Encouraging Engineering Students to Become Teachers

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A great divide exists between the dominance of technology in society and its nearly total eclipse as a topic of general study. Technology as a subject is basically non-existent in elementary education, and reserved largely for specialized students in the secondary grades. Although educational reformers and standards writers generally recognize the importance of technology in the curriculum, progress has been very slow in implementing programs in the schools. A major impediment is the lack of qualified technology teachers, or even of teacher education programs which could develop the next generation. This paper proposes a solution to this dilemma: preparing and certifying engineering students for careers in K-12 education. It describes a pilot project at the City College of New York (CCNY) which is encouraging engineering students to consider teaching as career. Finally, the paper outlines efforts to develop new pathways to teacher certification designed specifically for recent engineering graduates, as well as engineers returning from industry to education.

WHAT IS TECHNOLOGY EDUCATION?

The importance of technology is widely recognized by the standards which are now emerging at both state and national levels. Starting from the premise that "Science as inquiry is parallel to technology as design" (National Research Council, 1996, P.24) The National Science Education Standards call for the integration of the two types of activities. A similar point is made in Technology for All Americans, an effort to develop standards for technology education: "To meet the challenges of our technological world, individuals and society must achieve a basic level of ...technological competence [which] goes beyond understanding to include the ability to create, use, manage and assess technology." (International Technology Education Association, 1995, P.9).

Several common themes emerge from these standards, as well as other documents, such as (American Association for the Advancement of Science, 1993, P. 42), Banks (1994), Raizen, *et al*, (1995), Department of Education and Science (1994) and New York State Education Department (1994):

- ❏ Technology is broadly defined to include the entire array of artifacts, systems, activities and processes which constitute the designed — as opposed to the natural — world. Computers are only one example of technology.

- ❏ Children should learn to analyze existing technologies, and to develop, build and test their own designs. In doing so they should consider personal and social outcomes of technological decisions.

- ❑ The skills required for analysis and design of technologies include science inquiry skills, but also other skills more specific to technology.

- ❑ Children already live in rich environments for the study of technology. At the elementary level, technology education does not require expensive or specialized equipment; materials are already abundant and readily available in homes and schools.

Given this consensus about the importance and nature of technology education, it is ironic that "in the United States, unlike in most developed countries in the world, technology as a subject has been largely ignored in the schools." (American Association for the Advancement of Science, 1993, P. 41). The reasons for this lack are fairly obvious. Although technology education programs exist on paper in most states, there is a severe shortage of teachers qualified to teach technology in the sense described above.

For the most part, technology teachers in the U.S. fall into one of two camps. On the one hand there are the computer teachers, typically with licenses and training in other subjects, but who have developed an interest and expertise in educational computing. They teach students to use software and network applications as tools for learning a variety of subjects. Often this subject is called "technology", but learning to operate a computer does not imply learning computer technology any more than driving car means learning automotive technology. The other major group of technology teachers were formerly known as industrial arts — or simply "shop" — teachers. Their orientation is hands-on, product-oriented and usually industry-specific. As Hutchinson & Hutchinson (1991, P. 4) point out, "Much of current practice in technology education is mere 'cosmetic change' from [industrial arts]. Bird houses have been replaced with CO_2 or mouse-trap-powered cars; the t-square with a computer and CAD software." Neither the computer teacher nor the re-tooled industrial arts teacher involves students to any great extent in the analysis and design of technologies. Where will the new technology teachers come from?

TEACHING EXPERIENCES FOR ENGINEERING STUDENTS

Both National Science Foundation (1995) and Panitz (1996) have made the case for preparing engineering students for non-engineering as well as engineering careers, including education. For a variety of reasons, many engineering students find teaching to be an attractive career option. In New York City, for example, there are few entry level engineering positions, and those that do exist pay below industry standards, and frequently below starting salaries for teachers. Many students have already been involved in teaching — as tutors, workshop leaders, camp counselors or as big brothers and sisters — and have found it personally satisfying. They would like to combine their technical interests with interpersonal skills and social concerns, and see teaching as a way to do so.

Under NSF funding from the ECSEL Engineering Coalition and the New York City Collaborative for Excellence in Teacher Preparation (NYCETP), a pilot program at City College has been working to motivate a group of engineering students to consider teaching as a career. The origins of this project are described in Benenson, *et al* (1995), and more recent reports have appeared in Panitz (1996) and Florman (1996). The 15 participating students are serving as teaching assistants in exemplary design- and inquiry-based classroom settings at Brooklyn

Technical High School (BTHS). These include classes in Physics, Math and Mechanical Engineering, which have been the basis for an NSF Teacher Enhancement project, the Urban Mathematics, Science and Technology Leadership project. The Mechanical Engineering Program, led by one of us (Ed Goldman), is documented in Center for Children and Technology (1992).

