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J. Shelley, United States Air Force

Mickey Bowen, United States Air Force

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Innovation in Engineering Outreach: Engineering 11 as a tool for recruiting minority students to Engineering

Abstract:

A unique opportunity for recruiting engineering students has developed in the Antelope Valley of Southern California (AV). While the AV refers to itself as the "Aerospace Valley", with a high percentage of the workforce employed by Edwards Air Force Base and the major Aerospace Prime Contractors, it has had no local baccalaureate degree granting institution to support these high tech industries. A State University College of Engineering, has partnered with the City of Lancaster, the United States Air Force, and local employers to create a unique baccalaureate degree granting program in the AV. The existence of this program has created the opportunity to recruit engineering students from a high school population that is 31.7% Hispanic and 13.7% African American[i]. However, to successfully recruit students from this population into engineering careers and eventual employment in the local Aerospace industry, it is necessary to change the paradigm of the local high school student population. Under the current paradigm less than 21% of high school seniors graduate ready to enter the CSU system without remediation[ii]. Among those who are prepared to enter the CSU system, the prevailing attitude is to leave the AV permanently[iii].

To combat these prevailing attitudes and attract students to Engineering, the local staff and professors have modified the Engineering 11 course, offered by the servicing state University for the local population. Engineering 11, titled Engineering Applications, is a course designed to introduce qualified high school students to the principles and practices of engineering during their junior or senior years of high school. The course carries three units of transferable credit. In the AV, Engineering 11 has been designed and implemented by 'minority' instructors with the support of a Title V grant in an attempt to recruit students from underrepresented groups into engineering. An innovative project-based format allows the students to discover the basic principles of mechanical, electrical, and civil engineering while practicing trouble shooting, leadership, and project strategy. This paper discusses the details of the course, its "lecture on demand" style of instruction, the involvement of local industry, and the demographics of the students enrolling in the class. In its second semester, the course can already claim some accomplishments in preparing students for engineering undergraduate success.

Introduction:

This paper offers a 'snapshot' of demographic information and course development for a particular college outreach and recruiting course in engineering. A snapshot isolates a detail, freezes it in time and removes it from its active context. In developing the information for this paper, it became apparent that the 'action behind the snapshot', its context, is important to understanding the demographics of the course. As with any piece of information that is frozen in time and isolated from its surroundings, it is the greater background story that is of equal importance to the captured image. Therefore, this paper attempts to relate not only exact information about the course developed but also the history of the community efforts that preceded the course development and resulting demographics.

Background to AVEP Engineering 11 course:

Over a decade ago, Fresno State University developed an outreach course, Engineering 11, for qualified high school juniors and seniors. The Lyles College of Engineering uses Engineering 11 to inform and attract the minority and low income high school students from the communities surrounding the main campus. Engineering 11, titled Engineering Applications, meets on campus and presents brief introductory projects in each of the five engineering disciplines offered on campus. The course is taught by the faculty on the main campus on a credit/no credit grade basis and provides three credits of transferable CSU credit. High school juniors and seniors with acceptable grade point averages and transportation to campus after school spend the semester experiencing college student life and engineering programs before applying to University. An estimated 15% - 20% of Engineering 11 students on the main campus enroll in the Lyles College of Engineering[iv].

In Fall 2004, Fresno State University inaugurated its remote engineering program in the Antelope Valley, the Antelope Valley Engineering Programs (AVEP), with mechanical and electrical engineering majors. Both Fresno and Lancaster host largely Hispanic populations with a significant low income component. At the main campus, the population is 39.7% Hispanic and 8.4% African American[v] while at the remote campus the population is 37.5% Hispanic and 13.7% African American[1]. Median income in both areas is approximately $40,000 with as many as 71% of high school students qualifying for free lunches[3,vi]. However, the economy in the AV is driven primarily by the high tech aerospace/defense industry, rather than the commodity agri-business industry as it is in Fresno. To aid outreach and recruiting in the AV, the Engineering 11 course was first offered at the AV campus by the local instructors in Spring 2008.

