Bringing the K-12 Stakeholders onto the Engineering Education Team

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Abstract

The enhanced global perspectives brought on by exploding information technologies have precipitated dramatic changes in industry. Recognizing that suppliers and customers are stakeholders in the product realization process and bringing them onto the production team has resulted in significant improvement in quality and efficiency.

Engineering education would do well to follow this model. Communication and cooperation between colleges of engineering and those who hire our graduates are expanding everywhere. Now we must give greater attention to our suppliers. We can no longer afford to allow our K-12 suppliers to "throw high school graduates over-the-wall" to colleges of engineering resulting in high rejection and dropout rates.

Utah's Governor has recently called for a doubling of graduates from Utah's colleges of engineering within five years and tripling in eight. This paper describes some of the initiatives underway at Utah State University to motivate, guide, and help create a more seamless experience for students who could potentially do well in engineering.

Introduction

Horror stories from the over-the-wall era of American industry are legion. These stories describe engineering designs being thrown over-the-wall to those in manufacturing, who struggled and modified the designs. The product was then thrown over-the-wall to marketing. Marketing in turn threw the product over-the-wall to the customer. Results often included an inferior quality product, high rejection rates, low profits, and unhappy customers.[1]

Global competition and information technologies have brought a transition from the over-the-wall approach to a near universal embracing of total constituency teaming. In the successful teaming model, the team is diverse and multidisciplinary. All team members are talking to each other. Engineering, marketing, manufacturing, suppliers, and customers are all talking with each other, resulting in continuous quality improvement and happier stakeholders.[2]

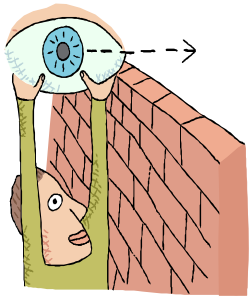
Education has much to learn from this new industrial model of total constituency teaming. Long after successful businesses have abandoned over-the-wall practices, we still see examples of education following this model. In this scenario students are thrown over-the-wall from grade to grade in the K-12 system and then catapulted over-the-wall into engineering colleges.[3] Engineering school survivors are then launched over-the-wall into industry. We are not claiming this practice is universal. Certainly there are many fine examples of articulation and communication; however, evidences that over-the-walling still permeates the system may be found in declining enrollments, unprepared disenchanted students, and unacceptable engineering

dropout rates. Any industry that rejected fifty to seventy-five percent of the raw material or supplied components coming through the door would soon be out of business. Further evidence that we on the engineering education product realization team may not be listening with sufficient attention to our industrial customers is indicated by the proliferation of industry-sponsored training and educational organizations and organized efforts to define competency gaps.[4]

We believe the results from more fully implementing total constituency teaming philosophy in education could reflect the productivity and quality improvement seen in industry. Hopefully the declining enrollments in engineering trends could be reversed, with higher retention rates, greater diversity in the profession, greater "customer" support of the educational enterprise, and greater quality improvement.

Engineering Education Constituency Teaming Model

The teaming model successful industries have used to improve quality, lower costs, and remain competitive in a brutal global playing field may be a model that merits increased attention from the engineering education enterprise.



In comparing the over-the-wall models of engineering education and manufacturing, we will refer to families, K-12, and community colleges as "suppliers". Engineering schools are the "product realization" team and our graduates are the "product". Those businesses, industries, and governmental agencies that employ engineering graduates are regarded as "customers". (We realize this analogy is greatly simplified and are aware, for example, that students may be regarded as suppliers, partners, and customers, and that our customers are, in a sense, partners.)

Following this model means that we regard K-14 suppliers and Business-Industry-Government (BIG) customers as part of the product realization team. Communication linkages would become truly wide-band, barriers would be identified and either dismantled or tunneled through, and expectations would be clarified. Mergers would be made wherever advantageous and cost-effective.

