AC 2011-2473: DEVELOPMENT OF THE SUPPLY CHAINAN AP ENGINEERING EXPERIENCE FOR HIGH SCHOOL STUDENTS AT THE STATE LEVEL

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DEVELOPMENT OF THE SUPPLY CHAIN—
AN AP ENGINEERING EXPERIENCE FOR
HIGH SCHOOL STUDENTS AT THE STATE LEVEL

In this paper, we describe a pilot project in which the College of Engineering at the University of Arizona offers their *Introduction to Engineering* course at high schools throughout the State of Arizona. At the high school (HS), the course is taught by HS teachers who are appointed adjunct instructors by the College. The participating instructors typically have experience teaching AP calculus or science or, alternatively, career and technical education (CTE) engineering courses. The adjuncts receive two-weeks training from university faculty members who have offered the on-campus version of the class. Curriculum is supplied by the college and the HS instructors are given the freedom to supplement the curriculum with their own materials (most do). The HS students are admitted to the university as non-degree-seeking students and register for three units of ENGR 102—the same credit and course designation used for the on-campus engineering students. Students are recruited into the class by the HS instructor acting locally. The course is targeted toward HS seniors who have previously exhibited an interest and proficiency in math and science. Tuition is assessed, though at a greatly reduced rate (approximately 75% discount). College algebra and trigonometry are required as co-requisites for enrollment, and many of the students have had, or co-enroll in, calculus and AP science.

Motivation and rationale—the inception of the project

For the Fall 2006 entering class, the College of Engineering (COE) at the University of Arizona moved in a new direction to improve incoming student quality. The COE was asked by the University to improve student retention and responded by asking to install procedures to simultaneously increase incoming student quality. Our approach was to screen applications and generally admit better students. We also initiated a pre-engineering program geared to retain students whose records suggest that they are unlikely to graduate in engineering. This pre-engineering group now takes part in a special "student success" seminar, is given priority for special mathematics tutoring, and is advised at the College level rather than the Department level.

Since 2006, we have made great strides:

- Our average SAT math and verbal average of new freshman has increased from 1195 to 1230+
- Our high school academic GPA of new freshman has increased from 3.35 to 3.62
- Our 1st year retention at the University has increased from 78% to 85% and we have had 4 consecutive years above 80%.
- Our (underrepresented) ethnicity of new freshman has stayed at approximately 30%
- Our percentage numbers of new freshman women students has increased from 18% to 22% and we have not seen a downturn in freshman women similar to what was seen across the Nation.[1]

Our new freshmen headcount has fluctuated between 453 (Fall 2006) and 561 (Fall 2009), and we enrolled 475 new freshmen in Fall 2010; our admissions numbers for Fall 2011 are closely tracking those of 2010 and quality is still improving. Our undergraduate enrollment has decreased, from 2513 in Fall 2006 to 2264, however the number of graduates has remained constant at approximately 450 per year. Our goal is to increase the number of graduates to 600 per year and this will require increases in new student enrollment (to ca. 3000) and an increase in student retention in engineering programs.

To this end, and at the suggestion of a HS principal in an affluent Phoenix, AZ, suburb (Dr. Fred DePrez, principal of Chandler (AZ) Hamilton HS), the COE piloted an "AP" introductory engineering experience. The program started in Fall 2008 at Hamilton HS, hereafter referred to as CHHS, with 20 students. The course was taught by a CHHS instructor, Mr. Jim R. Clark, whose credentials included a BS EE, an MS EE, an M Ed, and 5 years experience as an EE at Motorola. The course ran 36 weeks and expanded on what was covered in ENGR 102, viz. a broad survey of engineering, engineering professionalism, as well as a set of design/dissection exercises. The students had access to University computing and library systems.

To quickly launch the pilot, several decisions were made that helped avoid protracted bureaucratic and administrative delays within the school district. The first was that the HS course was not offered for HS credit; instead the students simply took the course for three units of University credit and the CHHS teacher was appointed a COE adjunct member of the faculty. The university-credit decision also made it easier to attract the best CHHS students to the course—there were no worries about HS GPA, honors credit, etc., and the students could say to their peers that they were taking a college course. To make the university-credit arrangement financially tractable for the HS students and their families, the COE waived their percentage of the University tuition bill, which reduced the course cost to $350/student; CHHS agreed to pay the instructor his regular salary, though part of his teaching assignment did count toward CHHS credit.

