AC 2011-2194: SPECIAL SESSION: WHAT WORKS TO RETAIN STUDENTS IN CHEMICAL ENGINEERING PROGRAMS

Adrienne R. Minerick, Michigan Technological University

Adrienne Minerick is an Associate Professor of Chemical Engineering at Michigan Tech having moved from Mississippi State University in Jan 2010, where she was a tenured Associate Professor. She received her M.S. and Ph.D. from the University of Notre Dame in 2003 and B.S. from Michigan Technological University in 1998. Adrienne's research interests include electrokinetics and the development of biomedical microdevices. She earned a 2007 NSF CAREER award; her group has published in the Proceedings of the National Academy of Science, Lab on a Chip, and had an AIChE Journal cover. She is an active mentor of undergraduate researchers and served as co-PI on an NSF REU site. Research within her Medical micro-Device Engineering Research Laboratory (M.D. ERL) also inspires the development of Desktop Experiment Modules (DEMos) for use in chemical engineering classrooms or as outreach activities in area schools. Adrienne has been an active member of ASEE's WIED, ChED, and NEE leadership teams since 2003.

Donald P. Visco, Tennessee Technological University
Susan M. Montgomery, University of Michigan

Susan Montgomery is Lecturer IV and program advisor in Chemical Engineering at the University of Michigan. She also serves as ASEE campus representative. She earned a BSEChE from the University of Michigan and MSEChE and PhDChE from Princeton University.

Daina Briedis, Michigan State University

DAINA BRIEDIS is a faculty member in the Department of Chemical Engineering and Materials Science at Michigan State University. Dr. Briedis has been involved in several areas of education research including student retention, curriculum redesign, and the use of technology in the classroom. She is a co-PI on two NSF grants in the areas of integration of computation in engineering curricula and in developing comprehensive strategies to retain early engineering students. She is active nationally and internationally in engineering accreditation and is a Fellow of ABET.

Neeraj Buch, Michigan State University

Neeraj Buch is a Professor in the Department of Civil and Environmental Engineering at Michigan State University. He is also the Director of Cornerstone Engineering and Residential Experience program at Michigan State University. He earned his M.S. degree in pavement engineering in 1988 from the University of Michigan, Ann Arbor and his Ph.D. in pavement and materials engineering from Texas A&M University, College Station, in 1995. Dr. Buch began his academic career at Michigan State University in 1996. Dr. Buch has worked on numerous projects funded by state highway agencies (MDOT, CDOT, South Dakota DOT), the FHWA, SHRP II, NSF and the NCHRP. Dr. Buch has performed research on characterization of Portland cement concrete mixtures and their impact on pavement design and performance, pavement response and performance modeling, and pavement preservation. Recent research includes the investigation of design and construction factors on the response and performance of new flexible and rigid pavements (LTPP program), the effectives of precast panels as a rapid repair alternative, the impact of dowel misalignment on the performance of concrete pavements, evaluation of the new ME-PDG for the state of Michigan and the characterization of thermal properties for the various aggregate lithologies in Michigan. Dr. Buch teaches undergraduate and graduate courses in concrete materials and pavement engineering. He is also involved in teaching short courses on pavement design and rehabilitation and pavement materials for practicing engineers in Michigan. Throughout his career Dr. Buch has consistently been recognized for his sustained excellence in teaching. He has received several teaching awards at the college, university, and state level. He is a co-PI on two National Science Foundation grants in the areas of integration of computation in engineering curricula and in the area of retention of early engineering students. He is a member of TRB committees AFN20 (Propoerties of Concrete), AFD50 (Rigid Pavements) and AFD70 (Pavement Rehabilitation), and the AASHTO TIG on Precast Concrete Pavements. He is also a member of the ASCE/T&DI highway pavements committee, ASCE LTPP Task Committee and the chairperson of ACI committee 325 on rigid pavements. Dr. Buch was recently (2009) elected as a Fellow of the American Concrete Institute. He serves on the board of the International Society

Concrete Pavements (ISCP). He is also an instructor for the Portland Cement Concrete (PCC) Overlays: State of The Technology Workshops sponsored by the Federal Highway Administration and the American Concrete Institute.

Jon Sticklen, Michigan State University

Jon Sticklen is the Director of the Center for Engineering Education Research at Michigan State University. Dr. Sticklen is also Director of Applied Engineering Sciences, an undergraduate bachelor of science degree program in the MSU College of Engineering. He also is an Associate Professor in the Department of Computer Science and Engineering. Dr. Sticklen has lead a laboratory in knowledge-based systems focused on task specific approaches to problem solving. Over the last decade, Dr. Sticklen has pursued engineering education research focused on early engineering; his current research is supported by NSF/DUE and NSF/CISE.

Colleen A. McDonough, Michigan State University

Colleen A. McDonough is a graduate research assistant at the College of Engineering at Michigan State University. She is the coordinator of two component projects of a National Science Foundation grant focusing on retention issues and engaging early engineering students, and also serves as an academic advisor. McDonough earned a bachelor's degree in sociology from William Smith College and a master's degree in Public Administration from the University of Southern California. McDonough is currently a third year doctoral student in the Higher, Adult and Lifelong Education program at Michigan State. Her areas of interest include educational theory, student development and engineering education.