In the BTHS classrooms, the City College students' roles have varied greatly. Initially, they are asked to do nothing but observe. A transition naturally occurs, in which they begin to raise questions with groups of high school students about the projects they are working on. These questions both suggest ways of approaching the problem, and also raise specific technical issues: "Do you have a diagram?" "Are you sure that beam can handle the load?" "How did you compare those alternatives?" Over time, some of the students gradually assume a collaborative role with classroom teacher, discussing the learning process in the classroom with him or her, and developing collective strategies for facilitating the progress of the groups.

Weekly meetings of the participating students provide opportunities to reflect on the classroom experiences. One recurring theme has been the kind of information students need beforehand to engage in inquiry or design projects. Some students have argued that basic technical information — for example, about series and parallel circuits or gear ratios — should simply be presented, while others say that it can only be acquired through guided experiences. Another common theme has been the responsibility of teachers to prepare students for standardized tests, versus the need to make learning exciting and fun. Many of the participating students have made the obvious comparisons between the active learning environments they participate in at BTHS, and their own experiences in more traditional settings.

A preliminary evaluation of the project, performed by one of us (Herbert Seignoret) independently of the faculty members, revealed that the project had affected both the students' view of education as well as their career goals. One student observed, "I learned more of what the role of teacher should be. Before the program my image of the teacher was where the teacher sat in front of the class and only lectured to teach the students. After the program started, I thought differently. Through my observations of the teacher's approach I was able to learn of the different approaches. For example, how groups can be used and the roles of different members of the group."

Nearly all of the participants now express interest in becoming educators at some point in their careers. One participant told the evaluator, "Before the program, I was interested in teaching, but I figured that was something I would get into when I got older or finished with my career. Now, I think that there is a greater possibility that I will go into education a little earlier in my career since this is something that I found rewarding and interesting. It kind of opens up some doors in my mind as to what I can do when I graduate." Another student has asked how she can obtain a teaching certificate as quickly as possible.

BECOMING A TEACHER

Any effort to encourage engineering students to become teachers must quickly deal with the certification problem. For good reasons, certification is an arduous process which usually

requires either that a student graduate from an approved program, or that his or her transcript be examined individually to determine whether appropriate coursework has been completed. Unfortunately, existing state standards are generally oriented towards students of education and liberal arts and sciences, and therefore make it difficult for engineering students to become certified. In New York State, for example, an engineering student who wants to become a science or math teacher is forced to take 15 - 20 additional credits in science or math, as well as 18 education credits. To become a technology teacher requires a completely new undergraduate degree in technology education, which can no longer be obtained anywhere in New York City.

During the past year and a half, faculty members from four engineering schools have met with officials from the New York State Education Department (NYSED) to propose a new certification path in K-12 Technology Education for recent engineering graduates as well as engineers returning from industry. The NYSED enthusiastically supports the idea, for several reasons. The transition from Industrial Arts to Technology Education has been difficult in New York, and engineering graduates would bring real expertise in technological design and analysis. Furthermore, there are few remaining programs for training technology educators, and engineering schools could be an important new source of teachers. In addition, the NYSED welcomes the involvement of engineering educators in setting new standards for technology education.

As an outcome of these meetings, the NYSED has agreed to approve ABET-accredited engineering programs as teacher education programs in Technology Education, provided that students also complete 12-15 appropriate credits in Education, plus student teaching. Six of the Education credits will be a specially designed, project-oriented technology education class, which would combine design and fabrication of projects with teaching methods, and include experiences with shop tools and safety practices. At City College, this course will be developed by a team including college faculty and master technology teachers from the New York City public schools, under support of the NYCETP.

Under this plan, it will be relatively easy for an engineering graduate to obtain certification in Technology Education, but many will also desire certificates in Math or Science. Approved programs currently exist at MIT and RPI which allow engineering graduates to become certified in these fields, with a minimum of additional coursework. In states which have no certification in Technology, or few jobs in that field, math or science certification would be the most viable alternative. At MIT, for example, Mechanical Engineering students are certified in Physics; Chemical Engineers, in Chemistry, etc.; in addition to the standard engineering curriculum, they are required to take education classes at Wellesley.

SPREADING THE WORD

This paper discusses our preliminary work in making teaching careers available to engineering graduates, and in establishing a new source of technologically literate teachers. This effort involves college faculty from both Engineering and Education, high school teachers, students and state education officials. It addresses several problems simultaneously: expanding career options for engineering students, increasing their awareness of educational issues, and potentially opening up the field of technology to K-12 students. We urge other engineering educators to

explore the possibilities for establishing similar programs in their own institutions and with their own state education departments.

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