The AVEP local Engineering 11 class is taught as a robotics project class where the variety of engineering disciplines available to students is presented by working professionals in the fields, not by the course instructors. Robotics is the natural intersection of the mechanical and electrical engineering disciplines, the only two engineering disciplines offered by the AVEP and two of the foundational disciplines in Engineering. The project-based format was chosen for the AVEP class because the instructors felt that experiential learning was the most appropriate technique for developing the desired learning outcomes[vii]. Rather than teaching short units in several engineering disciplines, Civil, Environmental, Computer, Mining, Materials, Systems, and Engineering Management professionals have addressed the class along with the primary Aerospace, Mechanical, and Electrical engineers. Hearing directly from professionals employed locally in the field affords students direct insight into the professional environment and the realities of the educational process.

The desired learning outcome of Engineering 11 is not a particular skill set, but rather the ability of students to choose a particular academic discipline for University study and a potential career. Creating this learning outcome in students requires more knowledge, introspection, and self-assessment on the part of the student than any of the higher-level knowledge assimilation activities in Bloom's Taxonomy[viii]. For this reason

an experiential approach was chosen where the students work with basic engineering principles and course discussion requires student introspection. The founding principles used to develop the class were straight forward. 1) It is about the students, not about the instructors. 2) Project-based, but not a design project. Engineering students have many design project opportunities and this class must offer something different. 3) Hands-on, visceral experience. 4) Provide role models. 5) Be honest brokers of information. What was necessary is that the students experience a close to real-world approximation of engineering activities. The students need an experience on which to base a career choice.

So, a project based on failure analysis of a mobile robotic system was chosen as the basis of the course material. Failure analysis provides structure for problem solving methodologies that is critical in engineering study. The basic concepts of mechanical engineering in structures, gearing, and motors must be presented to develop a functional robot body. The basics of circuit design and computer programming are necessary to create autonomous motion and specific task performance by the robot. Experience with civil engineering concepts is developed through development of a maze for the robots to autonomously navigate and development of handling procedures for rechargeable batteries and robot supplies. Immediate feedback and satisfaction of the students is derived by completing functional tasks and sub-systems checks on the robots. Systems engineering, teamwork, troubleshooting, and problem solving skills must be developed to complete the final class project. For the final project, all the students must build functioning robots that participate in a "task course". The task course awards points for a variety of autonomous activities performed by the robots. Limitations on the number of times points will be awarded for the same activity and a requirement that robots perform multiple tasks without human intervention drive diversity among the robots while simultaneously stimulating cooperation and communication between the students.

Students experience the teamwork, development of engineering specialization, and the reward of accomplishing a complex task through teamwork just as engineers do in the field. Working professionals provide insight into particular disciplines and the local employers. General course discussions inform students about planning routes through college to obtain a baccalaureate degree, choosing a University, paying for college, and professional activities such as professional licensure, membership in professional societies, and service organizations like Engineers Without Borders. Through the experiences developed in class, students develop a basis for choice between academic disciplines, technical careers, and military service.

