CHOOSING THE RIGHT MIXTURE OF TECHNIQUES AND TECHNOLOGY

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ABSTRACT: Recent years have seen the development of a variety of teaching techniques specifically designed to improve student learning in physics. In addition, new technologies have been developed that help to increase interaction between students and instructors. Choosing which techniques and technologies to use, and then merging these techniques and technologies into a consistent whole, can pose a significant challenge for physics teachers. In this talk I will describe the various techniques and technologies I have used in teaching a two-semester algebra-based introductory physics sequence over the past six years. These courses have gradually evolved to incorporate a mixture of Peer Instruction and Just-In-Time-Teaching using online quizzes, Physlets, and an electronic response system.

Overview

This poster describes my experience teaching introductory algebra-based physics over the last six years. I started off using a traditional lecture-based approach. Over the years my teaching style has evolved to a more student-centered approach. However, in spite of the availability of several high-quality student-centered physics curricula I chose not to adopt any one particular teaching technique wholesale. Instead I have tried to blend a variety of techniques to produce a coherent teaching style that suits my particular needs. Along the way I have incorporated several technologies into my teaching methods. Overall this approach has been successful, but I have certainly made mistakes along the way. The sections below give a semester-by-semester account of how my PHY 111 (General Physics with Algebra I) course has evolved. My hope is that by sharing both my successes and failures I can ease the path for others who might want to try mixing a variety of teaching techniques and technologies.

Fall 2001

•My first semester as a college professor.
•Traditional approach: pure lecture, homework problems from the textbook **[1]** checked for completion (not for correctness), 4 tests focusing on calculation problems.
•I received very high ratings on teaching evaluations (see Figure 1) and was nominated for a college-wide teaching award! Overall this left me with little motivation to change my teaching style.

Fall 2002

•Switched to a new textbook **[2]** and added a bit of group work: students worked in groups of 4 or 5 to complete a review assignment prior to each test.
•Made a hasty decision to switch to Peer Instruction **[3]** in October after attending the Workshop for New Physics and Astronomy Faculty. Although some students liked the new style, most resented the sudden change.
•My teaching evaluations for this course were the lowest I have ever had (see Figure 1).

Fall 2003

•Before class: online quizzes using a course management system from *Jenzabar*. Quizzes consisted of roughly five ConcepTest questions similar (or in many cases identical) to those found in Eric Mazur's *Peer Instruction: A User's Manual* **[3]**.
•In class: brief review of the material followed by Peer Instruction using the questions from the online quiz (if needed) as well as new questions. Questions were shown on a projector screen using PowerPoint and students responded using a number-card system.
•Created my own homework problems (multi-part problems integrating several concepts into a single question). Homework due at the beginning of each class, graded during class (by a student worker), and returned at the end of class for immediate feedback. Solutions posted online.
•New style worked well, but students resented the fact that the online quizzes were graded for correctness. My teaching evaluations improved somewhat (see Figure 1).

Fall 2004

•Added an essay question to the online quizzes (to be more in line with the strategies of *Just-In-Time-Teaching* **[4]**) and spent some class time discussing the essay and showing (on PowerPoint) a few sample student responses.
•Created a handout for each class meeting containing brief notes on the material, all of the questions from the online quiz (as well as a few new ConcepTest questions), and homework problems. Students no longer had to copy questions from my PowerPoint slides.
•Began using an electronic response system (Educue's PRS system) for Peer Instruction.
•Students appreciated having the handouts and enjoyed using the "clickers". However, there was still a great deal of resistance to the grading of the online quizzes and many students felt that I spent too much time on conceptual questions and not enough time showing them how to solve problems involving calculation. My teaching evaluations were about the same as for Fall 2003 (see Figure 1).
•For the first time, I administered the Force Concept Inventory (FCI) at the beginning and end of the semester. My students achieved an average normalized gain of 0.36, which is a bit low for courses with active-learning components ($\langle g \rangle = 0.48 \pm 0.14$) but well above the gains for traditional courses ($\langle g \rangle = 0.23 \pm 0.04$) **[5]**.

