The Interactive Classroom

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Why Stop Lecturing?

by Prof. Susan Wyckoff, Department of Physics and Astronomy, Arizona State University

Four years ago, in an effort to improve my teaching in a large enrollment introductory undergraduate physics course at Arizona State University, I sought advice from science education faculty in my own department and in the college of education. I was advised to: 1) reduce and deepen the course content; 2) ascertain what I wanted students to learn; 3) create a test to measure this; 4) coordinate laboratory experiments with the content discussed in the large class meetings; and, 5) change my teaching style from traditional lecture to interactive engagement.

Devising the achievement test was quite straight-forward, as was changing the course design and content. But converting a large class of 100 students from a passive to an active learning environment, while maintaining some semblance of control was both challenging and risky. Fortunately, the Physics Department was poised in 1996, to purchase a new electronic response system called Classtalk for the lecture hall for my class.

That fall semester, I took the plunge to utilize Classtalk to convert my life-long teaching style from lecture to interactive, student-centered discussion interspersed with mini-lectures (<10 minutes). Classtalk is both a classroom management and a learning feedback tool, which is easy to learn to use, and very popular with the students. Students, when answering the course survey question:

(continued on Page 3)

Pre-Calculus at MacArthur Pushes the Frontier

by Anne Davidian and Andy Lippai, Department of Mathematics, MacArthur High School, Levittown, N.Y.

After the installation of *Classtalk* was completed, small crowds of students and teachers gathered outside of Room 229 at MacArthur High School to discuss the possible purpose of the wires that were hanging from the ceiling. Speculation ranged from some kind of torture device used on lazy students to intravenous transfusions that would enlighten students on the finer points of mathematics. However, when they were informed of the real purpose of the wires, people were even more amazed!

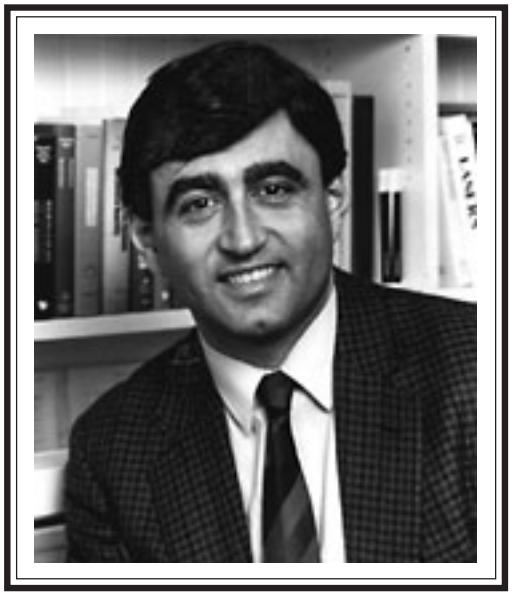
Classtalk has now become an established fixture, but the amazement at its capabilities continues to excite us daily. It is a true wonder to be able to have a constant pulse on what every student is doing at all times! Students can no longer

(continued on Page 3)

The Mazur Perspective

— An interview with Harvard Physics Professor Eric Mazur, by Marty Abrahamson, bE Staff.

Good questions are the perfect catalyst for classroom interaction. But what is a good question? The buzz over conceptual questions has been great but it is often unclear exactly what people mean when they talk about conceptual questions. What better person to help shed light on the matter than Dr. Eric Mazur inventor of the ConcepTest*.



Eric Mazur, Harvard College Professor and Gordon McKay Prof. of Applied Physics at Harvard University

MA: Ideally, the Socratic method involves questioning students in such a way that they are led to express their ideas and figure things out for themselves.** Can I assume that you believe ConcepTests, or conceptual questions in general, are best for accomplishing this?

EM: I would say that one-on-one with open ended questions is the best way. When combined with small group discussion, however, ConcepTests are an excellent way to force people to think, and to do so with a minimum amount of cost and time. If we had infinite time, of course, a better instruction could be devised. So given the constraints we have on the amount of material to cover and the time available, the answer to your question would probably be, "Yes".

MA: What makes answering ConcepTests so difficult?

(continued on Page 2)

The Mazur Perspective ....