S. Patrick Walton, Michigan State University

S. Patrick Walton is an Associate Professor of Chemical Engineering and Materials Science at Michigan State University. He received his B.ChE. from Georgia Tech, where he began working in biomedical research in the Cardiovascular Fluid Mechanics Laboratory. He then attended MIT where he earned his M.S. and Sc.D. in Chemical Engineering while working jointly with researchers at the Shriners Burns Hospital and Massachusetts General Hospital. Upon completion of his doctoral studies, he joined the Stanford Genome Technology Center, receiving an NIH Kirschstein post-doctoral fellowship. He joined Michigan State University in 2004, and his research is focused on the engineering of nucleic acid technologies through mechanism-based design. In addition, Professor Walton received MSU's Teacher-Scholar award in 2010 and was a 2010-2011 MSU Lilly Teaching Fellow.

Amanda M Portis, Michigan State University
Eldred H. Chimowitz, University of Rochester

Eldred Chimowitz is a professor of chemical engineering at the University of Rochester. He teaches courses in process design and control to undergraduates and statistical mechanics and thermodynamics to graduate students. He is the author of a textbook titled: "Introduction to Critical Phenomena in Fluids" which was published by Oxford University Press in 2005. It was nominated for an American Association of American Publishers Award for Excellence in Scholarly Publishing. Jennifer Condit who helped prepare this paper is the Chemical Engineering Undergraduate Program Coordinator at the University of Rochester. Part of her responsibilities include keeping a close eye on retention and enrollment issues for the program. She received a BA in English from Ithaca College.

Willie (Skip) E. Rochefort, Oregon State University

Skip Rochefort is currently an Associate Professor of Chemical Engineering and the Director of OSU Precollege Programs (http://oregonstate.edu/precollege) and the Center for Outreach in Science and Engineering for Youth (COSEY) at Oregon State University. He has degrees in Chemical Engineering from the University of Massachusetts (B.S., 1976), Northwestern University (M.S. 1978) and the University of California, San Diego (Ph.D., 1986). He has held several industrial research positions (Dow Chemical, Kodak, AT&T Bell Labs), and since 1993 he has been on the faculty in the OSU Chemical Engineering Department. He is an OSU Honors College faculty and has been recognized for his teaching and advising activities by ASEE, AIChE, the College of Engineering, and Oregon State University. His research interest for the last 35 years has been in all areas of polymer engineering and science, and for the last 18 years in engineering education. His passion is K-12 outreach for the recruitment and retention of women and minorities into engineering, with the current focus on introducing engineering science at the middle school and high school levels. His K-12 outreach activities can be found at http://cbee.oregonstate.edu/education/.

Keith L. Levien, Oregon State University

KEITH LEVIEN has an Engineering Science degree from Iowa State University (BS) and degrees in Chemical Engineering from the University of Wisconsin, Madison (BS and PhD). Between chemical engineering degrees he worked for four years at the Warrensville Research Center of SOHIO (now BP). His research areas are reaction engineering, process control, and supercritical fluid technology. He has taught process dynamics, control and reaction engineering since coming to Oregon State University in 1985 and has twice served as acting Chair of the Chemical Engineering Department. In 2001 he introduced the use of the LEGO RCX microprocessor for data acquisition, along with MATLAB, in a project-based design and programming course called ”Engineering Problem Solving and Computations”. This course is now required for all first-year students in the School of Chemical, Biological and Environmental Engineering.

Nimir Elbashir, Texas A&M University

Dr. Nimir O. Elbashir is an assistant professor at Texas A&M University at Qatar and has over fifteen years of research and teaching experience. His research activities are mainly focused on design of advanced reactors & catalysis for the Gas-to-Liquid technology, petrochemical industry and environmental processes. He held several industry positions in research and development (R&D), and business development in addition to several academic positions before joining TAMUQ. Dr. Elbashir holds several US and European patents with more than fifty scientific publications in forms of journal articles, conference proceedings, and special industry seminars. Dr. Elbashir completed research studies on design of reactor technology and applied catalysis for several world-leading chemical and petrochemical companies (e.g. BASF Corporation, SABIC R&T, and Nippon Oil Corporation). The scholarly of his research activities has been recognized by the Gordon Research Conference, BASF Corporation, and the American Institute of Chemical Engineers (AIChE).

Jennifer Condit, University of Rochester
Stephen Lindeman

Special Session: What Works to Retain Students in Chemical Engineering Programs

Introduction

Student retention is an important issue that every department and college must face, especially as more states link their appropriations to student retention rates (and shift from entering enrollments). This paper outlines the efforts of six works from five different institutions that contribute to the retention of students as well as any special efforts to retain students of differing demographics (gender, race / ethnicity, first generation college students, etc.). The efforts at each institution are discussed in separate sections below (with headings in underline). This session will include presentations from each contribution team followed by an open panel discussion on overarching best practices.

