AC 2008-2083: PRELIMINARY RESULTS OF USING PERSONAL RESPONSE SYSTEMS (CLICKERS) IN A CONCEPTUAL PHYSICS COURSE

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Preliminary Results of Using Personal Response Systems (clickers) in a Conceptual Physics Course

We report the results of a study investigating the effectiveness of using a Personal Response System (clickers) in a conceptual physics course for non-science majors. In order to determine their effectiveness, clickers were used while teaching some concepts and not used while teaching others. We used the Force Concepts Inventory (FCI) as a pre-test and post-test to measure learning gains because most of the questions on the FCI test only one concept. By comparing learning gains for those concepts taught using the clickers with those taught without using them, the effectiveness of clickers in this type course was inferred. We found a statistically significant difference in the pre-test and post-test means for the sets of questions on the FCI that tested the concepts taught using the clickers, while no significant difference was found for the sets of questions that tested the concepts taught without using the clickers. This suggests that using clickers in a course like this does indeed improve learning.

I. Introduction

Personal Response Systems (clickers) have been shown to improve learning in various classroom settings when effectively used.[1] After being prompted by a textbook sales representative to try them, I incorporated use of clickers into my conceptual physics course because I already used various methods to encourage student engagement in my classroom,[2] and this seemed like a good method as well. After incorporating clickers into my instruction and using them for two semesters, I began to wonder whether or not they were having a positive effect on learning in my conceptual physics classroom. They were certainly facilitating students' engagement with the concepts being taught, and anecdotal evidence suggested that they were improving learning, but I wanted more concrete evidence in order to justify the cost of the clickers for students. The Center for the Scholarship of Teaching and Learning at our institution offers assistance and small grants to faculty to study how their pedagogy is linked to learning. I was awarded one of those grants, called the Scholarship of Teaching and Learning (SoTL) grant, and became a SoTL Fellow. This study was designed to answer my question quantitatively.

Many institutions teach a conceptual physics course for non-science majors that students may take to fulfill their general education requirement in physical science. The textbook we use is *Conceptual Physics* by Paul Hewitt, although there are several textbooks available for this type of course. At our university, few academic majors require this course, so most students take it because it fits their schedule rather than because they must or because they are interested in physics. In addition, only one section of the course is taught each semester in large lecture format with from 60 to 80 students in lecture. It is always a challenge in large lecture courses to get students to genuinely engage the content of a class session, but this is especially true for a course like this where student interest and motivation are relatively low. Adding to the challenge is the fact that the chairs in the lecture hall are fixed to the floor, so group interaction is very difficult. The purposes of using the clickers are to facilitate student engagement with the concepts being discussed in a more active way than does simply listening or taking notes and to provide feedback to the instructor on whether or not more time needs to be spent on particular concepts.

II. Methodology

During a typical session of this class, the clickers are used one to three times and in two distinct ways. First, at least one question is chosen before each class to use as a "clicker question." This may be over a concept from the previous class period or something from that day's class. Students are usually asked to answer the question on their own or occasionally after discussing it first with their neighbor. Students are given several choices for the answer that usually include "don't know" and "don't care." The distribution of answers that is displayed when time expires gives the instructor immediate feedback as to understanding of the concept. If the distribution of responses indicates that the majority of students understand the concept, students who chose a particular response are asked to explain their reasoning. The correct answer is then revealed by the instructor and briefly discussed. If the distribution of responses indicates that a significant fraction of the class does not understand the concept, students are given a brief time to discuss the question with their neighbor and then answer the question again. In most cases after this neighbor nudge, the distribution of responses indicates that the majority of students understand the concept. Again, before the correct answer is revealed and discussed, students choosing each response are asked to explain their reasoning.

The second way the clickers are used is in an ad hoc manner to engage students. Neither the timing nor the question is preplanned. The clickers simply serve as a way of shifting the energy in the classroom and reengaging students with the material under discussion. When the distribution of answers is displayed, the same procedures described above are used.

When the topics are taught without using clickers, similar teaching methods are used, except only a show of hands is requested so there is no quantitative feedback immediately provided other than what is gleaned by looking around. The level of activity when these topics are taught is similar to that when clickers are used, as are the other procedures described above such as using the neighbor nudge if the show of hands indicates it would be helpful.