(Continued from Page 1)

EM: Children start life full of curiosity, they are all scientists - people who ask, "Why, why, why?" all the time. At some point in their middle school years, or maybe earlier, I don't know exactly, their curiosity gets turned off. From that point on, rather than ask, "Why, why, why?" people concentrate on facts. They want to know the fact, or the answer, so that they can memorize it. So when faced with a conceptual question, instead of thinking, what you do in your brain is begin looking for a fact. You look to see if you have seen the answer to that question before, and if it's a good conceptual question you will not have seen the answer to that question before. So they are difficult because people are not used to seeing them.

MA: What makes coming up with good conceptual questions so difficult?

EM: Any change is difficult! When you have been doing something in a certain way for a long time, and are suddenly asked to change, it's difficult. I think that's the only reason... I wouldn't look for more behind it.

MA: Would you say the majority of questions used by instructors are factual recall questions?

EM: I am convinced that most of the questions being asked are factual recall questions.

MA: Would it make sense to you that High School teachers would need to ask more factual recall questions?

EM: Well, high school and secondary teachers are often short on time and these are the easiest questions, right?

MA: Yes, I guess so, but I have actually heard from teachers that they think it is necessary to ask a certain number of factual recall questions in order to teach their students effectively.

EM: Well it has been shown that people memorize when tested with factual recall questions, and they memorize long enough to pass an exam, but research has shown that just after the exam everything is gone. In other words, they forget it again ... and what good is that?

MA: No good at all I suppose. I guess there are many objectives that an instructor may have in mind when asking a question or set of questions. All of these objectives tend to overlap. Questions, for example, may serve to motivate students to prepare. The students response to those same questions may provide the instructor with useful feedback. In considering the questions, the students may become aware of a discrepancy in their logic, or may be somehow inspired to deepen their understanding. Despite the fact that it is possible to accomplish all of these objectives and many more with a single question, do you think that it is useful to have a specific primary objective when designing and planning the delivery of a question?

*EM: Oh, yes ...! I often actually use students' questions. I actually use this now with a teaching technique called "Just-in-Time Teaching" ***. Basically, the students read before class and then they tell me in an e-mail what they find difficult or confusing. I use that to prepare my lecture. In other words rather than lecture on what I find difficult, I will take some of their confusion and bounce it straight back at them.*

MA: OK … so your objective in asking a student their own question is …

EM: ... to engage them appropriately! If they have a question, I know that it will engage them. I might have a question but it could be too hard, and if it is too hard it is an ineffective question because it discourages them rather than engaging them.

MA: Yes, but their own questions, the ones they ask you, aren't too hard for them … <I begin to chuckle> … that's interesting …<the irony continues to get me and I laugh>…..

EM: Exactly, they are exactly at the right level for them. You see the problem is recall questions are too simple. I could ask them , "Which of the following is Ohm's law? A) V = IR, B) I = VR" and so on. That's not a very interesting question and is unlikely to stimulate discussion, because it's recall. The other option is to ask them some sort of very deep philosophical question about Ohm's law that I might find very interesting, but that might be way too hard for them to answer, and then again it's not effective. The middle road is to give them enough of a challenge to stimulate their thinking, but in such a way that about half the students in the class get it right, so that they can help others learn.

MA: So you don't ever ask questions in class purely for the purpose of finding out whether or not students understand a certain thing?

EM: I used to, basically that's the only thing I could do, but those questions were always based from my own experience, and my experience is very different from that of most of my students, because my students are not going to become physics professors at Harvard University. In fact most of my students are not even going to become physicists, they're pre-meds or engineers. So my questions are generally not as appropriate as their own questions, because these questions are generally not as good at engaging them. Now, because I have asked so many questions over the years, I have a much better feel for what constitutes a good question. I can target the students much better than I could before.

MA: I would like to thank you on behalf of our readers for your insights. ♦

About Eric Mazur and the Mazur Group

http://mazur-www.harvard.edu

Dr. Mazur is author or co-author of more than 120 scientific publications. He has written on education and he believes that better science education for all — not just science majors — is vital for continued scientific progress. To this end, Dr. Mazur devotes part of his research group's effort to education research and finding verifiable ways to improve science education. Dr. Mazur's teaching method has developed a large following, both nationally and internationally, and has been adopted across many science disciplines.

* Mazur, Eric, "Peer Instruction: A User's Manual", Prentice Hall, 1997 (This book explains how to teach large lecture classes interactively, using *ConcepTests* and *Peer Instruction*.)