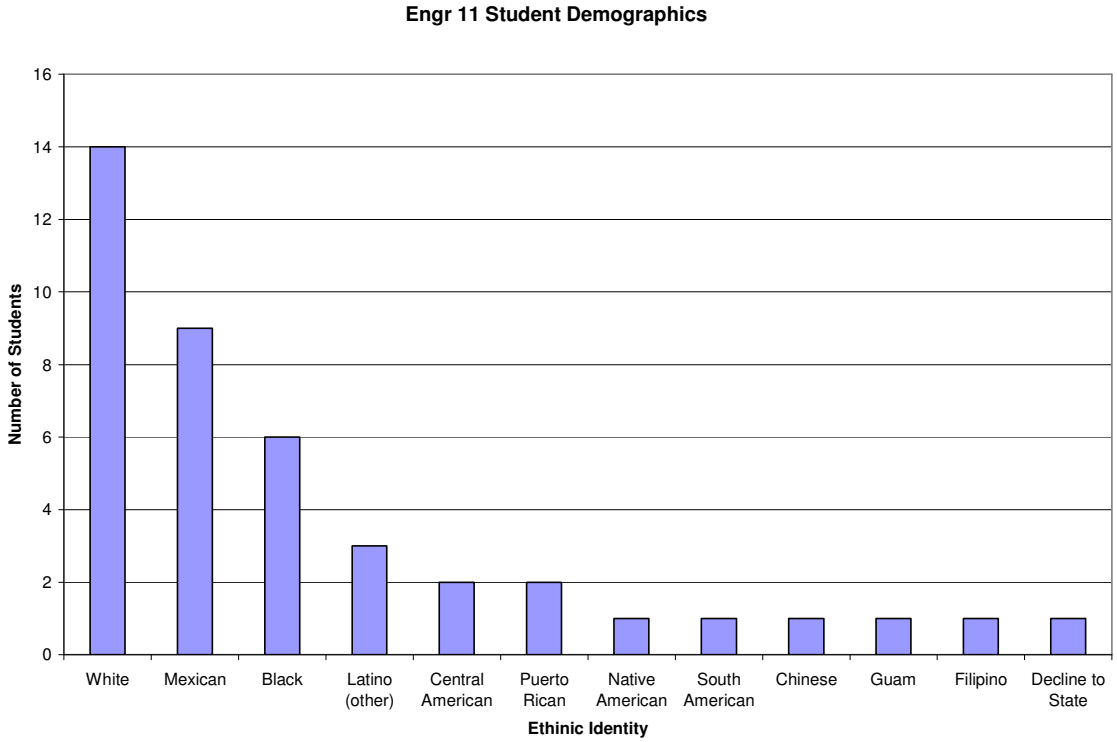
Requirements for the course were established by the AVEP local instructor and the University. Students must be juniors or seniors in high school, enrolled in algebra 2 or higher level math courses, be taking a college preparatory course load, and have a grade point average (GPA) of 3.0 or better on a scale of 4.0. These math, course load, and GPA requirements exclude approximately 80% of the local high school student population. However, several exceptions have been made for cases of lower GPAs for promising students. Application packages, including high school transcripts and counselor signatures, must be mailed to the main campus of the university and there is a $20 fee for the course. Five local high schools offer Project Lead the Way (PLTW)

courses. For students in those schools, PLTW instructor signatures can be substituted for counselor signatures. Eleven of the 18 regional high schools that have been sent information have been represented including both public and parochial schools. High schools that have not been represented either have few students qualifying for the class (Alternative Schools) or are more than a 30 minute drive from campus. (Three outlying high schools have been represented.)

The Snapshot (Data and Results):

Engineering 11 has been offered for more than two semesters in the Antelope Valley. Demographic information was collected from student applications and students were surveyed to develop sociologic information for the class in the AV. Students were not directly recruited for the class by the University faculty and staff. Students were recruited through high school counselors, science, math, and Project Lead The Way (PLTW) instructors. Only students involved in the ICAN (I College Action Network) program, a series of specialized college preparatory courses developed at the local community college, were directly recruited by the faculty (4 students total). A total of 43 students have been accepted into the class. Thirty-four students completed the class. Half of the students who drop the class do so within the first two weeks. Forty-two students answered the survey the second night of class, 30 Juniors (71%), and 12 Seniors (29%).