In the respective sections below, successful program-level and course-level efforts, especially at the Freshman/Sophomore level, are discussed. It is valuable to note the creative approaches that most enthuse students to continue to study chemical engineering and connect with their discipline, program, and faculty mentors. Personal interactions and sustained communication are themes that arise. In addition, connecting with the students via technology or by focusing on current topics are themes that have yielded success with regards to retention.

Creating a Caring Community in Large Program

Susan Montgomery, University of Michigan, Ann Arbor, MI

Introduction

It is a challenge for many students to feel a sense of belonging at large universities. We aim to develop a caring community to support our diverse student population of close to 500 undergraduate students. 34% of our students are women, and 11% are international students. Of our American citizens who listed a race, 76.3% are Caucasian, 14.4% Asian, 3.8% Hispanic, 3.1% African-American, and 2.4% multiracial. Faculty, upper level students, student groups and alumni help provide our students with support in both academic and career related matters. These activities, many of which are easily duplicated at other schools, are described below.

Connecting with first year students

The first year in the College of Engineering at the University of Michigan is a year of exploration, with no major-specific courses. Students who list ChE as first or second choice during freshman orientation or at majors' fairs are added to a "first year ChE" email list, which is used to provide relevant information such as how to make appointments and choosing appropriate courses. I meet with students to discuss our program and complete long-term course plans.

Welcoming and supporting our sophomores

The first 15 minutes of the first day of ChE 230, the Material and Energy Balances course, serve as a welcome to the department. The department chair, representatives from all departmental student groups and I extend our welcome, and provide information of how we can assist them. Students then complete forms letting us know their academic plans, organizations they plan to join, future goals, etc., which we include in their files and enter into our advising database.

We are fortunate that through our AIChE mentoring program. upper level students serve as mentors to sophomores, and officers prepare sophomore-specific career programming. Sophomore representatives also organize events such as "sophomore game night" to help build community. The Omega Chi Epsilon honor society provides group tutoring for our sophomore courses. In addition, the department hires upper level students to serve as Instructional Aides. Pairs of IAs run Sunday review sessions and offer additional office hours. Additional students are hired as tutors to provide additional office hours and one-on-one tutoring.

Many of our sophomores become disheartened after the first exam in the material and energy balances course. I invite our seniors who struggled themselves and are now close to graduation to share words of encouragement to pass on to our sophomores, and they respond with heartwarming expressions of support. Many discussions follow with sophomores on improving study skills and time management, as well as conversations about impostor syndrome. These activities have significantly decreased the number of students on probation or in front of the college's scholastic standing committee.

Our office arranges an industrial panel in ChE 230 the Friday prior to the college's career fair wherein alumni help our students understand the range of opportunities and encourage them to go to career fair. Three faculty members share their experiences in a similar research panel organized by the instructor later in the Fall.

Some chemical engineering departments might choose to address some of these career issues in a separate 1-credit survey course that serves as an overview to the field, with discussions of career paths, panel sessions and roundtable discussions. This is certainly an option some departments might consider.

Supporting all our students

At the end of every semester, I review all student transcripts and send email messages to about half our students commending them for improvements in performance or expressing concern about declines. Students who need to improve academically are invited to biweekly meetings to discuss performance and time management, and are referred to university resources as warranted.

Our undergraduate email group is used extensively to provide our students with information about summer and permanent job opportunities, upcoming academic deadlines, preparation for career fairs, resume reviews, international opportunities, registration planning advice, professional engineering exams, as well as share relevant advice, such as discussions of mental health issues and time management. I also invite students to let us know of any events they might be involved in, such as music performances, cultural events, or major sports activities, and share this information weekly with our students, faculty and staff.

Given the economic situation of many of our students, we are finding an increasing number of them not able to afford the expensive textbooks that we require of them. Our alumni have been supportive of our efforts to provide free ChE textbooks to students who would otherwise not be able to afford them themselves.

We use our alumni email group of over 700 alumni, and LinkedIn group of over 550 alumni and friends to solicit advice in many areas, such as how to prepare for internship fairs and interviews, why participation in extra-curricular activities is important, which elective courses to take, among others. Our "loyal alumni" also notify us of internship and permanent job opportunities, which we pass on to our students. In addition, many alumni participate in the college's student-alumni network program, and are always eager to mentor students individually.

Conclusions
An undergraduate office can help create a sense of community within a large population of undergraduate students. Upper level students, alumni and faculty are eager to assist and can easily be engaged to support undergraduate students. While we did not perform a thorough analysis to determine the quantitative effectiveness of these endeavors, anecdotal evidence, from students who were strongly considering leaving the program but chose to stay who cite some of these activities as instrumental to their decision to stay, gives us confidence that these efforts are worthwhile.

Effective Educational Practice for Student Retention: The Personal Touch

Colleen McDonough, Neeraj Buch, Jon Sticklen, Tom Wolff, and Daina Briedis, Michigan State University; East Lansing, MI

Undergraduate engineering enrollments have declined substantially over the last decade in the College of Engineering at Michigan State University. The local decline has been beyond that in most other areas of the US, exaggerated by the state's economic decline. Over the past two and one-half years, the College of Engineering has initiated aggressive recruiting and retention programs. This abstract describes a piece of the NSF-funded project aimed at student retention and specifically focuses on attracting students to chemical engineering within the context of the broader engineering student population.