Other active learning strategies are also used throughout the semester such as having students work in pairs on a short worksheet.

The FCI[3] was given on the second day of class and then again two weeks after the exam covering the pertinent topics. The choice of which topics to use clickers with and which topics not to was determined by looking at the FCI questions that cover each topic. On the FCI, questions 6, 7, 8, 10, 11, 17, 23, 24, and 25 test understanding of Newton's 1st Law, questions 8, 9, 21, 22, and 26 test understanding of Newton's 2nd Law, and questions 4, 15, 16, and 28 test understanding of Newton's 3rd Law.[4] Question 8 was excluded from our analysis since it covered both Newton's 1st and 2nd Laws. Newton's 1st Law was taught using clickers, Newton's 2nd Law was not, and Newton's 3rd law was.

III. Results and Discussion

For the Fall 2007 offering, the distribution of the percent of students answering questions correctly on the pre-test and post-test for each concept is shown in Figure 1. Here we see clear improvements in scores for Newton's 1st and 3rd Laws, which were taught using clickers, but none for Newton's 2nd Law. Figure 2 shows a comparison of the mean percent of questions answered correctly for each concept. The difference in the means for Newton's 1st Law and Newton's 3rd Law were significant ($p < 0.001$, paired t-test). No difference is observed for the means for Newton's 2nd Law.

Although not formally a part of the study, the FCI had been administered in the previous offering in Fall 2006, but the post-test had been administered about six weeks later in the semester. The course was taught in generally the same manner except that no effort was made to discriminate among concepts taught either using or not using clickers. Clickers were used pretty much throughout the course. Figure 3 shows the distribution of the percent of students answering questions correctly on the pre-test and post-test for each concept. Notice that like the results for Fall 2007, scores for Newton's 1st Law and Newton's 3rd Law showed improvement, while the scores for Newton's 2nd Law did not. Figure 4 shows a comparison of the mean percent of questions answered correctly for each concept. The difference in the means for Newton's 1st Law and Newton's 3rd Law were significant ($p < 0.001$, paired t-test). The difference in the means for Newton's 2nd Law was evident, but not significant.

IV. Conclusions

One obvious conclusion is that more emphasis needs to be placed on Newton's 2nd Law in teaching this course. In addition, the data seems to indicate that learning concepts is improved from using the clickers. In order to further study this and strengthen this conclusion, next fall the concepts taught with and without clickers will be reversed to see if the same results obtain.