The student self-identified ethnic identities as selected in check boxes on the course applications are shown in Figure 1. There were 26 options for identities including both "none" and "decline to state". Thirty-three percent of the course population self-identified as "white". Forty percent self-identified as what the general population statistics group as "Hispanic". Of the Hispanic population in the class, 52% identify as "Mexican" heritage and 17% as "other Latino" with "Central American" and "Puerto Rican" both represented at 12%. While the local population is 31.7% "Hispanic", the high school district reports that 42% of the student population identifies as "Hispanic". Therefore, a 40% "Hispanic" population in the outreach class is consistent with the general population. That 14% of Engineering 11 course students self-identified as "Black" also corresponds to the local population demographics where 13.7% of the general populations is "Black". However, the high school district reports that 21.3% of the high school student population is "Black". When compared to the high school population statistics, the capture rate of students self-identified as "Black" in the Engineering 11 course may be low.



The gender statistics for the first two offerings of Engineering 11 are impressive. In the initial course offering, the class population was 48% female. The second offering was significantly lower, just under 25%. In the third offering, for which complete statistics have not yet been evaluated, the percentage female population is only 17%. 49% of the general population is female. While the initial statistics on female student capture in Engineering 11 is impressive, that statistic is dropping rapidly with increased number of course offerings. The capture rate of female students is low, but still significantly above the near 10% enrollment rate of females in some engineering programs.

A non-attributed general information gathering instrument was distributed the second class session to generate statistics on the level of math preparation students had in high school, their computer usage, and family history of college attendance. The course admission criteria for math achievement ensured that a high percentage of the course population was enrolled in Advanced Placement Math courses in high school. Thirty-eight percent of the students were in calculus. The same percentage were in algebra 1 or 2, with the remaining approximately 20% of students in trigonometry or pre-calculus.

One third of the students had already taken the Scholastic Aptitude Tests (SATs) at the start of the class.

One student who started the class had difficulty communicating in English. That student chose not to complete the class.

Eight students, 19% of the population had jobs.

Eighty-three percent had computers at home while 12% responded that they programmed or otherwise created computer content at home. None of the respondents admitted to being heavily involved in computer gaming.

Nineteen percent stated that they would be the first member of their family to attend college while 21% said they had older siblings in college. Thirty-three percent had parents that graduated from college while the remaining 26% of students indicated their parents attended college but did not graduate. Anecdotal evidence from in-class discussions indicates that very few students had an engineer in the family. Only one student was known to have had one parent who was an engineer.

In the instrument, 29% students intended to apply to first tier in-state Universities, while 14% intended to apply to Ivy League or out-of-state institutions. Nearly 20% intended to apply to State Universities and another 20% wanted to attend Polytechnic Universities. Only 10% intended to begin their academic careers at the local junior college. Since the Engineering 11 students were pre-selected from students with high school GPAs above 3.0, the predominance of more renowned institutions in the list of Universities to which the students intended to apply testifies to the students' motivation for attending university and strong self-concepts. The college-going ethic appeared to be well established in the population.

While there is no formal tracking mechanism of students once they complete the course, 33 students who completed Engineering 11 were contacted by e-mail after the course. Nine responded. All but one of those who responded were still interested in engineering. Six of the respondents have been accepted to university and 3 are pursuing military scholarships. The evidence of how Engineering 11 affected student choice of Universities is purely anecdotal. One student, who was interested in Nuclear Engineering, chose to enlist in the Nuclear Navy and use the GI bill to fund the remainder of his education. One student who wanted to attend the only 'impacted' engineering program in California was accepted into the program of her choice at the school of her choice. While six students indicated that they wanted to attend one of the military academies in the survey at the beginning of class, no students from Engineering 11 actually applied to a uniformed service academy, in spite of having Air Force and Merchant Marine Academy graduates address the class. One student who did not think she could afford to attend university has planned a degree route in engineering through Antelope Valley Community College and Fresno State. One student, who was concerned about the rigors of the social environment at university, is enrolled at CSU Northridge in Mechanical Engineering.

