Observations on Curriculum Reform Efforts at the Universidad de Chile, the Universidad Católica, and the Universidad Técnica Federico Santa María: January 14, 2008 to January 20, 2008

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Introduction:

Active learning has made a foothold in a number of universities in Chile. Significant efforts are already underway in physics, engineering and computer science programs that encourage active learning in both classrooms and project-based learning. These efforts have benefited by enormous start-up efforts by individual faculty and are now entering the second phase of development, a phase that requires strong institutional support to insure sustainability. These efforts need to be extended across the curriculum, in particular to the first semester courses in which students are introduced to active learning techniques in all their subjects. Active learning techniques can be extended to generate a problem solving culture in which students are encouraged to become expert problem solvers in order to create a generation of engineers and scientists in which innovative and inventive thinking go hand in hand with traditional conceptual understanding and quantitative skills. A vigorous assessment program should coincide with the development of new curriculum materials including studies measuring the retention rates of women in sciences and engineering disciplines. A new set of collaborative efforts involving sharing active learning resources between MIT and the Chilean universities can enrich curriculum reform in both Chile and the United States.

I would like to especially thank my host in Chile, Dr. Patricio Poblete for making my visit possible. In addition I would like to thank Sergio Celis Guzmán from the U. Chile, Jose Ignacio Bilbao B. from the U. Catolica, and Dr. Jose Lino Contreras from the U. Technica Federico Santa Maria for their time and efforts explaining the education landscape and curriculum reform efforts in Chile.

Observation and Recommendations:

Galileo at U. Chile: The Galileo studio classroom and accompanying course materials developed by Hugo Arellano, Rodrigo Soto and Nicolás Mujica for the FIA2 – Sistemas Newtonianos represent a significant accomplishment towards introducing active learning into the physics sequence. The labs are excellently designed with an emphasis on numerical methods. (The MIT TEAL studio project will try to add materials based on the Galileo approach). Now that the first trial run has been completed, the development efforts should now shift towards closely linking the theoretical materials (currently taught separately) with the experiments in the Galileo room with a possible long term goal of consolidating materials from the first three semesters of mechanics into an integrated three semester sequence. This sequence begins with the assumption that the students are starting at the pre-calculus level and ending at the same sophisticated level of achievement as represented by the pre-existing third semester Newtonian mechanics course. In addition the Galileo room provides a learning environment that can cultivate strong teacher/student interactions based on mentoring and guidance. Additional 'whiteboard' space should be constructed in the Galileo room to facilitate multiple opportunities for interaction between instructors and students. Strong active-learning based components modeled after Eric Mazur's Peer Instruction should be incorporated into the very first semester of this sequence that emphasizes the conceptual foundations of mechanics and introduces students to collaborative learning.

Introduction to Engineering at U. Chile: The project-based learning in the Introduction to Engineering (first semester subject) with its emphasis on developing design skills and encouraging innovation is an excellent start. I would encourage bringing in local experts from engineering firms to act as consultants, mentors, and judges to create partnerships that would expose first-year students to engineers and scientists. For example projects based on developing business plans for new product designs would use local experts as judges with the goal of developing innovation and invention. The university should actively support such initiatives with programs modeled after the Lemelson-MIT Prize, "… bestowed upon outstanding mid-career inventors, who have developed a patented product or process of significant value to society, which could be or has been adopted for practical use. By recognizing and funding younger, mid-career inventors, the prize is designed to spur inventive careers and provide role models for future generations of inventors." [1]

Proposal: Introducing Problem Solving in the First-Year, Changing Student Practices. (Jose Bilbao B., Claudia Cameratti Baeza of the Universidad Catolica de Chile contributed to the following proposal).

Problem solving in traditional lecture/recitation courses is often a passive activity, students passively sit and watch their instructor solve problems on the blackboard. Homework assignments are used as checks on whether students understood concepts and analytic techniques introduced in class. When grades are assigned to homework, students often copy answers because the reward is the finished assignment and not how much they learned. In addition, students often do not have the expectation that 'homework' is a part of first and second year subjects.

Active problem solving can play an instrumental role in the learning process; students actively learn the key concepts and techniques via problem solving done outside the lecture/recitation environment. In this context problem solving measures understanding in technical and scientific courses. An educational goal for any curriculum reform should include the development of expert problem solvers who can combine factual and procedural knowledge, knowledge of numerous models, plus skill in overall analytic techniques to solve problems. This goal can only be achieved by constant practice on the part of students in solving well-designed problems.

In order to generate a problem solving culture, introduce new weekly one hour Problem Solving Sessions in subjects that are taught in the tradition lecture/recitation format that do not have any assigned and graded homework. These sessions meet at the university and are supervised by undergraduates teaching assistants. Since they meet at the university, they are suitable for a commuter student population, and are not considered homework. The students work collaboratively in groups. Their work is graded by the undergraduates immediately in the room and the grade is based on effort: either

[1] See http://web.mit.edu/invent/a-prize.html

acceptable (worked with others but the written solution is their own work) or unacceptable (the written solution has been copied from a group member). As a reward, students who only scored acceptable grades are invited to participate as undergraduate teaching assistants in future years. Solutions are posted online after the session is complete. The problems should be developed by faculty or drawn from on-line expert problem solving software with tutorial components (for example Mastering Physics). In the latter case, the undergraduate teaching assistants can use the on-line tutorials as part of their teacher training for the problem solving sessions. Consequently they will be able to answer almost all of the questions students may ask during the sessions.

Assessment and Long-term Studies:

Assessment studies should begin immediately while control groups consisting of students from traditional lecture based subjects are available. For assessment purposes, students could be given pre- and post-tests. Examples of such tests for physics are the Force Concept Inventory (FCI), Mechanics Baseline Test (MBT), or Force and Motion Concept Evaluation (FMCE)[2]. In addition, studies should be conducted regarding the impact of active learning in the first and second years on the retention rates of women in the fields of sciences and engineering. (Preliminary data at MIT suggests that retention rates increase significantly.)

Future Collaborative Efforts Between the Universities in Chile and MIT:

Based on discussions with the groups at the U. Chile and U. Técnica Federico Santa María, the Office of Educational Innovation and Technology (OEIT) at MIT will initiate the development of a central active studio learning 'portal' for the larger active learning community worldwide. In addition, two groups at MIT, the OEIT and the Experimental Study Group (ESG) would like to invite Chilean colleagues to MIT in the spring 2008 for a visit to observe TEAL, iLabs, and other educational technology projects and learning reforms currently underway at MIT (e.g., the Computer Science curriculum revision, the Cross Media Annotation System, XMAS, developed by Peter Donaldson, and other initiatives.) In addition, summer/winter exchange programs involving students at MIT and the U. Chile should be initiated.

Summary: The curriculum reform effort already underway should be strongly supported by all the universities, particularly with regards to the long process of developing, testing, and revising curriculum changes. Efforts should be directed towards the introduction of active learning at the onset of the students' educational careers. Active learning and project-based learning can play key roles in developing a new generation of engaged, innovative, and inventive students.

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[2] See for example http://www.wl.k12.in.us/hs/depts/sci/physics/hasti2005/assessment.htm for a variety of assessment tests.