# CWSEI – PHYS & ASTRO Newsletter

July 2010

Our department has always been committed to high standards in education. Recently, with support and leadership from the CWSEI, we have made increasing progress in successfully implementing research based educational methods in our classrooms. An increasing number of our faculty are showing keen interest in these developments. In response, we will distribute this monthly newsletter to keep you up-to-date with the latest CWSEI efforts.

In this issue, Mark van Raamsdonk is discussing his experience in teaching Phys200 for the past 3 years.

Mona Berciu

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***Professor Mark van Raamsdonk (PHYS2000)***

PHYS200 is our introduction to special relativity and quantum mechanics for physics students. The course enrollment is around 100 students; it is a required course for all physics students but also popular as an elective, with roughly one third of the class made up of non-physics students. I took over the course in 2007, and Carl Wieman was officially assigned that year to help me incorporate some research-based modern teaching methods to improve the course. The following year, Louis Deslaurier helped me to improve the course further.

With Carl's help, I came up with a set of learning goals for the course (see: http://www.physics.ubc.ca/~mav/p200/goals.html), including a set of broad, course-level goals, and a more detailed set (with roughly two or three goals per lecture) that would serve as a guide in preparing the day-to-day course material.

Carl also encouraged me to use clickers during the lectures, and based on student feedback and my own impressions, these worked very well. To me, the biggest advantage of the clickers is that it forced students to think about the material being presented to them and discuss it with their peers. I typically chose clicker questions that were conceptual (no calculations required) since these provide a direct way to uncover and eliminate common misconceptions about the material. The clicker questions often resulted in a series of questions from the students, and according to Louis' observations, the period of discussion after clicker questions was the time during my lectures during which the highest fraction of students were paying close attention. I based credit for clicker questions completely on participation, rather than correct answers, since the most useful questions tend to be those that most students will not answer correctly. By the third year, I had a pretty good idea of what fraction of the students would get a particular question right and chose questions such that this fraction was not too large. In this sense, the purpose of the clicker questions was not to inform me of how well the students are understanding my lecture, but rather as a tool to make sure students understand important concepts that I know they will not absorb simply by hearing me talk about them.

Another popular innovation in the lectures was the use of computer simulations (mostly from the PHET website). Especially in the quantum mechanics section of the course, there were excellent simulations available to help students visualize most of the crucial historical experiments (e.g. photoelectric, double slit) and physical phenomena (e.g. tunneling, wave-packet propagation, bound states). These worked well with the clicker questions; for example, after showing a simulation, I could ask "What will happen if I… ?" (e.g. change some parameter of the initial setup, etc…), challenging the students to really think about what's going on with the physics. The students generally really enjoyed seeing and working with the simulations, with several requesting that simulations be incorporated into other sections of the course.

Perhaps the most popular new feature of the course (introduced in my second year teaching P200) was the weekly tutorial, which lasted 80 minutes. Each week (for 13 weeks) I came up with a worksheet (see: http://www.physics.ubc.ca/~mav/p200/tutorials.html) focusing on one or more central concepts in the course. The students worked together on the worksheets in groups of three or four, with myself and two or three TAs there to help the students along when they requested. Worksheets would usually begin with a brief summary of what we'd recently been discussing in class, and continue with a mix of conceptual questions and simple problems, designed either to introduce material (e.g. asking a series of questions that ultimately lead them to derive some important formula) or help them apply what they've learned in a setting where they can ask questions as soon as they are stuck. Some tutorials also required the students to use the computer simulations introduced in class. At the end of each worksheet were a number of questions designed so that they would challenge even the best students in the class. Like the clicker questions, the tutorials were for participation credit only, so students who did not have time to complete all the questions were

not penalized. The goal was to have every student in the class learning at their own pace for the entire session, and based on the very positive comments I received both from students across the spectrum of abilities, this seemed to be successful. I would almost certainly incorporate a similar approach into any future course I teach.

Since many of the learning goals for the course were conceptual, I decided to include a substantial fraction of conceptual questions on the exams as well. For both midterms and the final exam, roughly half of the credit was based on multiple choice questions requiring little or no calculation, (with the rest of the credit for more conventional calculational problems). These were very similar to the clicker questions used during lectures. By emphasizing the conceptual aspects as well as calculational aspects during the course and on the exams, I hoped to avoid the common phenomenon of students who are able to do very well on calculational problems without really having a shred of physical intuition.

Overall, I would say that teaching physics 200 has been the most enjoyable teaching experience I've had at UBC despite it being the largest class I have taught. It was also the first class in which the students consistently performed better than I expected on the midterms and exams. I must say that coming up with tutorials, incorporating clicker questions and simulations into the lectures, and maintaining the course website (with problem sets, solutions, tutorials, tutorial solutions, clicker questions, clicker question solutions, course notes, and links to simulations) was a substantial amount of work that did not decrease as much as I expected in the second and third years teaching the class. On the other hand, even in the final year, I was still trying to improve the clicker questions and tutorials, so I could imagine that the workload would be less with a "perfected" set of clicker questions and tutorials to draw from.

Despite the extra work, I would certainly use most of the approaches employed again, using clicker questions for larger classes, making use of computer simulations (ideally with an opportunity for the students to use the simulations themselves), and incorporating more tutorial-style material in place of lecture. On the other hand, I think that a certain amount of lecturing can be helpful to get the students inspired about the material and to allow the students to see my enthusiasm for the subject. I also find that any given textbook presents material in a way that differs significantly from what I consider ideal, so I feel that there is some need to present my own logical framework for the various concepts to be presented. But, given my experience with physics 200, and based on Louis' close observations of my class, I think that the ideal is to restrict ordinary lecturing to relatively modest chunks to be incorporated with other learning activities.