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March, 2008

Statement of Teaching Philosophy

There is a condition which has been called the "curse of knowledge" by educational psychologists. Specifically, if you know something, as a teacher, it is extremely difficult to think about it from the perspective of someone who does not know it. Thus, I need to know what my student's base knowledge is and to always remember what it was like to NOT UNDERSTAND something that I now find so obvious. To bring them to a place of understanding I work to create a learning *culture*; I interact with students and teach by example, I use analogies that THEY will find helpful, not ones I like or find insightful. Also, I create web-based tools to help maintain a useful learning culture for when I'm not there.

Teaching should be about getting to the core of what the students know and then using this information to break the mold of teaching pedagogy that has come before me. It means creating substantively different methods and tools that focus on the student's real needs. It is my responsibility as a teacher to create the tools and courses that will engage students and introduce them to a new and amazing world. If I'm doing my job correctly the learning is fun and the goals are clear. Hard work is always rewarded but excellence is always expected. Together we can do something special.

Description of Teaching Practice: Innovations in Teaching, Learning and Assessment

Teaching Introductory Courses:

Since joining the faculty, the majority of my classroom teaching has focused on the introductory classical mechanics course (PHYS218) for engineering students. I typically teach a lecture section of ~120 of the 1,500 students taking the class (~600 in the spring). I chose this course because these students are typically in their first year, at a time when they are beginning higher education; my interaction with them occurs at a crucial point in their intellectual development. I like teaching a course with the largest opportunity to inspire students who will become the leaders and entrepreneurs of the future. The large class size increases the number of students I get to see each semester whose eyes light up when they really understand something new and exciting for the first time.

The students taking this course are typically engineers and others who will not continue on in physics. They are using the course as a basis to learn the principles of physical problem solving for their future studies. While many of these students are remarkable, a large majority come in with (1) inadequate mathematics skills and (2) poor study techniques. Having spent hundreds of office hours tutoring theses students one-on-one, I came to appreciate that these two deficiencies provide the largest impediment to both learning physics, and more importantly, enjoying the understanding of the physical world around them. In short, excellence was reserved only for the few who come in highly prepared relative to their peers, and/or those who sought out feedback on their own, before the exams.

To rectify this, I obtained the support of my department and the Center for Teaching Excellence in the fall of 2001 to assemble a team of graduate students who would create a suite of web-based teaching tools. The first is the Automated Math Evaluation System (AMES), which is purely a math-teaching tool. The average student, as mentioned above, has *taken* the pre-requisite math courses. However, they lack the skills to use the things they learned in these math courses to solve problems. The AMES system gives them highly targeted quizzes on material they should already know, and gives them feedback on their weaknesses. The student can take as many of these quizzes as they like until they achieve regularly at an acceptable level, with all missed problems repeated until done correctly (this is known in the literature as Precision or Mastery learning). By my estimates the average student takes over 200 quizzes a semester; that's almost 20,000 in my section, and over 100,000 in all of 218 a semester. Probably over a million have been given between my course and the math quizzes in other courses (PHYS 208, 201 and 202) since their inception. The enormous resources of Texas A&M networking and computing enabled this unprecedented level of quiz taking and learning.

The poor study skills of many students leave many ill prepared for the demands of the course. These are not *bad* students, but they are used to being the smartest in their class in high school and often did not have to actually work hard. Even if they were willing to work hard, no one had taught them what to DO. In addition, there were no resources to grade homework assignments to give them the feedback to help change this. I designed a second system, a Computerized Homework Assignment Grading System (CHAGS), and a set of after-homework quizzes and mini-practice exams (QUizzes Intended to Consolidate Knowledge, or QUICK). The results have been overwhelmingly positive, and these tools were incorporated with WebCT to allow for other professors in all the Physics Service courses (PHYS 201, 202, 208, 218, and 218 honors) to use them, with over 3,000 students each semester benefiting from my design.

Because of the innovation of these teaching tools, I, along with two of the graduate students who helped develop these tools, published a manuscript describing the pedagogy, the systems and results in *The Physics Teacher*, one of the top journals of physics education. “Integrating Web-Based Teaching Tools into Large University Physics Courses,” *The Physics Teacher*, Vol 43, 595 (2005). I have been the top user of WebCT quizzes for essentially as long as the system has been in use at Texas A&M, and I was also invited to give a talk on my work at the "Teaching With Technology 2006" Conference (Feb 2006).