Contemporaneously with the implementation of the one-HS pilot, COE submitted a successful proposal to the Arizona Department of Education to secure funding ($0.5M) for a larger scale pilot, on the order of 20 HS. As of Fall 2010, we have grown to 16 schools and approximately 200 enrolled students. The receipt of State funding has helped attract additional funding from large (national, multi-national) companies with local interests in Arizona's STEM workforce development. Pledged private sector support has totaled $150k to this point. The first increment of project funding came in the form of a $25k education grant from a high-technology company with operations in the CHHS suburb (Intel Corporation), which pushed along the one-HS pilot and helped lay the foundation to pursue the larger funding from the State.

We started with the postulate that this approach will lead to increased numbers of engineering students in the COE and the State, and would be:

- effective at increasing student self efficacy for engineering which has been shown to be critical for eventual enrollment and retention in engineering programs,[2]
- effective at increasing the interest of high quality students in pursuing an engineering degree and this will lead to larger enrollment in schools across the country.

There are no nationwide AP Engineering courses for a variety of reasons including:

- There is no standardized nationwide "intro to engineering" curriculum or common education learning outcome standards. Each University has a different class with different outcomes and objectives.
- There is no teacher training for engineering courses and there is a perception that there will be a shortage of qualified and interested high school teachers. If the experience is poor, then the class will not be a gateway towards university level engineering programs.

There are however many "engineering in high school" approaches that are currently being tested, including the approach of taking a freshman course back to the high schools (for example - the Ohio State Project with Walnut Hills High School[3–5]) and:

- **Infinity Project**[6] **–** This is largely a digital electronics program that is rather narrow in focus. It makes use of Labview software for visualization but can be short on explaining "why" things are happening. In some nearby local/regional implementations of Infinity Project, we learned that the strongest students were not satisfied with the explanations and the materials. In all cases, the students were not satisfied with the breadth of the class and wanted to know more about other fields.
- **Project Lead the Way**[7] **–** This is a four-year (trying to expand to 7 years to include middle schools) program that has some 250,000 students enrolled in various phases throughout the Nation. The program starts with a design/drawing course and then eventually leads to a capstone experience. It is well received and has significant university support. Courses in years 2 and 3 can be from specific disciplines. The program can be accepted for college credit in many engineering technology programs and a few engineering programs. From the PLTW web site - "High school students involved in PLTW strive to complete a minimum of the three foundation courses, one specialization course, and the capstone course." Typically this will be 5 high school credits. In our State's HS system, taking the entire 4-year program covers all of the electives that a student has available. This is rather confining for high caliber students and restricts the ability to take courses beyond the minimum required in fine arts, foreign language, social and behavioral science, humanities, and physical education and athletics. At our University, 95% of the students in the Honors College (honors program) have some "fine arts" component in their profile and take AP classes in Literature, Psychology, Economics, Government, and Music. If we are to attract the top students, then we must accommodate and engage their broad interests, as well as introduce engineering ideas. The initial costs for the program can be large ($100k+), but there may be funding sources within the "technical education" (CTE) dollars provided in some school districts. We would rather that engineering not be tightly associated with technical education; we would prefer that it be considered in a professional framework with medicine, law, business, and science.
- **Engineering Your Future**[8] **–** This is a set of text books that can be used in high schools and in freshman experiences. The material is project based and covers a broad array of topics including professionalism, history, and employment. This is a set of materials that could be used to support a class and there are many other competitor textbooks in this market. There is a "student manual" that has exercises and case study type problems.
- **First Robotics**[9] **–** This is a 6-week contest experience that is designed to be exciting and, challenging. The basic idea is to use an electronics/mechatronics design project to get kids thinking that engineering is interesting and rewarding. The students work with industry mentors and this is a major strength of the idea. One could build a course around the experience, however the basic idea centers on the competition. Success at the competition level entails commitments to travel, and often involves financial resources beyond what the typical household wants to invest.

