Chapter 6A: Engineering and Education Partnership – Developing Highly Qualified Teachers for Colorado

Rational and Structure for Using the BS Degree in Engineering Science for the Technology Education Teacher Licensure Endorsement

Few issues evoke more passionate conversation than the education of our children. As the economy becomes increasingly global and technologically complex, our educational programs need to be strengthened to prepare today's students to be tomorrow's productive workers, citizens and leaders. Recently, the Institute for Electrical and Electronics Engineers (IEEE) cited the growing influence and complexity of technology that has resulted in the increased need for a citizenry that possesses a certain level of technological literacy to make informed decisions and maintain a reasonable quality of life.

Engineering Education requires students to learn about how people design, make, use, maintain, and manage things and systems with hands-on problem solving activities. The mission of both a nationally accredited (NCATE) Technology Education teaching endorsement and nationally accredited (ABET) Engineering Education program is to develop and educate students who can:

- Understand why and how people design, engineer, and innovate to meet human needs and wants,
- Apply ways of thinking and doing that are essential to designing and problem solving, developing, making, managing, and assessing technological systems in various contexts,
- Safely use, manage, and evaluate technological systems and engineering processes,
- Relate technology with science, mathematics and other subjects,
- Communicate technology content and processes, individually as well as in teams,
- Understand the historical and future significance of engineered designs and impacts of technological solutions, and
- Develop an awareness of, appreciation for, and engagement in career paths and opportunities in technology and engineering.

Therefore, the College of Engineering will contribute to CSU's outreach mission by improving K-12 education through a joint program with the School of Education. This program will prepare engineering students to become middle and high school teachers, thus improving education in the STEM disciplines.

Objective: **Improve K-12 education in Colorado and the region,**

Goal: Prepare K-12 teachers to better educate middle and high school students in the STEM disciplines.

Strategy: Implement a joint program with the School of Education to prepare engineering students for careers in middle and high schools.

Metrics:

- Program accreditation,
- Program enrollments, and
- Placement of graduates in K-12 teaching assignments.

The following is an excerpt of the rationale for this new program.

The National Science Board's (NSB) Task Force on National Workforce Policies for Science and Engineering (2003) has raised concerns about declining numbers of students pursuing engineering and scientific careers in the US. Likewise, an analysis of ACT data found that the percentage of high school seniors who took the ACT test and reported plans to major in engineering in college has declined from 8.6% in 1992 to 5.6% in 2002 (Noeth et.al., 2003). The declining percentage of high school students who reported that they plan to major in engineering in college exacerbates the workforce situation noted by the NSB.

Given declining numbers of people pursuing engineering, and the need to attract underrepresented minorities and women into engineering, the engineering profession has great interest in strengthening the educational pathways to engineering for K-12 students. In effect, many in the engineering profession want engineering content and method to become part of the K-12 curriculum. However, in general engineers are not aware of the efforts of technology educators to include the concepts and processes of engineering in the schools. Therefore, engineering societies have initiated projects to bring engineering into the K-12 schools. For example, in 1989 the Society of Automotive Engineers (SAE) developed *A World in Motion*. The American Society for Mechanical Engineering (ASME) proposed legislation through state by state efforts to include and strengthen science, technology, engineering, and mathematics (STEM) education content in the schools. According to ASME:

> There appears to be a logical educational continuum within which the knowledge of science, technology, engineering, and mathematics is cumulative. This implies that, without a strong and vibrant K-12 education system, the potential educational and economic impact is severely diminished. Yet . . . the cumulative benefits of science, technology, engineering, and mathematics are less than they could be (ASME Position Statement – 2002, ID #2-32, http://www.asme.org/gric/ps/2002/02-32.html, March 24, 2004).

Through academic collaborations of Schools of Education and Colleges of Engineering, we can impact science, technology, engineering, and mathematics education. By providing education in a contextual engineering environment in K-12 school programs, we can:

- Build cumulative STEM competencies in students by building on the foundation of knowledge established at each level in education, from elementary grades where students have innate curiosity about their world and how it works through middle school, high school, and beyond,
- Provide students with hands-on, open-ended, real-world problem solving experiences which are linked to the curriculum; using science, engineering, and technology modules; and grouping such experiences and modules by discipline and level of difficulty,

- Promote hands on activities for students, including research-oriented classes . . . appealing to students through authentic [contextual] research projects that emphasize the use of mathematics in reporting results, and promoting engineering and technology . . .in high school (ASME Position Statement – 2002, ID #2-32, http://www.asme.org/gric/ps/2002/02-32.html, March 24, 2004).

Schools have made great strides in upgrading Educational Technology (devices and systems such as computers, software and infrastructure used to deliver education) but have largely left out educating students in the engineering design process, how technology and engineers shapes society, and the benefits and costs of the technology engineers design for the good of humans and society. In a sense, engineering education is a primary delivery subject for delivering technological and engineering literacy using practical reasoning. This leads us into the core relationship technology shares with science, engineering and mathematics.

The Logical Combination: Engineering, science, technology, and mathematics

It is not "ground breaking news" that science, technology, engineering and mathematics tenets intertwine. For example, much of mathematics is done because of its intrinsic interest, without regard to its usefulness. Yet, most mathematics does have applications, with science and engineering providing a large share of such *applications and stimulants* to motive and inspire students to inquire, design, build, and seek solutions to problems using their scientific, mathematical, and technological knowledge, therefore it only makes solid academic and professional sense to prepare teachers who are highly qualified to deliver this content in a k-12 setting (AAAS, 1993 pg. 30).

