________ Date:___________________

- (N.B. Witness must be present for the assent process, not just the signature by the minor.)

APPENDIX D
IRB APPROVAL FORM

Application for Exemption from Institutional Oversight

Unless qualified as meeting the specific criteria for exemption from Institutional Review Board (IRB) oversight, ALL LSU research/ projects using living humans as subjects, or samples, or data obtained from humans, directly or indirectly, with or without their consent, must be approved or exempted in advance by the LSU IRB. This Form helps the PI determine if a project may be exempted, and is used to request an exemption.

LSU
Institutional Review Board
Dr. Robert Mathews, Chair
131 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.6792
irb@lsu.edu
lsu.edu/irb

-- Applicant,Please fill out the application in its entirety and include the completed application as well as parts A-E, listed below, when submitting to the IRB. Once the application is completed, please submit two copies of the completed application to the IRB Office or to a member of the Human Subjects Screening Committee. Members of this committee can be found at http://research.lsu.edu/CompliancePoliciesProcedures/InstitutionalReviewBoard%28IRB%29/item24737.html

-- A Complete Application Includes All of the Following:
(A) Two copies of this completed form and two copies of part B thru E.
(B) A brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts 1&2)
(C) Copies of all instruments to be used.
*If this proposal is part of a grant proposal, include a copy of the proposal and all recruitment material.
(D) The consent form that you will use in the study (see part 3 for more information.)
(E) Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project, including students who are involved with testing or handling data, unless already on file with the IRB. Training link: (http://phrp.nihtraining.com/users/login.php)
(F) IRB Security of Data Agreement: (http://research.lsu.edu/files/item26774.pdf)

1) Principal Investigator: Joseph F. Siebenaller **Rank:** Professor

Dept: Biological Sciences **Ph:** 225-578-1746 **E-mail:** zojose@lsu.edu

2) Co Investigator(s): please include department, rank, phone and e-mail for each
*If student, please identify and name supervising professor in this space

Nicole Harvey, Biological Sciences, Graduate Student - LaMSTI, MNS Program
Science Teacher, Zachary High School
225.654.2776 nicole.harvey@zacharyschools.org
Dr. Joseph F. Seibenaller is the supervising professor.

IRB# E6006 LSU Proposal #
✓ Complete Application
✓ Human Subjects Training

3) Project Title: The Effectiveness of Peer Instruction on Students' Conceptual Understanding of Motion and Forces

Study Exempted By:
Dr. Robert C. Mathews, Chairman
Institutional Review Board
Louisiana State University
203 B-1 David Boyd Hall
225-578-8692 | www.lsu.edu/irb
Exemption Expires: 6/24/2015

4) Proposal? (yes or no) No **If Yes, LSU Proposal Number**

Also, if YES, either
○ **This application completely matches the scope of work in the grant**
OR
○ **More IRB Applications will be filed later**

5) Subject pool (e.g. Psychology students) High School Physical Science Students

*Circle any **"vulnerable populations" to be used:** (children <18; the mentally impaired, pregnant women, the ages, other). Projects with incarcerated persons cannot be exempted.

6) PI Signature [signature] **Date** 1 June 2012 (no per signatures)

** **I certify my responses are accurate and complete.** If the project scope or design is later changes, I will resubmit for review. I will obtain written approval from the Authorized Representative of all non-LSU institutions in which the study is conducted. I also understand that it is my responsibility to maintain copies of all consent forms at LSU for three years after completion of the study. If I leave LSU before that time the consent forms should be preserved in the Departmental Office.

Screening Committee Action: Exempted ✓ Not Exempted ____ Category/Paragraph 1

Reviewer Mathews **Signature** [signature] **Date** 6/25/12

VITA

Nicole Congine Harvey was born in Crystal Lake, IL in January 1981. She attended school in districts 47 and 155 before she graduated with honors from Crystal Lake Central High School in Crystal Lake, IL in June 1999. The following August Nicole entered McHenry County College and in May 2001 earned an Associate of Science degree before transferring to Louisiana State University Agricultural and Mechanical College in August, 2001. She earned the degree of Bachelor of Science from Louisiana State University Agricultural and Mechanical College in December 2003. Nicole entered Louisiana State University Agricultural and Mechanical College in June 2011 and is a candidate for the Master of Natural Science. She is currently teaching at Zachary High School in Zachary, Louisiana.