First year students
About 900 first-year students declare engineering as their intended major in our college annually. Long-standing efforts to retain these students have been accelerated, and new developments include a newly redesigned first-year experience and a residential program that includes freshman and sophomore engineering students in one living, learning community. Students may declare a discipline or "no preference," but are not admitted to engineering until they satisfy certain course requirements at specified levels of achievement. The challenge faced by our faculty is how—given these 900 new students--

to attract them specifically to chemical engineering. In particular, we are interested in retaining those highly qualified students who may leave engineering for other pre-professional majors.

Causes of attrition from STEM majors, particularly beginning students, have been studied extensively and are fairly well known. The noted National Survey of Student Engagement (NSSE) identifies five benchmarks of effective education practice, two of which deal directly with various aspects of the work described in this abstract—student-faculty interactions and a supportive campus environment. The program, called the Connector Faculty project, has been developed to nurture faculty-student interactions. The approach includes both social and personal interactions between students and faculty and is targeted at the qualified students who leave engineering because they perceive it as sterile and uncaring.

First year courses

The new first-year engineering courses, EGR 100 (Introduction to Engineering Design) and EGR 102 (Introduction to Engineering Modeling), are taught by a faculty team with one lead instructor. Course projects are developed by the team, which includes a chemical engineering faculty member. The projects are designed to have broad appeal and must be conducted safely without special equipment. Unfortunately, these constraints and "majority rule" have limited what can be done to specifically demonstrate inspiring chemical engineering problems.

Thus, to specifically encourage students interested in chemical engineering, a particularly strong group of Connector Faculty volunteers has been established in our program. Students in EGR 100 are assigned to Connector Faculty based on declared major; some "undeclared" majors are also matched with chemical engineering faculty. These faculty members meet with their students individually and in groups for informal discussion, for career advice, sometimes for study help, and frequently for meals or coffee; faculty tailor their student interactions to suit their schedules and their personalities.

As suggested by NSSE data, getting students over the threshold of faculty offices may be one of the most difficult steps in establishing connections. Students often view faculty as having threatening personas, so enhancing the approachability of faculty is a major factor in establishing continuing relationships.

To do this in a non-threatening way, a formal course requirement and a large social event were combined in one venue. First, the EGR 100 students were given a writing assignment to determine how engineers in their declared disciplines might address some of the Grand Challenges for Engineering (http://www.engineeringchallenges.org/). Next, early in the semester, each department in the college hosted a two-hour evening open house—the "Freshmen Connect"--for the EGR 100 students. This social event which included refreshments (sponsored by Shell Oil in our department) was linked with the required written assignment for EGR 100. Students attended the gathering, listened to selected faculty talk about their research, and then divided into small break-out groups to talk about chemical engineering in the context of the Grand Challenges. The evening was concluded by tours of the chemical engineering research and teaching lab facilities.

After the week of large-group meetings, informal face-to-face meetings between faculty and student continued through the semester.

Conclusions

Early results show both that the program is viewed positively by students and that retention rates are improving. MSU is a Carnegie Foundation RU/VH institution, and the faculty reward system is typical of all other such institutions—significant reward for scholarly research with a nominal expectation for "good" teaching and service. It appears that at least a core group of chemical engineering faculty, most already with significant commitment to excellence in undergraduate education, has shown a willingness and commitment to participate in an academic culture that values personal student-faculty interactions and to make engineering the caring environment that it can be.

Text Messaging as a Tool for Enhancing Student-Instructor Interactions and Increasing Student Retention

S. Patrick Walton*, Daina Briedis*, Stephen D. Lindeman*, Amanda M. Portis*, Jon Sticklen#, *Department of Chemical Engineering and Materials Science, #Center for Engineering Education Research, Michigan State University; East Lansing, MI

This generation of student is more interconnected than any generation to date. From a variety of social networking opportunities to the pervasive use of mobile devices, students are fully comfortable interacting with people that, in some cases, they have never even met face-to-face. Current modes of communication among instructors, however, still typically default to, in some order or preference, face-to-face meetings, email, and phone calls. As such, there may be a disconnect in the ways students would prefer to interact with their instructors and the ways available to them. It would seem, then, that to maximize student engagement, retention, and support, *instructors should consider interacting with their students using means that the students prefer.*

The genesis of the project was the observation that attendance at office hours has decreased dramatically in the last 5-10 years, an observation supported by anecdotal evidence from colleagues. Over the same time period, social networking and text messaging have become pervasive and essentially universal among our students. Thus, we seek to leverage the comfort students have with texting to enhance students' willingness to venture further outside of their comfort zone in their interactions with their instructor. In doing so, we hope to establish stronger faculty-student connections. It is well-established that students who feel a personal connection with their instructor are more likely to persevere through the scholastic and personal challenges that inevitably arise during an undergraduate career.

Project Goals

The goal of the project was to test two **hypotheses**. Firstly, we hypothesized that **students will prefer to interact with their course instructor via text messaging**, as compared to other means such as email, phone calls, and office hours. Second, it is hypothesized that **students who utilize text messaging to communicate with their instructor will also be more likely to use more traditional interaction methods**. The basis for this hypothesis is that if a student makes initial contact with the instructor via a method with which the student is most comfortable, then the student is more likely to engage further with the instructor through means, such as office hours, with which the student is less comfortable.