Teaching the Excitement About the Physical Universe:

I decided that after many years of working on the large introductory courses and having set them up with a program of long-lasting impact using the Web, it was time to bring the excitement of the recent discoveries about our understanding of the origin and evolution of the universe to non-scientists. The Big Bang, Black Holes, Dark Matter and Dark Energy are topics that fill newspapers and Stephan Hawking’s book “A Brief History of Time” is one of the most famous books of our time. I decided that there needed to be a course, without the math, that conveyed the excitement in a way that every student, no matter what major, could understand. I realized there were no courses at any department around the country I could use as a model so I decided one needed to be created from scratch. I debuted my course, entitled “Big Bang, Black Holes, No Math”, in the spring of 2007. I taught the course again in the fall of 2007 with an even larger enrollment. This course has been approved as a new course in the department of physics and is the first new (non-special topics) course introduced in the department in many years

Overwhelmingly this course is dominated, as designed, by non-majors. Developing and teaching a course where students experience the excitement of cutting edge research has been one of the highlights of my teaching career. The class emphasizes *communicating* the understanding of the exciting topics in cosmology. This is done having the students write, and polish, essays rather than in-class exams. For example, the students are asked to write a 2-page document summarizing in their own words, in language their mother can understand, "Why do scientists believe in the Big Bang?" They must explain the evidence and tell the story of the universe from the Big Bang until today. My goal is to bring this course to as many students as possible, so I have started the process of turning this course into an approved Writing course, and approval is expected shortly. Finally, since there are no good books on the subject I have made significant progress on turning my lecture notes into a textbook for the course and I expect a strong draft to be completed for the fall when I expect to teach the course again. A draft of the materials can be found at http://bigbang.physics.tamu.edu/

Mentoring of Research Students:

I mentor faculty, post-docs, graduate students and undergraduates as part of my basic research and my teaching agenda. Working with students on a long-term project on a daily basis and watching them flourish is the part of being a professor that I find the most fulfilling. Often the best time of the day is when a student I am working with comes into my office to talk, or calls, usually just to get "unstuck" on a problem. The process of helping them work through ideas and the passing on of insight or methodology is deeply satisfying to me. When our time together is over, my hope is for them to be able to carry on the conversation in their heads as if I were there with them. I am particularly proud when a student I have worked with for many months brings me a set of plots that display some new data results and says to me, "What do you think of these?" I ask a question and they say, "I figured you would ask that, so I made this plot that shows…."

I have supervised a number of post-docs, graduate students and undergraduates, and five have won various awards for their work with me. In addition, I served as official Mentor for Irina Novikova as she participated in the Graduate Fellows Program at the Center for Teaching Excellence on our work on the WebCT materials. After graduation she became a postdoc at Harvard, and is now on the faculty at William and Mary. I am particularly proud of this because there are so few women on the faculty in physics around the world.

Direct comments on the Evaluation Criteria:

IIA: Dissemination of Knowledge: Leadership/Scholarship

I have shared my innovations and leadership with my colleagues and my profession through many avenues. They include:

- Development of WebCT tools, Mastery/Precision learning tools and pedagogy for use in PHYS201, 202, 208, 218, 218 honors, and 289. Over a million quizzes have been administered. There was no web-based learning before I arrived in the physics department.
- Teaching Publication: "Integrating Web-Based Teaching Tools into Large University Physics Courses," *The Physics Teacher*, Vol 43, 595 (2005)
- Invited talk on Teaching Research and Technology: ``Integrating Web-Based Teaching Tools into Large University Physics Courses" Texas A&M "Teaching With Technology 2006" Conference (Feb 2006)
- Grants: *Montague Award* from the Center for Teaching Excellence to develop the WebCT tools listed above.
- Creator/administrator of the Physics 218 Challenge Exam and Mechanics Scholars Program since spring 2002