Our approach is different in the following ways:

- The approach requires a one-year investment on the part of the student, as compared to multi-year programs such as Project Lead the Way. This allows students with a variety of interests to try engineering. There is the notion of a “false negative” here – a student that does not major/study engineering in university, yet can be successful and happy doing engineering. This program can reduce false negatives as strong math students who are exploring different educational paths can do so with little risk in a known and safe high school environment. The high school teacher is far more likely than the university instructor to get high school students to try engineering It is more expensive to explore at the university level and hence students do little exploring in engineering. The approach can also reduce “false positives” – students that think they want to do engineering at the university level, do not know much about the discipline or university programs, and eventually leave university programs from lack of interest or lack of performance.
- The approach is an opportunity to show high school students that engineering is really about helping people and making use of skills in mathematics and science. Students in the class will also be taking advanced math and advanced science as co- and pre-requisites. The existence and reputation of such classes will give younger students a tangible, realistic, and exciting target. We can use students in the high school classes as ambassadors down into the middle schools.
- The approach targets the stronger students in each school (this was the Principal DePrez’s main interest). The data for AP calculus classes show that this is a gender balanced group; nationwide the Math AP test taker group is 250,000 students and 52-48 male-female. Retention studies show that students that come with AP calculus are highly successful in the COE. Currently only 30 - 40% of the freshman students from the 2006 and 2007 entering classes had calculus AP credit. There is room for growth and this is a large pool of students on a national level.
- The approach shows the student the academic expectations of a university level engineering class/program and includes on-campus experiences. The students earn university credit (if they opt to do this) and it gives them an ability to move to more advanced courses if they decide to persist in engineering.
- The approach is flexible. We work with private and public high schools. We work with selective (e.g. magnet) schools; we work with schools that are not. The schools do not have to serve affluent communities. We work with schools that have CTE engineering programs (our course serves as the senior-year capstone); we work with schools that do not.

The remainder of this paper describes the program, as well as the evaluation relative to the goals of self efficacy.

Project tasks: key steps

Setting up such a program is difficult in a college of engineering, as it is far different from what one would normally do with residential students. Our efforts were aided by the arm of the University that runs continuing education and educational outreach programs. The following key tasks were required for implementation:

- Creating content – we had to take the content of the on-campus ENGR 102 course and put this in a format that is accessible to HS teachers. At the time the project was initiated, we did the following activities in our on-campus course:
  - The course is taught in a large main lecture format (1-time per week, professionalism) and a small section format (2-times per week, design process, teamwork).
  - 2 design projects – one project is a solar oven as it is especially interesting in the southwest as it dovetails with our efforts in sustainability. The second project is "instructor choice" and has been both construction oriented as well as dissection oriented. The projects have a mathematical modeling step where the students use engineering science models to predict performance in advance of construction.
  - Outside lectures – speakers to show what engineers doing in real world situations.
  - Major selection – we run open house presentations where students can do some exploring. At this point, our largest majors for incoming freshman are "undecided" and "pre-engineering" so there is real demand for this material.
  - Software tools – introducing, for example, SolidWorks and MSExcel.
  - Teamwork, ethics, and strategies for academic success – items such as how to work well in teams, engineering ethics (using case studies), student ethics (what is expected from students), and how to be a successful engineering student including: where to get help, what are the key processes that you have to navigate, and what is expected in terms of study time and grade achievement.
- Training teachers – we had to design and run a two-week summer training program for teachers. This required the effort of our administration team, as well as our teaching faculty. Over 30% of the $0.5M funding for the project is tied to this task.
- Recruiting schools, teachers, and students – to get a school into the program, one must forge a relationship with the principal and a key teacher. Both are critical as there was no progress when we did not have administration support.
  - We found that nearly every school had an enthusiastic math or science or technology teacher that was highly interested in moving forward with the approach. Usually, it was a calculus/advanced math teacher or a physics teacher.
  - We also presented at state-level teacher conferences and met with district-level administration. We worked with the State Department of Education to help identify and advertise our programs to relevant HS's. We, in turn, agreed to serve on state education committees related to HS engineering programs.
  - Students select classes in February of the preceding semester so this lead-time must be considered in planning. We also spoke with students and parents if necessary to explain the program.
- Administering the classes and blending our processes with existing university systems – the University has well-structured processes for application and bill paying and these were constraints on the program. We went into each class to ensure that students filled out the applications appropriately. For billing, the COE rebated tuition in order to make the class affordable and competitive with community college tuition rates.
- Community building – besides the teacher training, we held community building events for teachers and administrators. One of our strategies to help improve teacher quality was to develop a set of projects/activities that anyone could use.

