Final Report: Radio-Frequency Responders to Augment Active Learning Peer Instruction Techniques in General Physics

Eric Wells
Physics Department

As described in the initial proposal, two rooms [1] in the Gilbert Science Center were equipped for a radio-frequency response system [2] which was purchased with $1500 from the Bush Foundation and a match of $1180.90 from the Augustana IT fund. Fifty-five personal responders with programmable ID numbers were purchased as part of the system. The system elements are shown in Fig. 1. The system was used in PHYS 222 (fall 2004) and PHYS 221 (spring 2005) to enhance active learning teaching strategies, specifically peer instruction techniques [3].

Fig. 1: The handheld RF transmitter (left) and one of two RF receivers installed in GSC 201. The receiver is linked to the smart classroom PC.

Technically, the system operated to specifications for the most part. Questions may be asked using the smart classroom computer projector system either by integrating the responder software into powerpoint or using it as a stand-alone module. Answers are collected and displayed at the end of the allotted time. The only technical issue of note seemed to be bandwidth. Each receiver should handle up to 30 transmitters, but my experience was that if the answers come in rapidly, some responses are lost in a large class. PHYS 221 had 53 students, or

26.5 transmitters/receiver. For this reason, I would not recommend using the system for testing or voting activities.

Student response to the system, based both on anecdotal responses and more formal surveys, suggest that the students are quite fond of the "clickers". There was usually a bit of complaining when I did not use the responders for a particular class session. My observations indicate that class participation increased with the RF responders compared to the low-tech index card version of peer-instruction. Moreover, the numerical data generated for each *ConceptTest* [3] question proved quite valuable for evaluating those questions post-lecture.

More quantitative results of student learning were confined to PHYS 221 this last spring and utilized the Force Concept Inventory (FCI) [4] exam as a diagnostic instrument. The FCI is a 30 question multiple-choice test that requires no mathematics and covers Newtonian mechanics concepts. The multiple choice answers contain distracters that have been carefully selected to draw out common misconceptions students have about mechanics. The FCI is given both pre- and post-instruction. The generally recognized figure of merit for evaluating instruction is the normalized gain, G,

$$G = \frac{N_{correct}^{Post-Test} - N_{correct}^{Pre-Test}}{30 - N_{correct}^{Pre-Test}}.$$

The results of FCI testing are summarized in the next few figures.

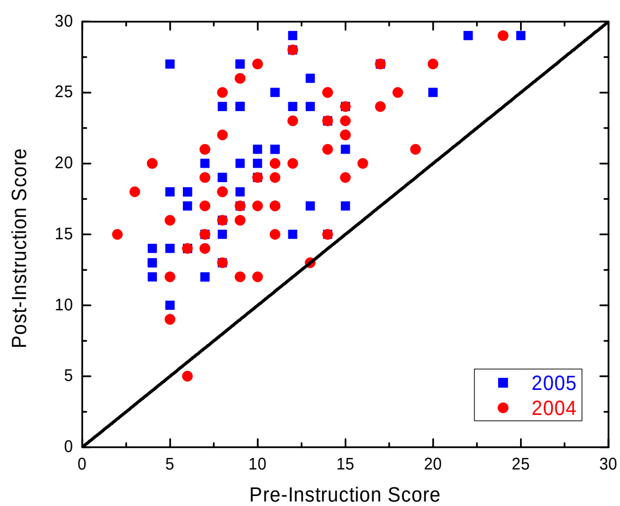

Fig. 2: Post-instruction vs. Pre-instruction score distributions for the last two PHYS 221 classes. The 2005 course used the peer instruction based instruction with the RF responder system, the 2004 class with index cards.

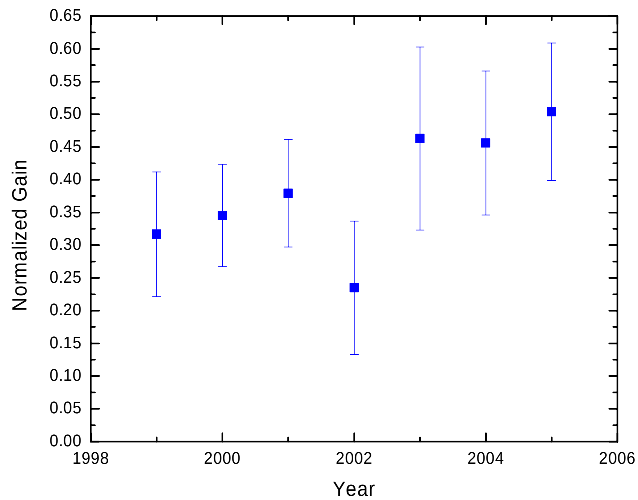

Fig 3: FCI normalized gain vs. year. The error bars reflect a one standard deviation.