Business-Industry-Government (BIG) Partnering

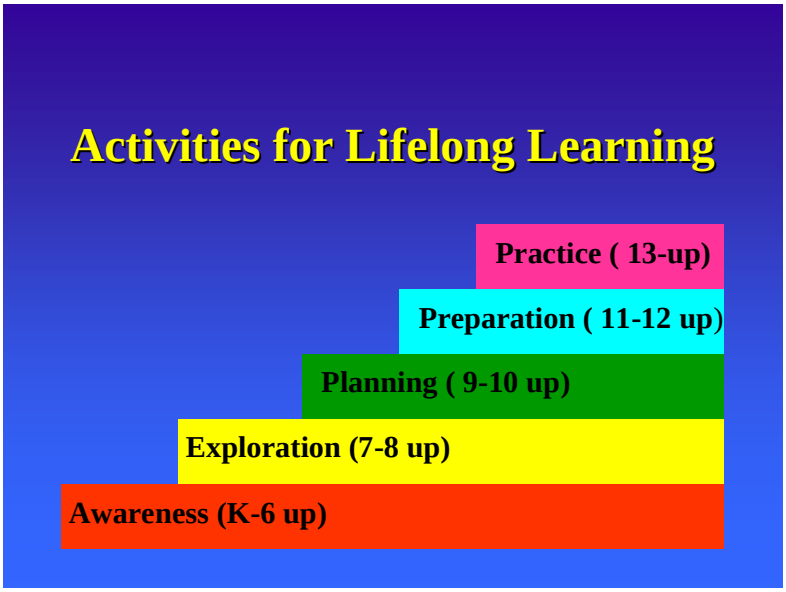
Significant attention has been devoted to fostering the ties between engineering education and our BIG customers. Colleges and departments have advisory boards that meet, pontificate, and, of course, advise. Internships/coops are becoming widespread. Industry experts are coming on campus to lecture and demonstrate. Faculty sabbaticals to industry are pointed out as being desirable though perhaps not yet adequately recognized and rewarded in the promotion and tenure process. Much of the equipment in university laboratories has been donated or heavily discounted. Government laboratories and military installations are mandated to cooperate with universities and make facilities available. Partnering with our customers seems to be growing and thriving.

K-14 Engineering Education Teaming−School-to-Careers Model

It is our observation that teaming or partnering with our K-12 or K-14 suppliers is lagging the partnering with our BIG customers. There are challenges to K-12 teaming. We have found that K-12 teachers and counselors are often fearful of math, science, and technology and thus either consciously or unconsciously do not inspire and motivate their students to consider technical careers. Engineering faculty are extremely busy and have other priorities such as qualifying for tenure and promotion. The incentives for working with K-12 are not always self-evident. Certainly the supplier connection is receiving increased attention; but while much has been done, much more could and must be done. We are suggesting that a worthy model for K-12 teaming is found in School-to-Careers/Work, a revolutionary new approach to education, which broadens educational, career, and economic opportunities for all youth.

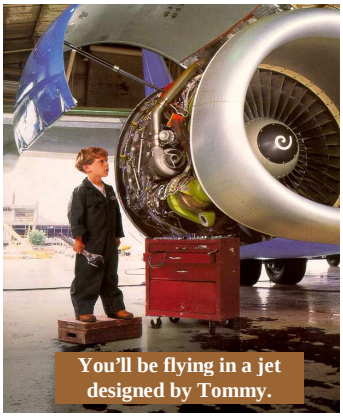
This model was proposed to assist with the problem that most schools have been slow or resistant to change while the world around us continues to change at unprecedented rates. This model helps students find learning more relevant to the world around them and prepares them to compete in the global economy. The School-to-Careers philosophy is based on the proven concept that education works best when students apply what they learn to real life and real work situations and is implemented through partnerships among business, schools, government, and community-based organizations.