We are testing these hypotheses during Fall, 2010 in CHE 201, Material and Energy Balances, at a large, public university. Because of the newness of the material, the relative difficulty of the problems as compared to their prior experience, and the relative youth of the student population, this class provides an ideal setting for testing whether new modes of interaction can improve the utility and frequency of student-instructor interactions and, in turn, improve student performance, learning, and retention.

The experimental approach is as follows. The students in one of two course sections have been provided a texting number. Each day at the end of class, the students in both sections are asked to submit "muddiest point papers" describing the most confusing part of the day's lecture. In one section, all of the submissions are using paper, while the "texting" section is allowed to use either paper or to text their responses, as they choose. The students in both sections are also regularly reminded of the available office hours, should they need any assistance.

The students in the “texting” section also have the number at their disposal for use outside of class, should they want to do so. This provides students another means to contact me with any concerns or questions they have. This allows students to communicate with me without having to call, which can be intimidating, or without first having to access a computer to send an email. This is also far more accessible to students than chat utilities such as that available through instant messaging. In addition, the brevity of text messages may also be preferred to more "formal" emails.

To assess the project during the term, we are collecting all of the "muddiest point" responses and recording attendance at office hours (name and section of each student) and class. At the end of the term, we will compare these data between the sections, to ascertain if the "texting" section in more, less, or equally likely to attend class and office hours. Also, we are surveying the students at both the beginning and end of the term to determine their attitudes towards communication and any changes to those attitudes, in particular, whether they felt that texting improved their interactions with me, their interactions with their classmates, and their understanding of the course material. These data will be compiled along with end-of-term student evaluations, student grades, and demographic data to provide a broad description of both the students' attitudes/perceptions and their performance.

Data to date suggest a few interesting trends and caveats, though strong conclusions are difficult to draw with the limited amount of data. First, when interacting with their instructor, students choose text messaging (8 muddiest point messages and 14 other messages) over voice calling (1 call), though not nearly as often as email (186 messages). This is biased in part by the fact that email was the preferred mode of dissemination of course information from the instructor and TA, whereas neither the TA or instructor initiated course discussions via text message. Students used texting to set up appointments and check on the status of events (e.g., review sessions). The results argue that students will use texting if it is available and will do so preferably to voice calling, even if both require accessing a phone. As it is well-known that instructor accessibility is strongly related to student persistence, it suggests that making text messaging available to students is a low effort, big payoff means of enhancing student-instructor interactions.

Second, given the option of using paper or texting for turning in “muddiest point” comments, students overwhelmingly chose paper (over 1000 paper submissions vs. 8 by text message). This was somewhat unexpected given the universality of texting among these students for communication outside of class. Perhaps with their pencils/pens already in hand for note-taking, paper submissions proved more convenient. Another explanation is that longer submissions are more easily completed by paper. Regardless, the reasons for this discrepancy remain unclear. Nonetheless, it appears that our first hypothesis should be rejected.

In testing our second hypothesis, there may be encouraging results. Overall, the class section with the option to text had higher average attendance at office hours over the course of the term (0.92 visits/student) versus the section without texting (0.87 visits/student). Also, students in the section where texting was used were more likely to email than students in the other section (3 messages/student vs. 1.8 messages/student). We do not have sufficient data to test the statistical significance of these results, but they do suggest that the availability of texting, whether used or not, may have encouraged student interactions with the instructor and persistence in the class. Continued analyses will delve further into these interesting results.

Summary

The evolution of student-student communication would seem to necessitate an evolution in student-instructor communication. Initial results suggest that making texting available to students may be a means by which to foster improved interactions, even if students generally are unwilling to text their instructor. Further study will be required to confirm this conclusion and establish a downstream relationship to improved student retention.

Methods and Results: Improving Student Enrollment and Retention in the Undergraduate Chemical Engineering Program at the University of Rochester

E.H. Chimowitz, B. Ebenhack, J. Condit, Department of Chemical Engineering, University of Rochester, Rochester, N.Y.

Concerned with decreasing enrollments in the chemical engineering major the Department of Chemical Engineering at the University of Rochester set out to publicize and educate the student body at the university about the program. From a pedagogic point of view we instituted a new **Green Engineering Cluster** of courses intended to educate students in the opportunities afforded by the profession. A few years ago we began offering a new introductory, non-calculus based freshman engineering course called **Green Energy**. Topics in the course have included: i) fossil fuels, ii) energy conservation, iii) fuel cells, iv) solar cells, and v) environmental economics. These areas have been carefully chosen to reflect the University of Rochester Energy Initiative. Each topic is taught by a different faculty member which means that the course is fast-paced and students have the opportunity to meet many of the department faculty early in their stay at the university. This often leads to further opportunities for students to pursue internships with faculty as early as the summer following the freshmen year.