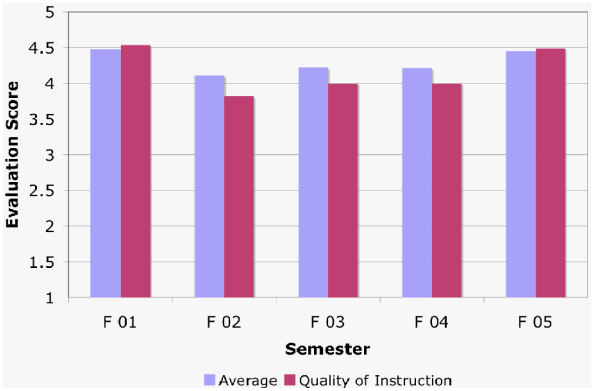

Figure 1
Histogram of teaching evaluations from Fall 2001 to Fall 2005. Blue bars represent my average rating on all evaluation items. Red bars represent my average rating for "Overall Quality of Instruction". All questions use a Likert scale from 1 to 5 with 5 being best.

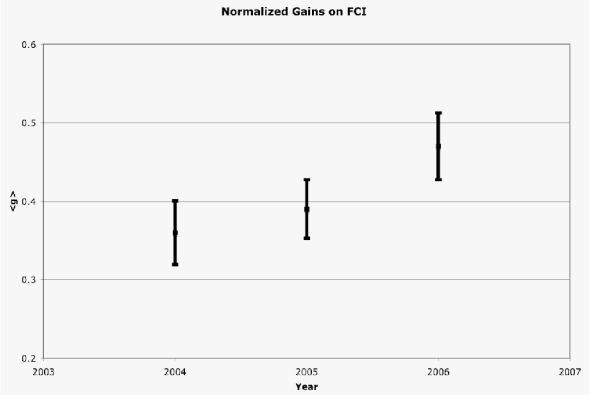

Figure 2
Plot of normalized gains on FCI for Fall 2004, 2005, and 2006. Points show the mean normalized gain (<g>) for all students, while error bars indicate the standard error of the mean.

Fall 2005

•Switched to grading online quizzes for completion (one point for answering the multiple choice questions and one point for giving a relevant answer to the essay).
•Devised a "demo problem" for each topic. The demo problems were designed to be very similar to the homework problems I assigned. The demo problem was discussed in class if there was time, but in any case the solution would be posted online.
•My teaching evaluations improved significantly, matching my evaluations from Fall 2001.
•More importantly my students continued to show good gains (0.39) on the FCI.

Fall 2006

•Began using Physlets **[6]**. Online quizzes now typically consist of two questions on previously covered material using Physlet Problems, one question straight from the assigned text reading, and two questions on new material using Physlet Illustrations or Explorations. Quizzes are graded for correctness.
•Class time is spent on a brief review and Peer Instruction (using the ConcepTests used in previous semesters) with some discussion of the Physlets if needed. If time allows, I present the demo problem.
•Used a new textbook **[7]** because it came packaged with the *Physlet Physics* **[8]** CD.
•I have not yet received my teaching evaluations but my sense is that grading the quizzes produced some student resentment as it has in the past. This resentment was exacerbated by technical problems with the VikingWeb system, which went down frequently.
•The good news, though, is that my students showed significantly higher gains (0.47) on the FCI. I believe that this improvement is attributable to the incorporation of Physlets.

Lessons I've Learned

•NEVER change your teaching style significantly in the middle of a semester.
•Be willing to mix and match teaching techniques to find the combination that works best for you and your students.
  •You must be comfortable with what you are doing.
  •Your students should hate your teaching methods (although you may need to overcome some initial resistance).
  •Teaching methods must fit with your available resources (technology, classroom space, teaching assistants, laboratory/demonstration equipment, etc.).
•Don't make more than one major change to your teaching methods per semester.
•Experiment with new technologies, when feasible, to see if they can aid your teaching.
•Become familiar with new technologies before using them in your course. If possible, try to avoid relying on technical support from others.
•How you implement your teaching strategies can have a big impact on student attitudes in the course.
  •If you give online quizzes on material prior to covering that material in class students may resent having those quizzes graded for correctness. If you grade for completion only, then students may put minimal effort into answering the quiz questions.
  •Peer instruction works best if the questions are given to students on a handout (rather than displayed on the screen) and students can respond using "clickers."
•Technology problems can also have a serious negative impact on student attitudes, so try to avoid using unreliable technologies or technologies that you cannot fix on your own.

References

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