- Evaluation – we will speak more to this, but the entire project went through a "human subjects" review process to ensure a safe and fair evaluation. Surveys were largely used to measure student attitudes, teacher attitudes, and overall effectiveness. Evaluation reports are due semi-annually to our major funding agency.
- Develop funding – At the current level, the program needs funding for a full-time coordinator, as well as graduate student and faculty support for material development and teacher training. There are also funding needs for paying HS teachers during summer training (the individual schools pay the teachers as part of their regular class load), financing the training costs, financing extraordinary school supplies and projects, evaluation costs, and travel to and from the University campus. We have enlisted the help of corporations, as well as state-wide STEM networks/patrons. We have also submitted proposals to NSF (pending) and EPA (denied) for funds to develop new materials (sustainability and engineering grand challenges) that can also be used in our on-campus ENGR 102 class. Finally, the COE obtained an NSF GK-12 grant that is associated with the program and with this; we can put engineering graduate students presenting exciting research topics in the local HS classroom.

Assessment/evaluation activities

We carry out assessment/evaluation activities on several levels:

- We evaluate the course at each HS, much as we would an on-campus course in the COE. In this case, we are trying to establish if the HS instructor is doing a good job of teaching the course. The results of these evaluations for AY 2009-10 were remarkably good (data not shown), which suggests that the HS instructors execute their part of the project in ways that leave the students satisfied with their experience.
- We do before-and-after self-efficacy surveys of the HS students. Here we want to know if the course has affected the self-efficacy of the students in engineering. We use the AWE Longitudinal Assessment of Engineering Self-Efficacy (LAESE) survey.[10] We visit each school early in the Fall and late in the Spring to administer the survey. Parental consent for the survey is secured when the student enrolls.
- We administer a survey that includes questions from the Arizona Department of Education, which are directed toward determining whether or not the course has increased student interest in math and science; we also look at whether or not students took the course in HS, when they might not have taken the course at the university level.
- We also assess the summer workshop that we use to train the HS teachers (we will not report on these results here).

As noted, an important goal of the project is to evaluate the effect of the HS engineering experience on student self-efficacy, viz. the effect of ENGR 102 on student beliefs and motivations regarding engineering as an attainable goal. Rittmayer & Beier[11] provide a recent overview of self-efficacy in STEM fields. Here, we put forth selected results on the self-efficacy aspects of our assessment activities.

To evaluate the effect of ENGR 102 on HS students' self-efficacy pertaining to engineering, before and after surveys are administered each academic year. The AWE Longitudinal

Assessment of Engineering Self-Efficacy (LAESE) — High School Version survey is the primary instrument for evaluating student self-efficacy, feelings of inclusion and outcomes expectations.[10] The LAESE undergraduate instrument has been tested and validated on male and female engineering students and measures self-efficacy of undergraduate students studying engineering or high school students. [10] LAESE survey instruments are available through the Assessing Women and Men in Engineering web-site: www.AWEonline.org. LAESE covers the following aspects of self-efficacy:[10]

- Student efficacy in "barrier" situations
- Outcomes expected from studying engineering
- Student expectations about work load
- Student process of choosing a major
- Student coping strategies in difficult situations.
- Career exploration
- Influence of role models on study and career decisions

Pre-survey and post-surveys are administered per the following steps:

1. A letter which describes the study and invites the students to participate in the study are mailed to the prospective study participant's home at the beginning of the school year. The letter clearly states that participation in the study is strictly voluntary and that the student's enrollment or grade in ENGR 102 HS (or any course) will not be affected in any way by his or her decision to participate or not to participate in the study. The Subject Informed Consent Form/Parental Informed Consent Form and a stamped envelope are included with the letter.
2. When a signed consent form has been received from the student and his/her parent(s), a Participant ID will be assigned to the student.
3. Depending on the availability of computer labs, the students may have the opportunity to take the survey during class time. If so, only the representative from the University is present. No one from the high school is present in the classroom. All students are informed that participation is strictly optional. If a computer lab is not available, participants are asked to take the survey outside of regularly scheduled class time on any computer with internet access allowing for full privacy.
4. The ENGR 102 HS instructors do not know which of their students choose to participate and which choose not to participate in the study. All ENGR 102 HS students are allowed to remain enrolled in the class regardless of whether or not they choose to participate in the study. The students grades or standing in the class will be in no way affected by the study.
5. The survey begins with a statement informing the student that he/she may elect to discontinue participation at any time during the study.
6. The survey results are gathered by the Project Coordinator and Project Evaluator and stored on a secured server and/or in a locked file cabinet. Only the Project Coordinator and the Project Evaluator will have access to the list of Participant ID numbers and the individual responses to the surveys.
7. The results of the surveys are aggregated, evaluated and reported by the Project Coordinator and/or the Project Evaluator. The data, results, evaluations and reports are be stored on the secure server and/or in a locked file cabinet.