The course has been a success. It now draws more than **half of its students from outside the department, many coming from social science and humanities disciplines and is widely considered to be one of the most successful courses in the freshman curriculum. Enrollment and retention of undergraduate students in chemical engineering have also improved enormously as a consequence of this effort-see the data in the attached two tables.** Our data shows that enrollment in the course has increased from approximately ten to seventy students over the past four years and freshmen-sophomore chemical engineering retention rates have been in the neighborhood of 90% or higher. We define retention as the percentage of declared chemical engineering undergraduate students in CHE 150 who go onto their sophomore year as chemical engineering majors. The course outline and teaching materials can be seen by visiting the department's website (www.che.rochester.edu).

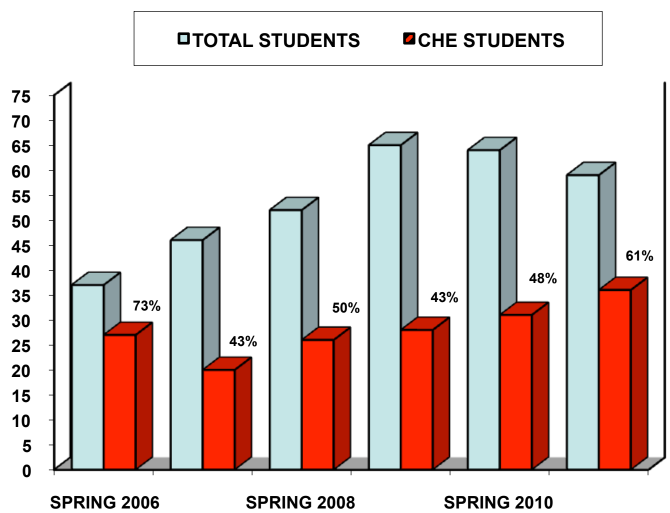

Figure 1 – Distribution of Undergraduate Students in CHE 150

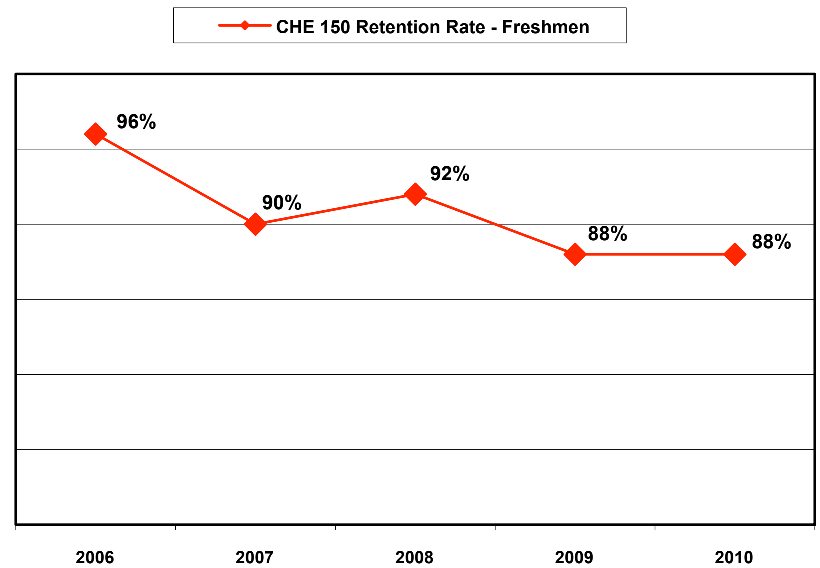

Figure 2 – Retention Rate of Chemical Engineering Students in CHE 150

<u>Recruiting and Retaining Students in Chemical Engineering Through First Year Experience Courses, First Year Student Research Experiences, and K-12 Outreach Activities</u>

Skip Rochefort and Keith Levien, School of Chemical, Biological and Environmental Engineering, Oregon State University, Corvallis, OR

The Chemical Engineering Department at Oregon State University recently combined into the School of Chemical, Biological, and Environmental Engineering (CBEE), offering ABET accredited BS degrees in Chemical Engineering, Bioengineering, and Environmental Engineering (CBEE). As with many programs, our student numbers are rapidly growing, with the first and second year class sizes increasing by approximately 25% per year over the last 3-4 years to current levels of 180-200 per class. The School of CBEE student population is also approximately 35-40% women, which is by far the highest in the college of engineering. This has led to a substantial increase in the number of students in the First Year Experience courses. The goal of the first year courses is to both provide career guidance to the students looking for the correct career path, as well as personal attention they need to make these decisions, and to fully integrate them into the "CBEE community" at the very beginning of their college experience. The retention activities include two first year courses that are heavily project oriented; individualized student advising with a faculty member in the student's chosen discipline; an active and supportive CBEE Student Club (AIChE Student Chapter); K-12 outreach activities with first year students acting as mentors for middle and high school students; and the Johnson Scholar and Internship Program, a summer research experience for up to 20 first year students. These retention activities will be discussed in more detail in the following sections.