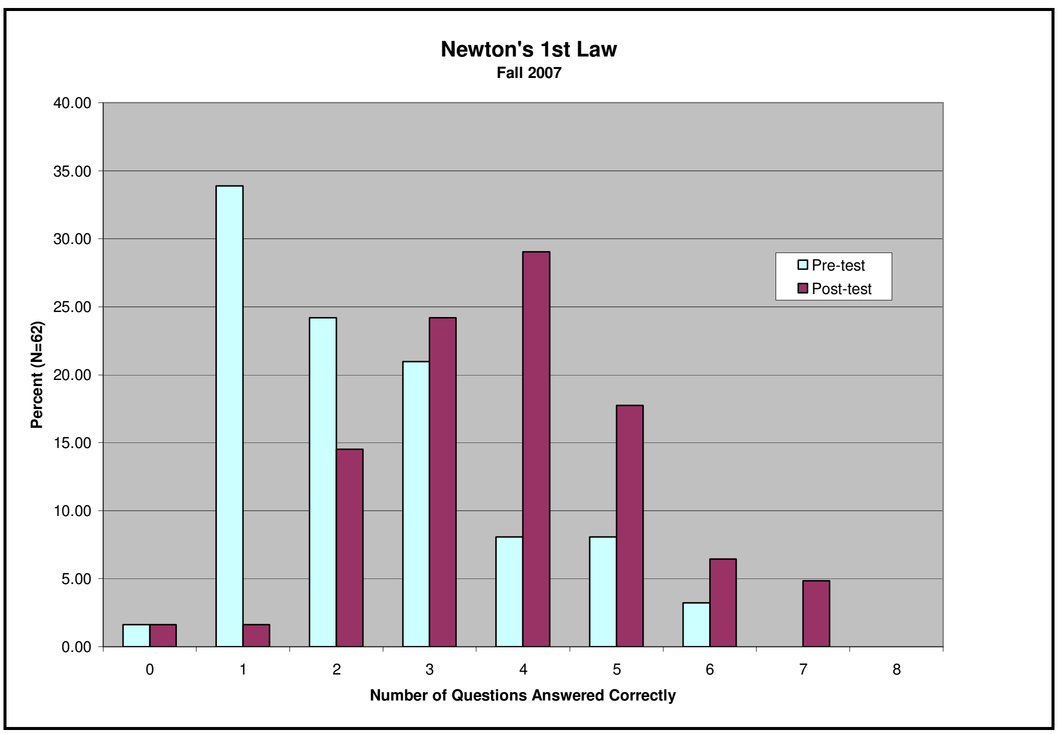

Figure 1a. The distribution of the percent of students answering questions correctly on the pre-test and post-test for Newton's 1st Law (N=62).

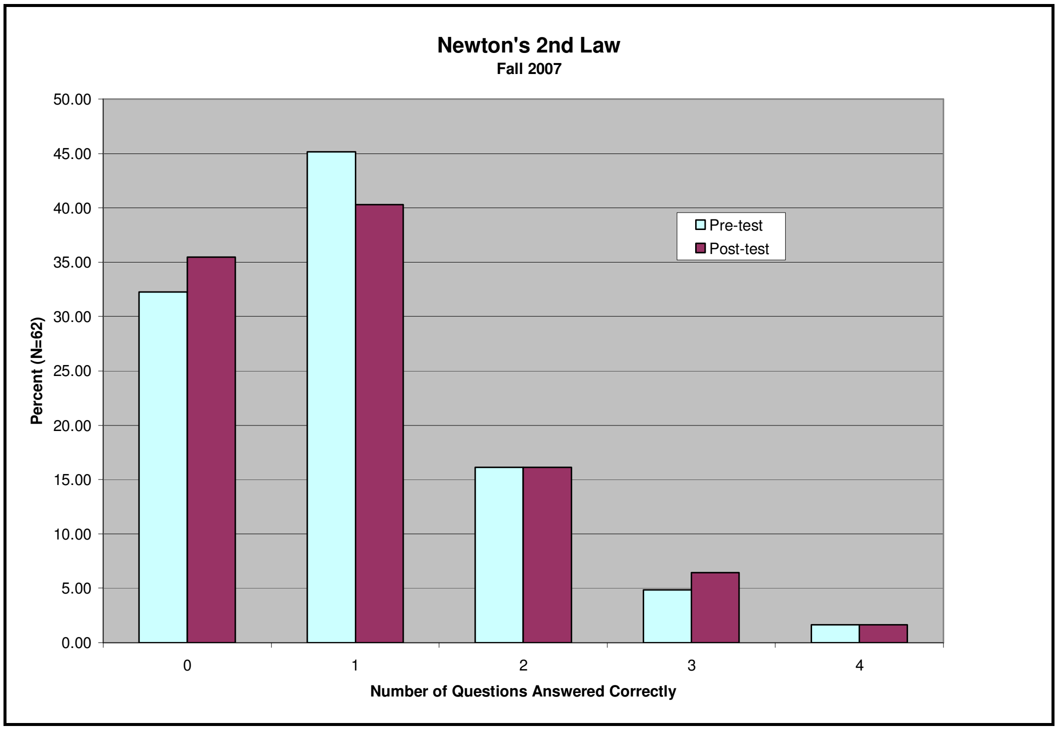

Figure 1b. The distribution of the percent of students answering questions correctly on the pre-test and post-test for Newton's 2[nd] Law (N=62).