Every community is crying out for more skilled and productive workers. We must teach students in the way they learn best, recognizing that all students can learn. This model focuses on articulation with post-secondary schools, smooth transitions for students with planned coordination and sequencing of courses and curricula that foster competencies, provides for contextual learning, promotes lifelong learning, and promotes high standards of academic learning and performance. Students acquire work experience related to their field of interest. School-to-Careers connects young people with supportive adults, mentors, and other role models. See Utah State University's efforts to promote this model at www.usu.edu/stc.



K-12 Initiatives at Utah State University (USU)

The national decline in students enrolled in engineering has been documented and is cause for concern[4]. Utah's energetic Governor, Michael J. Leavitt, has recently announced an initiative to double the current number of engineering, technology, and computer science graduates over the next five years and triple the current number within eight years as part of a plan to stimulate economic growth. Realization of this very ambitious goal will require some dramatic increases in system capacity, including more faculty and facilities. We are hopeful that some of the high tech industries poised to benefit from a highly trained and educated technical workforce will help provide the necessary funding.



Perhaps an even greater challenge lies in doubling and tripling the number of students adequately prepared and sufficiently motivated to succeed in these challenging disciplines. Here are some of the ongoing and proposed initiatives at USU to attract more and better-prepared students into engineering and technology.

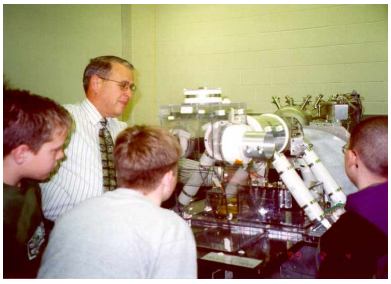
Engineering State is a program in which about 400 high school juniors nominated by their math and science teachers come to the USU campus for four days of interaction with engineering faculty and students. While on campus they participate in hands-on challenge sessions, compete for scholarships, and get acquainted with the campus. They return to their high schools and effectively serve as engineering ambassadors among their classmates during their senior year. The program is planned and coordinated by an administrative assistant in the Dean's office. Faculty members devise and revise the content of two-hour sessions in which groups of about twenty high school students are introduced to a topic and then presented with a hands-on design challenge. Students select from 28 different sessions including such titles as "Wind and Wings" (wind tunnel experiment), "Ultra Cool" (cryogenics), "Go Cad Go" (graphics), "Marvelous Machines" (gears), "Egg Drop", (parachutes), "Sound Hunt" (acoustics), "Burning Dinosaurs" (biofuel). An effort is made to ensure that at least half the delegates are women. Minorities are strongly encouraged to apply. Parents and/or high schools arrange for transportation to and from. Expenses of about $300 per delegate for housing, t-shirt, learning materials, etc., are covered through alumni and industrial sponsors. Participating faculty members donate about two days of their time and receive no additional compensation. Preliminary evaluation indicates the program is attracting more top performing high school students into engineering. See www.engineering.usu.edu/estate.

Junior Engineering State is a program in which modular self-contained hands-on demonstrations are taken to K-6 classes. Most modules are designed to delight and entertain as well as demonstrate an engineering principle and have proven extremely popular. The grade school teachers have an opportunity to become "certified" on any particular module. The result is that many of these former "technophobes" are becoming

advocates for engineering, science, and technology. Where as Engineering State involves only a few hundred students each year, Junior Engineering State modules reach more than one hundred thousand students each year.

Beginning in February of 1997, the program has been delivered by truck and van to more than 360,000 students in 650 schools in Utah, Idaho, New Mexico, Nevada, Wyoming, and Arizona. Initial funding came from the College of Engineering at Utah State University, School-to-Career funds allocated to individual school districts, and a one-time allocation of funds from the Utah Legislature. The program is seeking foundation funding to expand staff from two to four persons and reach more schools. The program director estimates the costs of delivering five to seven lessons or modules to 500 students on a typical school visit to be approximately $1200. The delivered cost per module per student is about forty cents. This seems to be a tremendously cost-effective approach to raising the awareness of science, math, and engineering in the K-12 system. See www.engineering.usu.edu/jestate.