IIB: Dissemination of Knowledge: Recognition

- *University Professor for Undergraduate Teaching Excellence (Not yet decided),* College of Science Nominee, Texas A&M University, University-Level Award, Fall 2007
- *Distinguished Achievement in Teaching Award,* Association of Former Students, Texas A&M University, University-Level Award, Spring 2007
- *Distinguished Achievement in Teaching Award,* Association of Former Students, Texas A&M University, College-Level Award, Summer 2004
- *Presidential Professor for Teaching Excellence Award,* one of two Department of Physics Nominees, Texas A&M University, Spring 2003
- *Montague Scholar Award,* Texas A&M University, Center for Teaching Excellence, Fall 2002

- Award from the Corps of Cadets, Texas A&M University, spring 2002. I am perhaps most proud of this award. The citation reads “For true interest and enthusiasm while teaching, supporting and counseling students”
- *The Wayne C. Booth Graduate Student Prize*, The University of Chicago Award for Graduate Student Teaching, Spring 1992
- *The Gregor Wentzel Prize*, University of Chicago, Department of Physics Award for Graduate Student Teaching, Spring 1992

IIC: Dissemination of Knowledge: Mentorship

My success as a mentor is measured by the success of the students and faculty that I have worked with. Probably the best evidence of their success is that most have given presentations on their work at a conference and/or had their results published in a top journal. All of the ones who have chosen to stay in the field after graduation have gotten jobs in the field. I have been very lucky to have worked with such an outstanding group of people. A few examples of my students/faculty mentees:

- Dr. Sungwon Lee, the most recent postdoctoral student who worked with me, is now Assistant Professor of Physics (tenure track) at Texas Tech University
- Dr. Peter Wagner, my first research Ph.D. student, is now a postdoc at Penn.
- Mentoring of Alexei Safonov, junior faculty at TAMU, who was named a Center for Teaching Excellence *Montague Scholar* and an *Outstanding Junior Investigator* by the Department of Energy for his research in experimental particle physics.
- Mentor for Irina Novikova, Center for Teaching Excellence Graduate Fellow Mentor, then a graduate student at TAMU, now junior faculty at William and Mary
- Paul Simeon, an undergraduate who did research with me, was the recipient of the Goldwater Fellowship and is now a graduate student at Stanford.
- Other students of note: I helped supervise Bruce Knuteson (a graduate student at Berkeley) while I was a postdoc. He got a postdoc at the University of Chicago and is now on the faculty at MIT. The two other graduate students I worked with on the WebCT program were Andreas Mershin, now a postdoc at M.I.T and Joel Walker, now on the faculty at the Univ. of Houston.

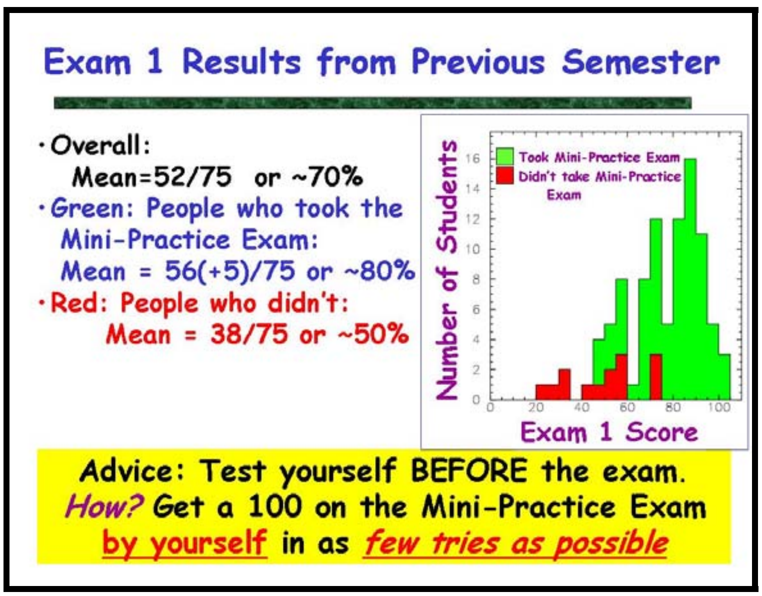
- Other students I have supervised on teaching: Jonathan Asaadi, Matt Cervantes and Eunsin Lee. Each now also has a Masters under my direction, but none yet have their Ph.D.

IIIA: Classroom practices: Teaching and Learning Goals

In many ways the essence of my teaching in PHYS 218 is an extension of my Mastery and Precision learning techniques. This makes the goals quite specific.