8. The ENGR 102 HS instructor will not know which students participated in the study and will not see the data of any individual student.

Assessment results for self-efficacy in engineering

To date we have results for AY 2009-10, when six HS's participated in the program (16 HS's are participating in AY 2010-11). During the Fall 2009 semester, all students enrolled in ENGR 102 HS were invited to take the LAESE survey. Signed consent forms were obtained before students were allowed to participate in the online survey, which was administered via Survey Monkey. Participation in the survey was strong (though better in the Spring than Fall). Table I shows the number of students enrolled in ENGR 102 HS in 2009-10 and the number of students that completed the surveys by gender. During AY 2009-10, only students enrolled in the course were invited to participate in the study. In future years, students in a control group (student who are eligible to take ENGR 102 HS but choose not to enroll) will be invited to participate in the study.

Table I: Class Enrollment and Survey Participation

Gender	**Enrolled in ENGR 102 HS**		**Participated in Survey**			
			Fall 2009		**Spring 2010**	
Male	67	80.7%	23	71.9%	63	84.0%
Female	16	19.3%	9	28.1%	12	16.0%
Totals	83		32		75	

The data collected are shown in Tables II thru V. Students generally expressed high levels of self-efficacy and expected outcomes both prior to and following the class. Although the significance of the data has not yet been established, our findings are discussed below.

As shown in Table II, the percentage of male students that believed they could succeed in an engineering curriculum decreased slightly from the beginning of the school year to the end of the school year (87.0% vs. 82.3%), while the percentage of female students that believed they could succeed in an engineering curriculum increased slightly (77.8% vs. 83.3%). The difference was greater when considering whether "someone like me can succeed in an engineering career". Males' agreement with this statement declined considerably (91.3% to 78.7%) while females' agreement with this statement declined little (77.8% vs. 75.0%).

Similarly, the percentage of male students that believed that they would succeed in their math and sciences courses decreased (91.3% vs. 82.0% for science and 87.0% vs. 73.8% for math) while the percentage of female students that believed that they would succeed in their math and sciences courses decreased less (88.9% vs. 83.3% for science and 77.8% vs. 75% for math).

As shown in Table III, while the percentage of students who believed that they could complete the math requirements for most engineering majors did not change substantially over time

(90.6% vs. 89.0%), the percentage of students who believed that they could complete the science requirements for most engineering majors declined (96.9% vs. 83.3%).

Table II: LAESE - Feelings of Inclusion and Expected Outcomes

To what extent do you AGREE?	% Agree and Strongly Agree					
	Fall 2009			Spring 2010		
	All	Male	Female	All	Male	Female
I can relate to the people around me in my classes	81.3%	78.3%	88.9%	73.0%	71.0%	83.3%
I can succeed in an engineering curriculum	84.4%	87.0%	77.8%	82.4%	82.3%	83.3%
I have a lot in common with the other students in my classes	37.5%	30.4%	55.6%	45.9%	45.2%	50.0%
Someone like me can succeed in an engineering career	87.5%	91.3%	77.8%	78.1%	78.7%	75.0%
The other students in my classes share my personal interests	37.5%	34.8%	44.4%	31.5%	29.5%	41.7%
I can succeed in an engineering curriculum while not having to give up participation in my outside interests	68.8%	69.6%	66.7%	69.9%	72.1%	58.3%
I can relate to the people around me in my extracurricular activities	65.6%	65.2%	66.7%	76.7%	73.8%	91.7%
I think I will succeed (earn an A or B) in my science courses	90.6%	91.3%	88.9%	82.2%	82.0%	83.3%
I think I will succeed (earn an A or B) in my math courses	84.4%	87.0%	77.8%	74.0%	73.8%	75.0%

Some of the results shown in Table III are cause for concern. For example, only 16.7% of female students agreed with the following statement on the post LAESE survey, "*I am confident that I can cope with doing poorly (or not as good as I had hoped) on a test*" and only 54.5% of female students expressed confidence that, "*I will feel 'part of the group' on my job if I enter engineering*". In the post LAESE survey, 91.7% of the girls that participated indicated that they can relate to the people around them in their extracurricular activities. Only 50.5% of the girls taking the post survey indicated that they have a lot in common with the other students in their classes.