The relationship between science, technology, engineering and mathematics is cyclical with each area relying on the other for advancement. For example, as scientific research discovers a new composite material, technology designs and engineers an application for that material that improves the way we live or work. Mathematics is the universal language that science, technology, and engineering use to communicate. Additionally, the needs of natural science and engineering often lead to the formulation of new mathematics. These four disciplines should not be taught in isolation in a school curriculum, but interdisciplinary reinforced, and continually cross referenced, as part of a dynamic triangle that ultimately researches, designs, and creates the way we live, work and play. This is a powerful, yet critical void in most public education. Therefore, engineering education as the pre-service academic preparation for the technology education teaching endorsement in Colorado would add a dynamic element to our K-12 schools. The product, a highly qualified teacher versed in the sciences, technology, engineering, and mathematics who would close the teaching gap through authentic application, exploration, design, and inquiry in Colorado classrooms.

Summary

We ask you to imagine a world, in which workers are technically competent but technologically illiterate. A world in which a person can "fix" a hardware problem with a personal computer but may not be able to evaluate the risks, benefits or tradeoffs associated with understanding if a gas-electric hybrid engine is a good investment, or if it would be better for the environment than a traditional internal combustion engine (Pearson and Young [NRC], 2002 pg. 22). Our citizens, our economy, our environment, our democracy

are all dependent upon a certain level of "technological understanding". How can a person reasonably vote in an election on issues such as "Star Wars Defense System", "human cloning", "fuel cells", "flexible transistors", "robots", "nanotechnology", etc… without having general background knowledge in engineering and technology? Unless action is taken, we are at a crossroads where citizens can be trained to do a skilled job but not understand the benefits or consequences of using a present or future technology rationally and responsibly. In reality, few students are leaving schools in Colorado today with adequate literacy in engineering and technology to become the informed citizens of tomorrow.

The study of engineering in education helps create a citizenry that is highly literate, disciplined, capable of thinking critically and creatively, knowledgeable about a range of cultures, and able to participate actively in discussions about new discoveries and choices. Students are leaving our K-12 educational systems with an adequate understanding of educational technology (computers), but dangerously lacking in the skills and abilities to make informed decisions on present and future engineering and technological issues.

In closing, we ask you to take a leadership role in initiating systemic change that will positively influence all of our children's future. The faculty at Colorado State University is committed to forging new partnerships across traditional academic and disciplinary lines to innovate, cooperate and prepare highly qualified teachers for the children and citizens of Colorado.

References

American Association for the Advancement of Science, Project 2061 . (1993). Benchmarks for Science Literacy. New York: Oxford University Press.

American Society of Manufacturing Engineers, . (2002). Improving K-12 Science, Technology, Engineering, and Mathematics Education: Options for State Legislatures. Washington , DC:

National Science Board (August 14, 2003). *The Science and Engineering Workforce: Realizing America's Potential.* http://www.nsf.gov/nsb/.

Noeth, R.J., Cruse, T., & Harmston, M.T. (2003). *Maintaining a strong engineering workforce: A policy report.* Iowa City, IA: ACT.

Pearson, G., & Young, A. T. (Eds). (2002). *Technically speaking: Why all Americans need to know more about technology.* Washington, DC: National Academy Press.

Informational Resources

National Science Foundation
http://www.nsf.gov/home/eng/
The National Science Foundation promotes the progress of engineering in the United States in order to enable the Nation's capacity to perform. Its investments in engineering research and education aim to build and strengthen a national capacity for innovation that can lead over time to the creation of new shared wealth and a better quality of life.

Science, Technology, Engineering, and Mathematics (STEM)
http://www.engineeringpolicy.org/education/
This site discusses the need for a technologically literate citizenry. There is an urgent need to develop a technologically capable workforce that can compete in the global economy. Employers are increasingly concerned about the lack of technically skilled workers. Much more emphasis must be placed on pre-college STEM education if this skill deficit is to be overcome.

Technically Speaking: Why All Americans Need to Know More About Technology,
http://www.nae.edu/nae/techlithome.nsf/
Technological literacy, a broad understanding of the human-designed world and our place in it, is an essential quality for all people who live in the increasingly technology-driven 21st century. This website explains what technological literacy is, why it's important, and what's being done to improve it.

Technology for All Americans Project
http://www.iteawww.org/TAA/TAA.html
In 1994, the International Technology Education Association (ITEA) launched its Technology for All Americans Project (TfAAP) as a means to advance student attainment of technological literacy. Technological literacy is far more than the ability to use technological tools. Technologically literate citizens employ systems-oriented thinking as they interact with the technological world, cognizant of how such interaction affects individuals, our society, and the environment.

The Accreditation Board for Engineering and Technology
http://www.abet.org/
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The Society of Manufacturing Engineers
http://www.sme.org/cgi-bin/getsmepage.pl?/new-sme.html&&&SME&
This site is dedicated to the world's leading professional society supporting lifelong manufacturing education. Through our member programs, publications, expositions and professional development resources, SME promotes an increased awareness of manufacturing engineering and helps keep manufacturing professionals up to date on leading trends and technologies.