Through **Job Shadowing**, the School-to-Careers Coordinator makes arrangements for a K7-12 student to be in an engineering workplace for a few hours. The student gets acquainted with a real live engineer, watches what goes on, asks questions, and develops a better concept of what a certain kind of engineer does. See www.usu.edu/stc.



Through **Workplace Tours**, the School-to-Careers Coordinator facilitates arrangements for a group of students to tour a workplace where exciting, impressive engineering work is taking place. Perhaps they watch designers using parametric-based graphics to create dazzling 3-D images or white-coated technicians assembling components in a clean room. During such visits we have heard students comment about how they had never thought engineering could be so cool.

With **Engineering Student Ambassadors**, some truths become self-evident. The K-12 student body relates much better to young enthusiastic engineering students than to tired older highly stressed engineering professors. We have found that engineering students enjoy visiting K-12 classes to demonstrate some "gee-whiz" senior design product, chat with the kids, and send the "if I can do this, you can too" message. Our women engineering student ambassadors make particularly effective role models for the younger women.


Future engineers?

As engineering curricula become increasingly crowded and legislative limits cap numbers of credits required for the BS degree, we have seen some upper division engineering courses moved into the graduate curriculum. We are also seeing lower division courses that have long been part of the freshman and sophomore engineering curriculum moved into the high schools through **Concurrent Enrollment**. Many have resisted this

trend, claiming loss of quality and difficulty in articulating with the high schools. We think concurrent enrollment makes sense in the teaming environment we are advocating. Many engineering students are entering the university armed with advanced placement calculus, chemistry, English, history, graphics, and economics. We are now involved with an articulation effort to move the freshman Introduction to Engineering course into Concurrent Enrollment status in Utah high schools. The course, involving extensive hands-on design and build, seems to be more successfully directed by the high school technology faculty than by math or science faculty. As an incentive for high school students to more aggressively pursue concurrent enrollment opportunity, Utah's Governor is proposing that the State subsidize university tuition for those students who enter the university with substantial university credit already on their transcript.

Teaming with Colleges of Education

The fundamental national need to further enhance the technical awareness of K-12 teachers is becoming more urgent.[5] One approach is through in-service workshop experiences to convey the message that engineering is fun. If the enthusiasm level of the teachers toward engineering, science, and technology increases, hopefully that enthusiasm would spread to the students.

Massachusetts has officially mandated engineering in the preschool through twelfth grade curricula.[6] Other states are sure to follow as educators recognize children in a technological world need to be taught problem solving skills. Engineering faculty in other states are already devising strategies to assess the effectiveness of reaching out to K-12 programs.[7]

Another approach is to take a longer-range view and address the issue from a pre-service perspective. We are working toward approval of an Engineering Education degree in which the candidate would major in engineering and complete the typical engineering and science courses through their junior year. In order to keep degree requirements within a reasonable four-year schedule, they probably would not take all of the senior design and technical courses required for an engineering degree. They would take the secondary education courses required to obtain their teaching certificate. Internships could include student teaching as well as field experience. We believe such a degree would be particularly attractive to women who are concerned about finding a career compatible with family life. Many women are attracted to teaching in K-12 because the work schedule would be similar to their own children's school schedule. It seems with more teachers who are proficient in the basic engineering sciences, more K-12 students would be motivated to pursue engineering careers and thus help to reverse the current trend of declining enrollments in engineering.

Summary and Conclusions

We have strongly suggested that engineering education should adapt the teaming model of successful industry and better utilize and build on the School-to-Careers philosophy in the K-12-14 relationship. This will require rejecting all vestiges of the "ivory tower" or "elitist" mentality that has been associated at times with university academics. We must recognize that engineering faculty are not alone in the engineering educational enterprise and bring our K-12 suppliers onto the team.

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