The results shown in Tables IV and V indicate that the class may have achieved a desired goal to help students decide whether engineering is a suitable choice for them. The number of students that were very confident that they would be in an engineering program in the next five years increased from 37.5% to 52.1%. Unfortunately, the percentage of students that indicated that they were not planning to pursue an engineering degree increased from 6.3% to 16.4%.

Table III: LAESE - Self-Efficacy, Interests and Expected Outcomes

I am confident that......	% Agree and Strongly Agree					
	Fall 2009			Spring 2010		
	All	Male	Female	All	Male	Female
I can complete the math requirements for most engineering majors	90.6%	95.7%	77.8%	89.0%	88.5%	91.7%
Doing well at math will enhance my career/job opportunities	96.9%	95.7%	100.0%	87.7%	85.2%	100.0%
A degree in engineering will allow me to obtain a well paying job	100.0%	100.0%	100.0%	87.7%	85.2%	100.0%
I can excel in engineering	90.6%	91.3%	88.9%	83.3%	83.3%	83.3%
I will be treated fairly on the job. That is, I expect to be given the same opportunities for pay raises and promotions as my fellow workers if I enter engineering	80.6%	81.8%	77.8%	76.7%	78.7%	66.7%
I can complete any engineering degree	75.0%	69.6%	88.9%	65.8%	65.6%	66.7%
I can cope with doing poorly (or not as good as I had hoped) on a test	50.0%	47.8%	55.6%	53.4%	60.7%	16.7%
A degree in engineering will give me the kind of lifestyle I want	78.1%	78.3%	77.8%	75.0%	73.8%	81.8%
I can make friends with people from different backgrounds and/or values	100.0%	100.0%	100.0%	80.6%	78.7%	90.9%
Doing well at math will increase my sense of self-worth	75.0%	78.3%	66.7%	66.2%	66.7%	63.6%
I will feel "part of the group" on my job if I enter engineering	73.3%	71.4%	77.8%	67.6%	70.0%	54.5%
I can complete the science requirements for most engineering majors	96.9%	95.7%	100.0%	83.3%	83.6%	81.8%
Taking math courses will help me to keep my career options open	100.0%	100.0%	100.0%	84.7%	82.0%	100.0%
I can cope with friends' disapproval of my chosen major	90.6%	87.0%	100.0%	86.1%	85.2%	90.9%
A degree in engineering will allow me to get a job where I can use my talents and creativity	90.6%	91.3%	88.9%	76.4%	75.4%	81.8%
I can cope with being the only person of my race/ethnicity in a class	90.6%	91.3%	88.9%	83.1%	83.3%	81.8%
I can adjust to life as a college or university student	90.6%	91.3%	88.9%	85.9%	83.3%	100.0%
A degree in engineering will allow me to obtain a job that I like	83.9%	86.4%	77.8%	77.5%	78.3%	72.7%

Table IV: Expectations to Enroll in an Engineering Program

At the present time, how confident are you that you will be enrolled in an engineering program in the next 5 years? (Check one)

	Fall 2009			Spring 2010		
	All	**Male**	**Female**	**All**	**Male**	**Female**
Not at all confident; I am already planning not to pursue engineering.	6.3%	8.7%	0.0%	16.4%	16.4%	16.7%
There's about a 50% chance that I'll be in engineering	12.5%	13.0%	11.1%	12.3%	13.1%	8.3%
I'm fairly confident that I will be in engineering then	43.8%	43.5%	44.4%	19.2%	21.3%	8.3%
I'm very confident that I will be in engineering then	37.5%	34.8%	44.4%	52.1%	49.2%	66.7%
Fairly confident and very confident	81.3%	78.3%	88.8%	71.3%	70.5%	75.0%
Not at all confident	6.3%	8.7%	0.0%	16.4%	16.4%	16.7%