First Year Experience Courses and Academic Advising in CBEE

The School of CBEE currently has 18 faculty and 600 undergraduates in the three disciplines, with approximately 65% ChE, 20% BioE, and 15% EnvE. Oregon State University is on the quarter system and there are five CBEE specific courses offered in the first six quarters that the students are on campus, all of which are taught by faculty and not instructors or graduate teaching assistants. This in itself provides a substantial degree of direct contact with the students in the first two years and affords them the opportunity to get to know both the School and the faculty early in their careers. To enhance the connection to the School and the students chosen major, each of the First Year students is assigned a discipline specific faculty advisor. These advisors stay with the students throughout their entire time in the program, providing continuity in advising and helping to build relationships which are very important when students require recommendation letters for internships, REU programs, and eventually graduate school applications or entering the workforce. There is also a Head Advisor for the School who is available to all undergraduate students.

Most of the First Year students take CBEE 101 Introduction to CBEE and CBEE 102 Engineering Problem Solving and Computations in their first two terms. These are both 3 credit courses with five hours of contact time in the format of lecture (1 hr), lab (2 hr), and recitation (2hr). Both have a significant amount of group project work. The labs and recitations are limited in size to 30-40 students with typically two undergraduate student mentors in each section, in addition to the faculty instructor. While this is a time intensive format for the faculty, we have found that it is almost irreplaceable in providing the students with the exposure to the profession that they are looking for early in their college careers. This connection is especially vital to the retention of our top students, who are always looking for something more and have a drive to understand how all the math and chemistry they are doing will help them to "change the world". While technical skills, time management, and other necessities for survival in college are addressed in CBEE 101, the overarching goals (and those most important for student retention) are best summarized in the first two (of five) Course Learning Objectives:

By the end of the course, each student must demonstrate the ability to:

1. Describe the kinds of professional activities in which engineers are involved, including the social, ethical, and environmental responsibilities of the profession in the 21st century;
2. Recognize the roles of Oregon State University, the College of Engineering (COE), the School of Chemical, Biological, and Environmental Engineering (CBEE), and the Accreditation Board of Engineering and Technology (ABET) in their undergraduate education.

CBEE 102 is a bit more pragmatic in that it must address the ABET requirements of teaching a structured programming language. However, this is done in a novel format of a group RoboLab project in one lab session (with an extensive round-robin tournament at the end of the term) and the use of MatLab programming in the recitation section. Limiting these sections to 30-40 students with undergraduate mentors and faculty provides this large class (220 students in Winter 2011) with a significant amount of small class interaction. Summarizing, the key to retention in both First Year courses is the concept of large classes being subdivided into smaller class sections with a significant amount of group work (allows students to meet each other) and contact with undergraduate student mentors and faculty.

CBEE Student Club and K-12 Outreach Activities
The Chemical, Bioengineering, and Environmental Engineering departments combined into a single School several years ago. At that time the faculty decided that there should be a single Student Club, with AIChE as the professional affiliation for the club. The CBEE Student Club encompasses the three majors with leadership distributed equally amongst the three (ChE, BioE, and EnvE President, VP, representatives for each year, with shared positions for secretary, treasurer, social and marketing chair, etc.). That format has worked very well in unifying the undergraduate population, while still providing them with that unique identity that they crave. All First Year students in CBEE 101 are required to join national AIChE (why not…it's free!). The CBEE Student Club is the social hub of the School and is charged with everything from hosting recruiting visits by companies to organizing volunteers for University Days and other student recruiting events. One area where the CBEE Student Club has been particularly active as a community service component is in K-12 Outreach. Each year, a dozen K-12 outreach events are hosted on campus, and 8-10 Family Science and Engineering Nights (FSEN) are presented in collaboration with the Students of the American Chemical Society (SACS) at local elementary school science fairs. This has been a great way to get first year students engaged in both the School and in promoting their disciplines, and consequently in feeling good about their chosen career path (which translates to high retention!).

In summary, we have found that the key to student retention is in getting them connected and involved with the School in their very first days on campus. This is accomplished by providing them significant attention and support in the first year classes, getting them connected early with upper division students and faculty, and quite simply providing them with a community that they can relate to at the very outset of their college careers. These concepts were inspired by, and are an extension to the larger scale, of the Transitional Learning Community movement of recent years.

A Program to Recruit and Retain Students to the Chemical Engineering Major The Experience of the Chemical Engineering Program of Texas A&M University at Qatar (TAMUQ)

Nimir O. Elbashir, Chemical Engineering Program, Texas A&M University at Qatar, Education City, Doha, Qatar

Texas A&M University opened a campus in the Education City of Qatar in 2003 by offering Bachelor of Science degrees in four engineering majors; chemical, electrical, mechanical and petroleum. The curricula offered at Texas A&M University are materially identical to the ones offered at the main campus in College Station, TX and courses are taught in English in a coeducational setting. The reputation for excellence is the same, as is the commitment to training engineers equipped to lead the next generation of engineering discovery. Qatar has world-class natural gas reserves, as well as significant reserves of petroleum and it host the most advanced existing plants and refineries in Gas-to-Liquid (GTL) technology, Liquefied Natural Gas (LNG), in addition to several chemical and petrochemical plants. Nevertheless, our program has experienced challenges in recruiting students to the Chemical Engineering major as well as retaining number of our freshmen despite the high demands for chemical engineers in Qatar and the Gulf region. The loss of students in the freshman and the sophomore years exceeded 30% from the original intake between 2004 to 2007 with the majority switching major to the Petroleum Engineering followed the Mechanical Engineering and the Electrical Engineering majors. Students who requested to change major attributed their decisions to one or more of the followings: the difficulty of the Chemical Engineering courses compared to the other majors (specifically compared to Petroleum Engineering), lack of interest to work in refineries or chemical plants, parents request to change majors, the challenges they faced in chemistry freshmen courses and others.