- I Require 100's on all the quizzes in my course to pass the class. In the many semesters I've taught, I have never had a student fail because they couldn't get a 100. I have the students keep taking them until perfection without penalty.

- I created a mini-practice exam utility in WebCT as *THE* way to study for the exam. I give them 5 bonus points if they get a 100 on it *BEFORE* the in-class exam. I show them the following slide in lecture to show *THEM* how well it works



I note that in the last semester my 80 students took almost 500 quizzes. I don't know a better way to push my student to study correctly and master the course content.

- A quick comment on the evolution of my course goals: Started with no web-based learning. Moved to SOME web-based learning. Based on the above type results I moved to all-out emphasis on problem solving using web-based homework and quiz systems.

IIIB: Classroom practices: Preparation and Methods

Some quick comments on the Physics Education Research and other sources of research I have used over the years:

- My journal article in *The Physics Teacher* draws heavily on the long-established teaching techniques of Precision and Mastery learning. These have not been widely used in large physics classroom settings because of the limited resources to implement them.
- In recognition of my expertise in the area web-based learning and large classroom teaching pedagogy I have been asked to be a reviewer for *The Physics Teacher*
- I directly address diverse learning styles by using web-based homework systems. For example, I give an unlimited number of tries so the weaker students are not penalized for their poor preparation, and all students get feedback on what they know and what they don't know. The stronger students are not held back as they quickly finish them.
- I directly challenge my top students to do well on the Mechanics Scholar Challenge exam
- I work especially hard to make my lectures accessible by trying to use language that the students know and feel comfortable with. Since the class time is long, I take a 5-minute break every class and tell one joke so that we can learn intensely during the remaining time (interactive engagement). I expect my students to have read the material before class, and reward those that do with easy quiz points. I ask lots of question in class so that they are not sitting like a drone copying down my notes to be looked over and learned later. Most importantly, I spend real effort trying to teach them how to be their own best study partner.

IIIC: Classroom practices: Presentation

I believe that that being an effective presenter in the classroom is different from being an effective teacher in the classroom. My students have been very generous with their expressing my success as both a lecturer and a teacher, which I believe to be the greatest evaluation of presentation success. Since I am not always there I developed the WebCT materials in order to supplement the classroom teaching time and maximize the opportunity for my students to find success. To maximize the number of students affected I have published and spoken at conferences on how to use technology in the classroom as a teaching tool.

IIID: Classroom practices: Results

I believe showing evidence of student growth and learning is perhaps the most challenging, and most important thing for a scientist/teacher. For my part, my students have gone on to do good things and have been recognized for their results. I try and assess how well students in my section of PHYS 218 do compared to other sections. I encourage my top student to take the Mechanics Scholar Challenge exams (which I neither write nor grade) and many, those I have inspired to have confidence in their abilities, participate. Results from my last two times teaching PHYS 218: In spring 2005, 581 students took PHYS218, and 23 took the challenge exam. I am proud that while only 127 students were in my sections (22% of the course) 12 of them took the exam (52%). One might expect my students to take half of the top scores from these numbers (or perhaps ~20%). Remarkably, I had the top 5 scorers, 7 of the top 10 and 11 of the top 15. In spring 2006 I had similar results: 41% of the students who attempted the exam were from my section, and 2 of my students were in the top 5, with 5 of the top 10. I note that, citing how much they enjoyed the 218 Challenge Exam process, we've had on an average 2 students per semester switch to becoming physics majors or take on a physics minor.

Student evaluations are another way to determine the effectiveness of my teaching style. For my “Big Bang, Black Holes, No Math” course I had a 4.77 overall average in the spring of 2007. My course evaluation numbers for a large, introductory class taught at 8AM were: spring 2005: overall mean 4.55, spring 2006, Overall mean = 4.53.

IIIE: Classroom practices: Reflection

I spend a lot of time evaluating my own work and figuring out how to improve my teaching practices. My teaching style has changed dramatically over the years as evidenced by the evolution of my web-based teaching tools, especially the development of the mini-practice exams. The comparison of teaching methods using the Mechanics Scholar Challenge Exam has also had a profound impact on my thinking. Feedback from the students in one-on-one interactions in my office and during class is a constant reminder of what the students know and don’t know, and what they find helpful. I believe that for me to continue to grow as a teacher, I have to remember what it was like to be a student and use their success as a measure of my success.