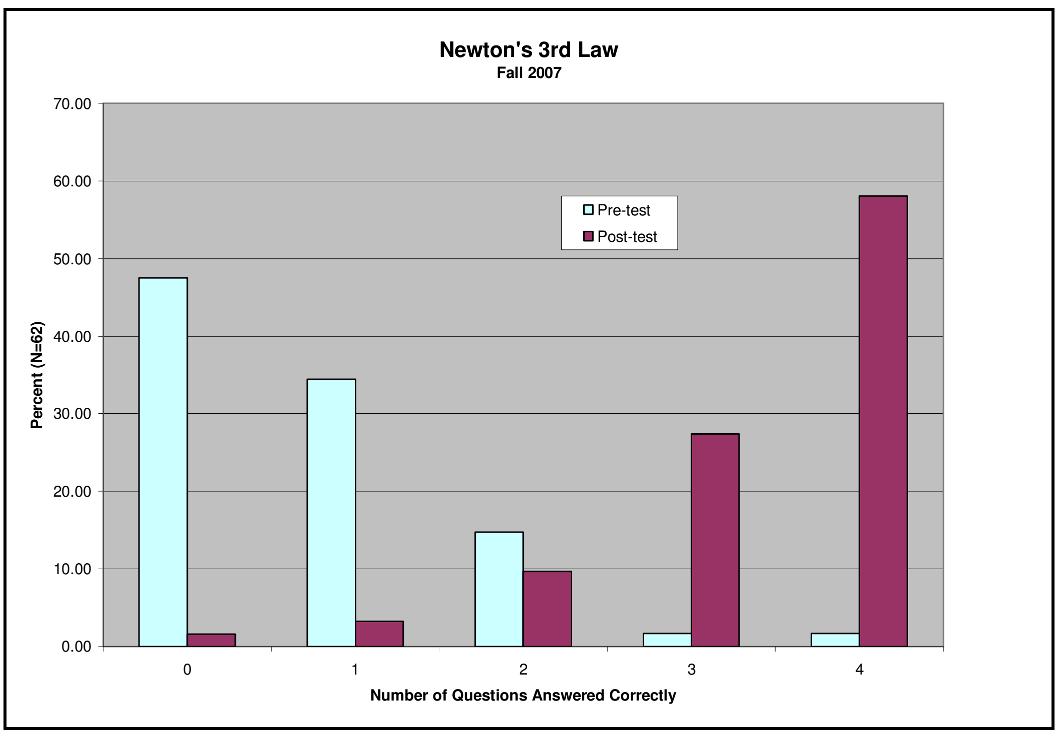

Figure 1c. The distribution of the percent of students answering questions correctly on the pre-test and post-test for Newton's 3[rd] Law (N=62).