** Hake, Richard R., "Socratic Pedagogy in the Introductory Physics Lab.", The Physics Teacher, 30, 546-552, 1992.

*** Novak, Gregor M., et al., "Just in Time Teaching: Blending Active Learning with Web Technology", Prentice Hall, 1999.

How HKUST Institutionalized the PRS

by Louis Abrahamson, bE staff

Many in the interactive teaching community in the United States have wondered about the PRS: where it came from, what was the vision, who was behind it, how it is used in other places, and what Hong Kong has to do with it?

Actually, it's a great story and it's time it was told. Especially because the answers to all these questions are only part of the story. Even more important is the pioneering work that has been accomplished after the courageous and visionary decision of one institution to take interactive teaching "University-Wide". Fittingly enough, this ground-breaking effort came from a wonderful new institution in an old old country - China. Located in the economic heart of a new Asia, on the side of a mountain overlooking the South China Sea, is the beautiful Hong Kong University of Science and Technology (HKUST).

It was at this institution in early 1996, that Prof. Nelson Cue, Chairman of the Physics Dept., opened a package. Inside was information about the first anticipated commercial Classtalk System that would be available later that year. He watched the videotape of interactive teaching research, and was fascinated. Later he visited bE in the USA and decided to buy a system for a networked computer lab. After buying and using two more systems (including a calculator-based lecture hall system), he decided that Classtalk was a great idea but impractical for his vision. Prof. Cue's vision was too big for a hardwired specialized network and complex graphing calculators. He wanted something that would appeal not just to physicists, or even just to scientists and mathematicians. He wanted something that could be used in any discipline. Above all, it had to be simple to use, and low cost.

With a grant from the Hong Kong Government and the involvement of a high-tech HK company - Varitronix, he designed the PRS. Prof. Cue saw the need for a system that was like Classtalk, but which could be used easily in any classroom from elementary school to post graduate, in any country - even developing ones, and which would be affordable. Regular networking was too expensive, so he settled on something that was pervasive and cheap: television infrared remote control technology. He built it, and it worked - even in large lecture halls with 400 students. Now it was time for bigger things. He decided to go university-wide.

In Fall 1998, Nelson invited me to give a Seminar at HKUST. The grand experiment was just beginning. It worked like this. If they were in a class using the PRS, students could go to the university library and check out a transmitter. The library had a special station set up for this purpose that included a computer connected to an ID Changer which could personalize a transmitter with the student's unique university ID. Students were expected to carry their transmitter, which was smaller and lighter than a computer mouse, with them to classes. In participating classes, they would simply take it out, and use it to answer questions posed by the professor. Their answers (tagged by their ID) would instantly be transmitted to the teacher's computer and logged. A histogram of the class response would be plotted, and could be shown to the class (see http://www.bedu.com for more details).

Now, one and a half years later, the experiment has been a resounding success. Eight lecture halls and eleven large classrooms are "PRS ready". The system is currently being used in more than thirty courses. More than 4,000 transmitters have been issued to students. In this large-scale experiment, they find that interactive teaching works as advertized. Namely that, students pay more attention in class, there is immediate feedback and reinforcement, class understanding can be checked before going on to the next topic, test and quiz results are promptly and automatically graded, and shy and disadvantaged students become proactive. It's a great accomplishment, especially when you consider the cost. ♦

Why Stop Lecturing ....

Continued from Page 1

What do you like best about the course?" have responded 80% of the time, "Classtalk", for the past four years. Furthermore the pretest/posttest gains for the course over three years indicate Hake gain factors* of two in students' learning of fundamental physics concepts, compared with students in traditional lecture classes (control groups). This test, the Physics Concept Survey, incorporates several Force Concept Inventory** items in addition to concepts in electrostatics, circuits, magnetism, light and optics.

This four-year teaching experiment has taught me that significantly greater learning takes place in an active-engagement classroom environment, compared with traditional passive lecture environments, and that even large-enrollment classrooms can be converted successfully to active learning environments, when managed with an efficient electronic response system like Classtalk. ♦

*Richard Hake 1998, "Interactive-Engagement versus Traditional Methods: A Six-Thousand Student Survey of Mechanics Test Data for Introductory Physics Courses", Amer. J. Phys, vol 66, p. 64-74)

** David Hestenes, Malcolm Wells, Greg Swackhamer 1992, "Force Concept Inventory", Phys. Teach., vol. 30, p. 141-158.

Pre-Calculus at MacArthur

(continued from page 1)

hide in anonymity. As one student stated, "I have to do all of my homework now, since Mrs. Davidian can see our answers and know if we don't answer."