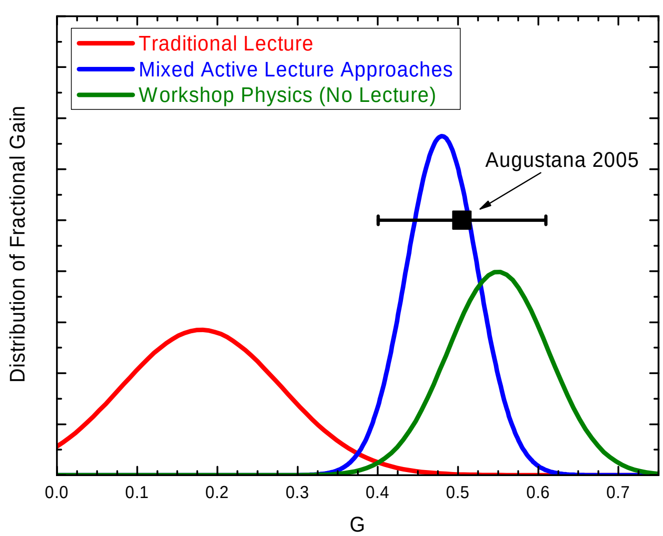

Fig 4: FCI normalized gain distributions for a variety of instructional techniques [5]. The FCI normalized gain for PHYS 221 at Augustana this last year is indicated by the data point. The normalized gain achieved last semester is consistent with instructional approaches that seek to bring active learning strategies into a large lecture setting. Approaches that abandon lecture (at the cost of a significant decrease in efficiency) show somewhat higher gain.

Figure 2 shows the pre- and post-instruction scores for all students in PHYS 221 in 2004 and 2005. While the FCI normalized gain did increase marginally in 2005, with the response system in place, the increase was not statistically significant, especially since no control group was established. However, the increased gain with time is encouraging and shows that a systematic series of reforms can improve student learning. Based on the FCI normalized gain, PHYS 221 instruction at Augustana is now at least as effective as most similar instructional styles aimed at large lecture courses nationwide. More troubling is the fact that the increase in gain can be attributed almost entirely to a decrease in pre-instruction scores. This may indicate that a large population of students is enrolling in PHYS 221, or it may indicate that pre-college physics preparation is decreasing. This issue is most likely complex and outside the scope of this report.

In summary, a RF responder system has been installed in the Gilbert Science Center and used for two semesters in the introductory calculus-based physics courses. The system can be easily implemented, and was described by the author of this report at a faculty luncheon. GSC 241 and GSC 201 have both been outfitted for use, and the receivers may be moved from room to room in about five minutes. Student response has been favorable, and it provides helpful feedback for both students and instructor. While the FCI normalized gain did increase somewhat, there is no statistical evidence that high-tech RF instruction is better than the low-tech index card method.

References

[1] GSC 201 and GSC 241

[2] http://www.gtcocalcomp.com/interwriteprs.htm

[3] E. Mazur, *Peer Instruction: A User's Manual*, Prentice-Hall, Upper Saddle River, NJ (1998); R.D. Knight, *Five Easy Lessons: Strategies for Successful Physics Teaching*, Addison-Wesley, San Francisco, CA (2002); R. d'Inverno, H. Davis, and S. White, Teach. Math. Applications **22**, 163 (2003); C. Elliot, Inter. Rev. Econ. Ed. **1**, 1 (2003); D.R. Marburger, J. Econ. Ed. **32** 99, (2001).

[4] D. Hestenes, M. Wells, and G. Swackhamer, The Phys. Teach. **30**, 141 (1992); R.R. Hake, Am. J. Phys. **66**, 64 (1998).

[5] J.M. Saul and E.F. Reddish, *Final Evaluation Report for RIPSE Grant #P116P50026: Evaluation of Workshop Physics Dissemination Project*, University of Maryland preprint (1997); R.D. Knight, *Five Easy Lessons: Strategies for Successful Physics Teaching*, Addison-Wesley, San Francisco, CA (2002); E.F. Reddish, *Teaching Physics with the Physics Suite*, John Wiley and Sons, Hoboken, NJ (2003).