A Better Way to Teach Physics

Research in physics teaching at the university level over the last 30 years has shown that the traditional lecture is a poor way to develop conceptual understanding and analytical skills in students, whereas *discussion among students* is much more fruitful. Moreover, much of the time in lecturing is spent transferring relatively straightforward ideas, rather than using the instructor's expertise to concentrate on the areas that students find most difficult. The best study to show this is the one by Hake (http://www.physics.indiana.edu/~sdi/ajpv3i.pdf). Of the 6542 students over 42 courses in the study, those taught using interactive methods improved their performance on a standard mechanics test by more than twice as much as those taught using traditional lectures.

Since 1997-98, Trent University has been developing approaches in first year and several other courses to put into practice the recommendations of this research, which perhaps makes Trent the first university in Canada implement such methods. The main approach in Introductory Physics is based on *Peer Instruction* (Prentice-Hall 1997) by E. Mazur of Harvard University. Instead of lectures, the notes are distributed in advance of the class, with readings assigned from them. Students use the class web site to answer a few questions on the reading for that day, including one which asks "What part of this reading needs more clarification?" Before class, the instructor reads these replies and tailors the class discussion to the difficult areas. This approach is called *Just-in-Time-Teaching* (Novak et al., Prentice-Hall 1999), because both the instructor and the students are prepared for class, just as it starts.

A typical class begins with a short summary of the material by the instructor, who then presents a question which forces students to think deeply, with a list of multiple answers that include all the common misconceptions. After about a minute to decide on the answer individually, the students discuss them in groups of 2 to 4, and then vote on the correct answer. Electronic "clickers" (similar to a TV remote control) are used for voting, as this enables a bar graph of student responses to be projected onto the classroom screen. This lets everyone know immediately whether or not the class understands the physics. If almost everyone votes correctly, the instructor continues to another question. More usually, a significant fraction of the class chooses the wrong answer, and the instructor then takes the time to discuss the physics and ask for any questions.

Students are almost unanimously in favour of these approaches; they prepare them well for class, and give them instant classroom feedback on their understanding, which automatically removes most of the problems that the students had flagged on a first reading of the notes. The majority of students rate this approach superior to lectures, and state that it makes class more stimulating and fun.