As part of their daily homework, AP Calculus students are assigned practice AP multiple-choice questions. When they enter the classroom, the students type their answers into the *Classtalk* system. By the time the bell has rung to begin class, answers are entered and attendance is taken. Students can then check their answers, and see how well they have performed in relation to their classmates. One student commented that "*Classtalk* allows us to see that a few of us may need help, instead of a student feeling like he is the only one who doesn't understand." This system also enables us to see when the entire class needs reinforcement on a particular topic.

For our precalculus classes, we use *Classtalk* in many open-ended lessons. In our trigonometry unit, students were quizzed daily on the functions of "special angles". Students were required to not only know the answer, but also to answer the question in a limited amount of time. After

(continued on Page 4)

KSU Studies the effects of Multiple Choice format on the FCI

by: Marty Abrahamson, bE Staff

Most agree that the MC question format has its place, the point of debate comes in deciding when it is, and is not, appropriate. Currently this is a hot topic for States that have established "Standards of Learning" (SOLs). Multiple Choice tests have been designed to show which public school administrations, and even individual teachers, should be scrutinized for failing to meet these SOLs. With so much at stake every aspect of the test is likely be considered carefully and perhaps some interesting studies will emerge.

A study was done at Kansas State University that is of particular interest to Physics educators. There they began to probe the effect of the multiple choice format on the well known Force Concept Inventory (FCI). They did this by comparing students' performance on four FCI questions in the open-ended format with their performance of regular multiple-choice FCI questions. FCI questions addressing the greatest number of misconceptions were chosen for this study, and were presented in two questionnaires each containing two open-ended and two multiple-choice questions. A pilot study was first performed on students in a second semester calculus-based introductory physics course, and the main study was later performed on students in an introductory physical science course.

The results indicated that there were no significant differences in student performance in the two formats. Students' responses in the open-ended format can be categorized into the same choices that appear on the multiple-choice questions. In spite of the absence of distracters on the open-ended questions, most students gave the same incorrect responses that they did on the multiple-choice questions. ♦

Pre-Calculus at MacArthur ....

(continued from page 3)

several days of quizzing, the time allotted for an answer had decreased, while the number of students answering correctly increased.

In using the CBL (Calculator Based Laboratory), students tossed a ball in the air and graphed the height of the ball as a function of time. Students were then able to determine an equation to model the data. From this equation, they also calculated equations for the velocity and acceleration of the ball. Through the use of the *Classtalk* system, the students were able to share their equations with their classmates, and see the equations that other groups calculated. It was quite exciting to actually *see* how the same experiment that was performed independently by many different groups produced the same results.

We are truly enjoying our interactive classroom, both from the teaching as well as the learning aspect. ♦

Enticing Bio-Chemistry Students to Learn!!

At the combined South West and Rocky Mountain regional meeting of the ACS, Pat Shaffer from the University of San Diego gave a work shop to High School and University Chemistry teachers. At her workshop she showed how she has used Classtalk and Peer Instruction in class sizes ranging from 30 - 50 students. She did this by actually teaching the workshop participants some bio-chemistry - how to construct a restriction map of a linear DNA Fragment. One of the questions she always asks her students before she starts this class is: "Is DNA a chemical?"

"You would be surprised how many people don't think of DNA as a chemical," says Prof. Shaffer. "I think it is important to set them straight on this point right at the beginning." ♦

From Left to Right - Louis Abrahamson, Pat Shaffer and Marty Abrahamson are rewarded for a successful workshop with Mariachi music and good food.

The Interactive Classroom

The Interactive Classroom Newsletter is published for the users of interactive classroom technology, educators and researchers who are committed to using interactive classroom technology to improve teaching and learning. If you have any questions, or wish to share your experiences, please contact: Editor, Interactive Classroom Newsletter, Better Education Inc., 4824 George Washington Hwy, Yorktown, VA 23692. For more information, visit our Web Site,

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