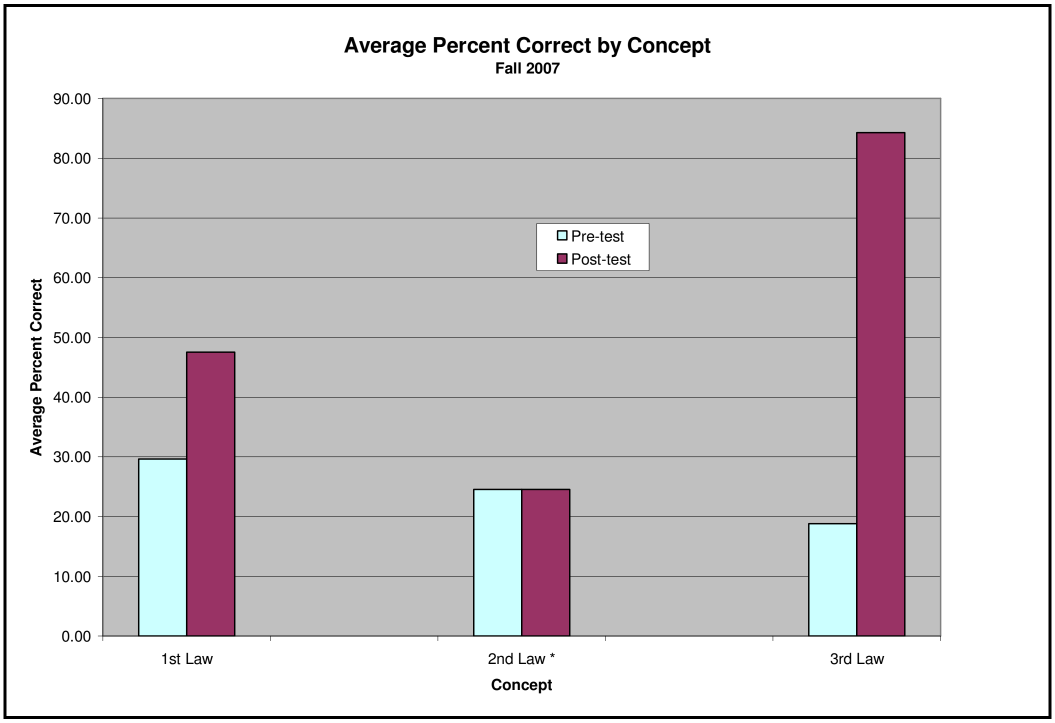

Figure 2. Comparison of the mean percent of questions answered correctly for each concept. The difference in the means for Newton's 1st Law and Newton's 3rd Law were significant ($p < 0.001$, paired t-test). No difference was observed for the means for Newton's 2nd Law.

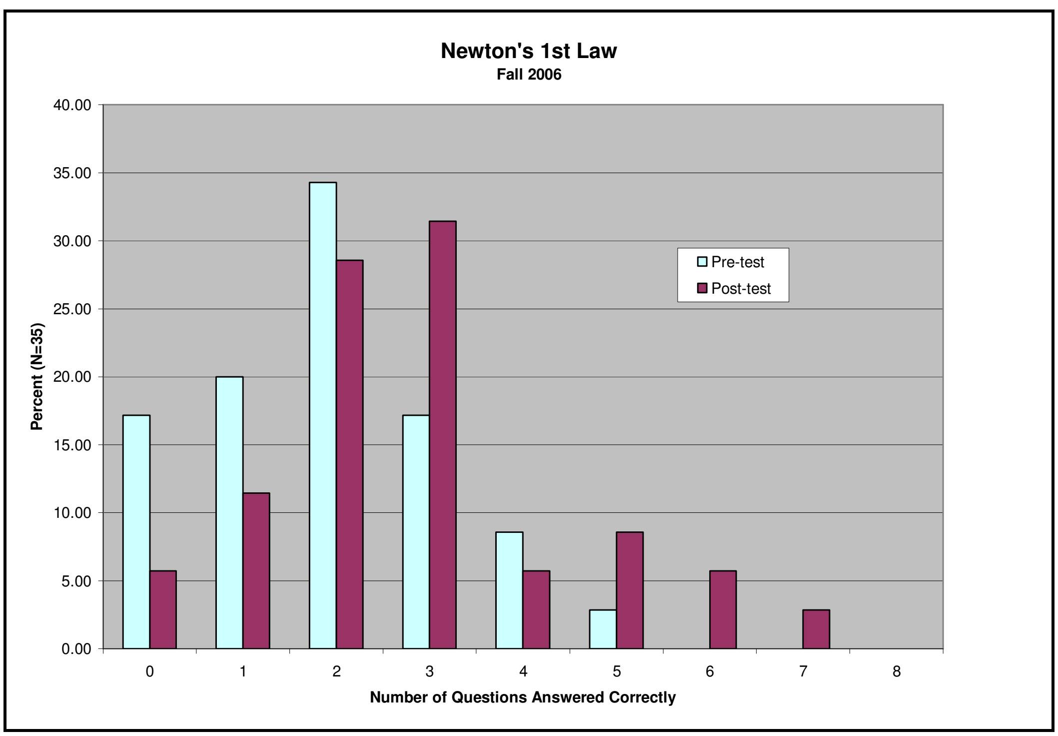

Figure 3a. The distribution of the percent of students answering questions correctly on the pre-test and post-test for Newton's 1st Law (N=35).