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Table V: Expectations to Complete an Engineering Program

At the present time, how confident are you that you will complete any engineering program? (Check one)

	Fall 2009			Spring 2010		
	All	**Male**	**Female**	**All**	**Male**	**Female**
Not at all confident; I am already planning to not pursue engineering	3.1%	4.3%	0.0%	13.7%	13.1%	16.7%
Not confident; it is highly likely I will not pursue an engineering program	3.1%	4.3%	0.0%	2.7%	3.3%	0.0%
There's about a 50% chance that I'll complete an engineering program	3.1%	4.3%	0.0%	11.0%	11.5%	8.3%
I'm fairly confident that I will complete an engineering program	50.0%	47.8%	55.6%	28.8%	29.5%	25.0%
I'm very confident that I will complete an engineering program	40.6%	39.1%	44.4%	43.8%	42.6%	50.0%
Fairly confident and very confident	90.6%	86.9%	100.0%	72.6%	72.1%	75.0%
Not confident and not at all confident	6.2%	8.6%	0.0%	16.4%	16.4%	16.7%

Additional assessment results

In addition to the LAESE survey, a program evaluation survey was conducted to provide feedback to the State Department of Education, especially insofar as the course influences student attitudes towards math and science. Several of the results were encouraging. For example, of the students who took the survey, 82.8% indicated that participation in the program improved their ability or grades in science and math and 63.4% indicated that they were more interested in taking advanced math or science courses in high school after participating in the program. Of the students who completed the survey, 74.2% indicated that they had significant interest in pursuing a career in science, technology, engineering or math/computer science and 22.6% had modest interest in pursuing a career in science, technology, engineering or math/computer science. Students were also invited to comment about the course. The majority of the comments were favorable such as: "I liked the projects we did. They were fun and hands on and I think I learn better that way." and "Great for learning different engineering concepts. Great overall course".

Closing comments

The ENGR 102 in HS program has grown from 1 to 6 to 16 HS over the period of three academic years, with attendant approximate enrollments of 20 to 80 to 200. The program has grown to the point where we now have HS's contacting us, asking to participate; we plan to grow to 25 HS in AY 2011-12. We have integrated our student recruiting efforts into the program and we are building relationships with students before they step on campus. We have introduced a one-unit course on the NAE Grand Challenges for our HS engineering students to take, if/once they matriculate at the main campus. We are starting to integrate into PLTW programs as a 4th year/capstone option and we are branching to schools in other States using our alumni network.

The primary advice that we would offer to colleges and universities that might want to do what we are doing (or something similar) is as follows.

- Make sure that you have the HS principal fully on board before you get too far into the HS recruitment process. There needs to be a common understanding of objectives. The HS is trying to accomplish something and so are you. Each needs to be supportive of the other's goals. For example, you can't do assessment surveys without the full cooperation/approval of the HS and the school district.
- Make sure that the HS teacher and HS principal have a similar understanding of what they are trying to accomplish for their students. It also helps if the HS teacher is an experienced, respected member of the HS faculty, which tends to foster confidence in the HS team—including the HS math/science teachers and councilors who can help channel students into the course.
- After the initial meeting(s)/discussions about the program, a HS might take anywhere from a day to a year (or two!) to decide to join. After the HS commits, and as you begin taking substantive steps to offer the course in the HS, it is useful to remind the HS of your objectives—they sometimes forget or become confused about what you are trying to accomplish on your end.

- Pay attention to when the high school students register for the coming fall—in Arizona this happens in late January to mid-March, depending on the HS. Make sure that a HS commits to join the team before their registration period, so recognize that there are times to recruit the HS and times to call for the question.
- Public high schools don't operate on a tuition basis. They won't necessarily recognize that you need to charge tuition for the course. You may have to explain that universities/colleges offer instruction in exchange for tuition. Similar comments apply to the parents of some of the prospective students, so it can be useful to organize a meeting with interested parents in advance of the HS registration period.
- Devise a system where the parent has to confirm approval of the student's enrollment in the course. We found that students might enroll in the course without their parents' full knowledge. This created a few surprises when the tuition bill arrived.
- You need a component within your university or college that has experience with distance education. You are offering your course at a distant site. Most college faculty members and administrators don't have first-hand knowledge about how to do this.

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