Beginning in 2008, the Chemical Engineering Program noticed the importance of addressing this challenge by developing a Retention and Recruitment Program focusing on our freshmen and sophomore students. This project also aimed at educating all TAMUQ students about the Chemical Engineering field and it also involves orientation sessions to high school students as well as to their parents. Several strategies have been developed to guarantee the success of this project including:

1. Teaching Freshmen Courses: We noticed the importance of participating in teaching freshmen courses as the first interaction between Chemical Engineering professors and freshman students. As part of this activity I have developed the syllabus for major freshman classes that cover special topics on fundamentals of engineering to freshmen class (e.g. ENGR 111 and ENGR 112 courses). In these classes, I developed special sessions about the role of chemical engineering in our life under the slogan that "the Chemical Engineering has wider career choices than virtually any other major". We have also invited experts from industry and government institutions to participate in these classes.
2. The Chemical Engineering program has also made an attempt to organize with the Chemistry professors the teaching of the basic Chemistry courses, specifically on the freshman chemistry courses. Many of the students who changed major from Chemical Engineering attributed their decision to the difficulty of the freshmen Chemistry courses and their worries of the Chemical field to be the same.
3. With the Students Affair Office we organized a "Career Exploration Day" that aimed at educating TAMUQ students and the community about the chemical engineering field and its potentials. We developed special show materials and presentations as well as we requested the help of our alumni and their companies to come and participate in this event and share their experience and success stories with their colleagues who are still students as well as to freshmen and sophomore students.
4. One of the most creative initiatives in this program is the development of the "Students' Mentor Program" where our senior and juniors students volunteered to mentor their freshman and sophomore colleagues. This program includes both academic advising and career advising under the supervision of faculty advisor. This program that recently started will provide a significant help in ease the myths

and worries about the difficulty of chemical engineering courses compared to others (e.g. petroleum engineering course).

Even though this program has so far positively impacted both our recruitment and retention efforts at the Chemical Engineering Program of TAMUQ (see Figure 3) it still has great potentials to significantly raise its intake for freshman students relative to the other three engineering programs (Petroleum, Electrical, and Mechanical). Preliminary data shows that from Spring 2008 to Fall 2010 we have achieved an increase of student intake from the freshman class while the number of students that changed major from chemical engineering dropped to below 8%. Our focus at this stage is to conduct a detailed assessment of each of the aforementioned projects, while working to further advanced them and look for other initiatives.

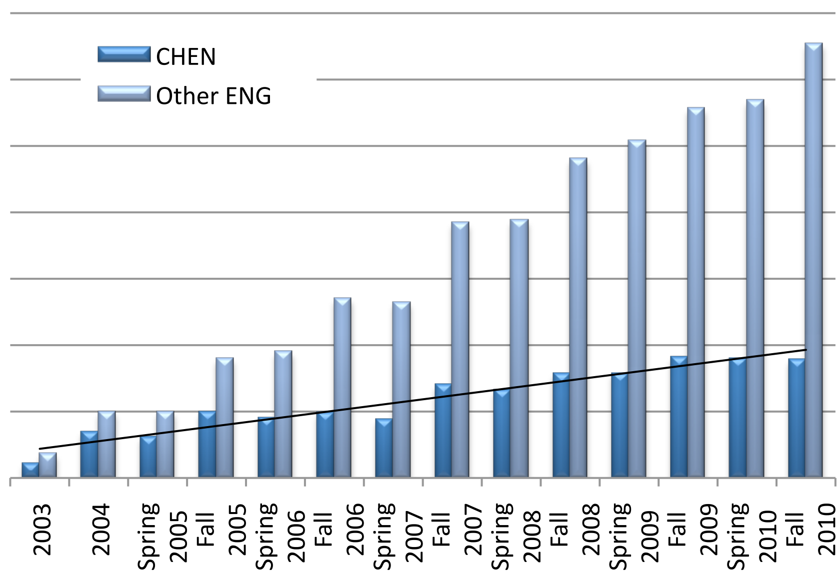

Figure 3 Student intake at TAMUQ to the Chemical Engineering Program and the other three programs.

Concluding Remarks

As demonstrated with the diverse programs discussed above, student retention in chemical engineering is an important issue that five programs have tackled with success. Strategies to increase or optimize personal interactions and communication are described. Course-level and program-level activities that enthuse students to continue to study chemical engineering and connect with their discipline, program, and faculty mentors were presented. Evidence is presented that upper-level students interacting with underclassman is both a popular and effective strategy for retention. Additionally, faculty interaction with students early in their career is important in establishing connections with students. It is the hope of the presenters and session moderators that the ideas presented in this work and during the presentations will aid other faculty as they attempt to develop or modify retention efforts at their institution.