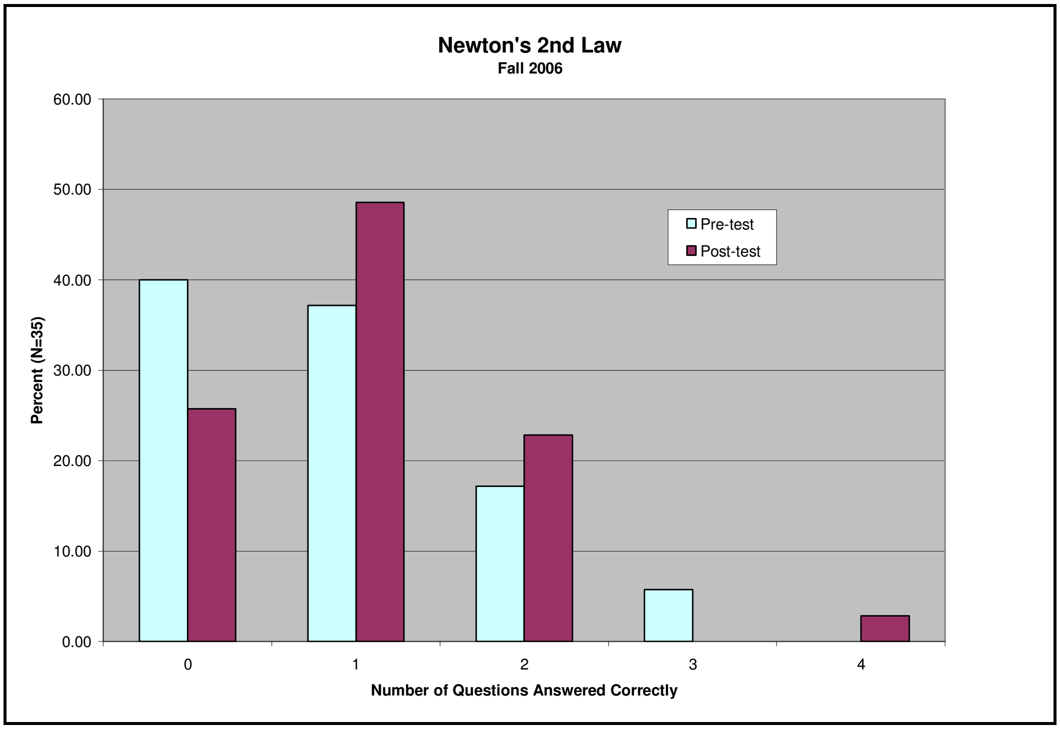

Figure 3b. The distribution of the percent of students answering questions correctly on the pre-test and post-test for Newton's 2nd Law (N=35).

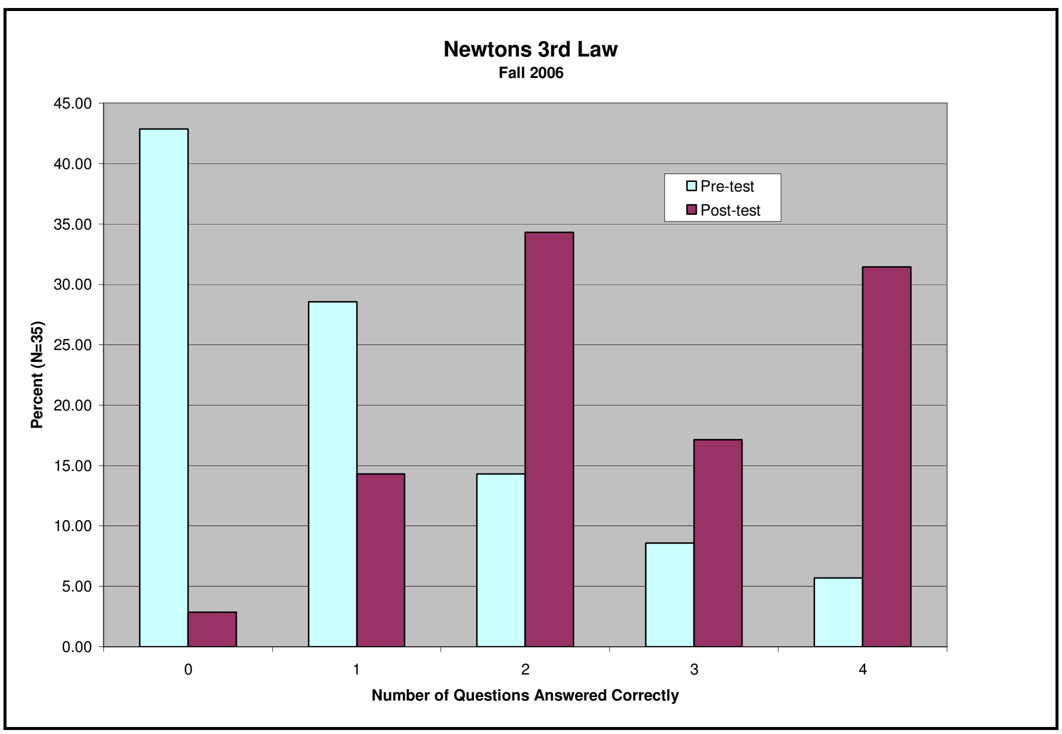

Figure 3c. The distribution of the percent of students answering questions correctly on the pre-test and post-test for Newton's 3rd Law (N=35).

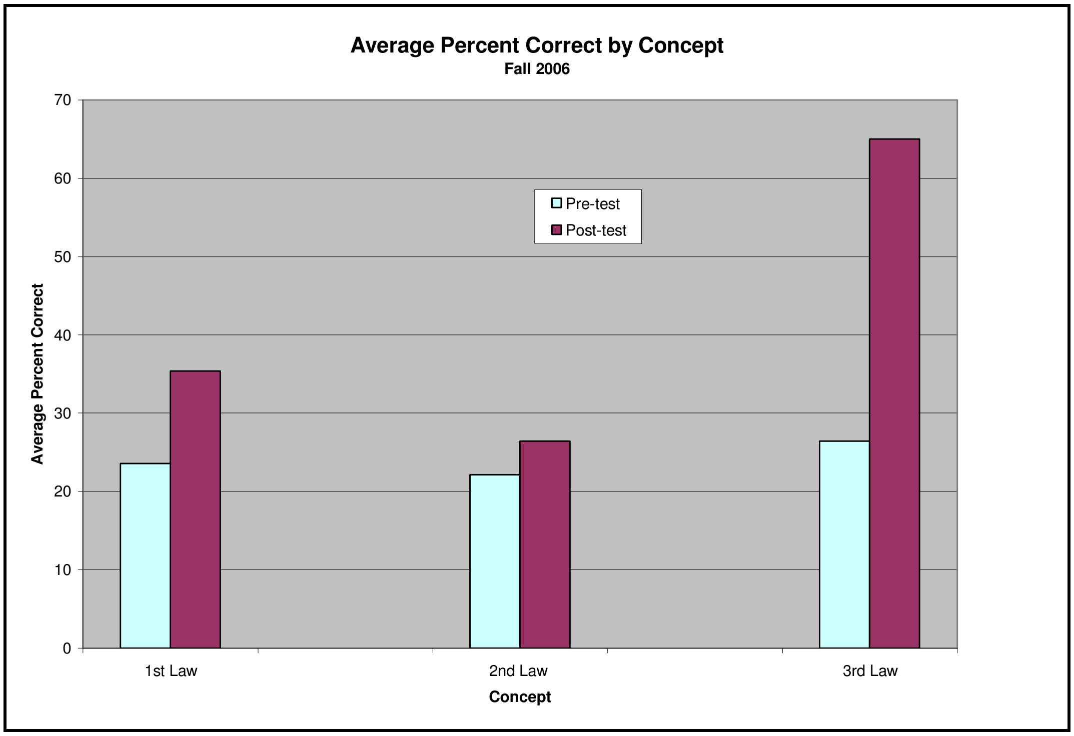

Figure 4. Comparison of the mean percent of questions answered correctly for each concept. The difference in the means for Newton's 1st Law and Newton's 3rd Law were significant ($p < 0.001$, paired t-test). The difference in the means for Newton's 2nd Law was evident, but not significant.

References

1. Beatty, I. D., W. J. Gerace, W. J. Leonard, and R. J. Dulfresne, "Designing effective questions for classroom response system teaching," *Am. J. Phys.* Vol. 74, No. 1, January 2006, pp. 31-39. See also references therein.

2. Mazur, E., *Peer Instruction: A User's Manual*, Prentice Hall: Upper Saddle Ridge, NJ, 1997.

3. Hestenes, D, M. Wells, and G. Swackhamer, "Force Concept Inventory," *The Physics Teacher*, Vol. 30, March 1992, pp. 141-158.
   See also http://modeling.la.asu.edu/R&E/Research.html.

4. See revised Table I in Reference 3 above at http://modeling.la.asu.edu/R&E/Research.html.