The college-bound ethic in the AV does not appear to correlate with ethnic identity in the selected population. "Hispanic" and "Black" students who both qualified and were self-selected to attend the class were represented in close to their appropriate proportions of the general population. Females were represented at less than their presence in the general population, but at significantly larger numbers than for a general University engineering population. What is *not* known from the data collected was the

ethnic identities of the first generation students, or ethnic identity information relative to generational status in America or number of languages spoken in the home.

However, the student demographic is shifting as the number of offerings of the class increases. Statistics for the third offering of Engineering 11 have not been completely analyzed. While the percentage of students self-identifying as one of the "Hispanic races" has remained consistent through all three offerings, the third offering of Engineering 11 has no students self-identifying as "black" and the female percentage population has dropped to 17%. It is interesting to note that along with these statistics, the number of high schools represented in class has dropped from 11 to 5, one third of the students come from the same Project Lead the Way (PLTW) class at the same high school, and the number of students who where recommended to the class by PLTW instructors rather than counselors increased from less than ten percent to more than one third.

The Engineering 11 course appears to be popular with the students. It enjoys a nearly 80% retention rate of students. Over half of the students, and many of their parents, request a follow-on class be developed. Feedback discussions with students at the end of class are overwhelmingly positive with most students being able to relate at least one incident from the class that changed their perspective on an aspect of engineering. Unsolicited comments from parents indicate that the desired outcome of creating a basis for career choice has been achieved[ix].

The action behind the snapshot (Community Context):

The demographics of the small sampling from the initial offering of Engineering 11 in the AV shows a course that has been successful in recruiting the ethnic diversity representative of the local population. Without special recruiting mechanisms or acceptance criteria, the appropriate ethnic diversity of the local population was achieved from motivated high school juniors and seniors with GPAs above 3.0 out of 4.0. (The diversity in the students applying for Engineering 11 implies that a similar ethnic diversity exists in the high achieving populations of the local high schools.) However, the Engineering 11 course is only one of the activities aimed at interesting pre-college students in engineering careers in the AV.

Pre-college engineering interest programs began in the Antelope Valley in 1999 with the establishment of a robotics club at Lancaster High School. The robotics club was an application brought to the High School by the Aerospace Professionals Pathways Program, a cooperative program between the Regional Occupation Program (ROP), and the High School district, that hired two aerospace professionals to teach in a local high school. With the positive press of the Lancaster Robotics team victory in the national robotics competition in 2002 and facing a Base Realignment and Closure (BRAC) investigation, the Edwards Air Force Base Community Alliance and the Antelope Valley Community College founded the Mathematics Science Engineering and Technology Consortium (MSET)[x] to coordinate the efforts of industry and promote preparation for technology related careers and the appropriate teaching of mathematics and science in the

local high schools. The aerospace/defense industry employers joined MSET to help coordinate solutions to their own recruiting and retention problems. Aerospace industries which dominate the local employers pay premium salaries and signing bonuses to US citizens holding ABET accredited degrees in engineering. Employees recruited from out of state tend to have poor retention rates in the AV[xi].

MSET is managed by a volunteer staff through the Aerospace Development Office in the City of Lancaster. Local aerospace employers like Lockheed Martin, Boeing, Northrop Grumman, Edwards Air Force Base, and NASA/Dryden coordinate educational outreach activities through MSET. MSET helped to support the Society of Automotive Engineers World in Motion Curriculum in the elementary schools and Project Lead the Way in high schools. Five of the 13 local public high schools participate in Project Lead the Way currently. MSET coordinates the Math Odyssey, a middle school outreach and motivational program, every year for local middle schools. MSET also helped to recruit the State University to create the AVEP and broker the arrangement that allows local engineering professionals to teach laboratory classes directly at the LUC. Because of its central role in coordinating engineering educational activities in the AV, the City of Lancaster Aerospace Office, which manages MSET, holds a seat on the local Industry Advisory Board for Fresno State's AVEP.

Other activities which support the engineering student pipeline in the AV are pervasive. In conjunction with another servicing state university with a program in teacher education, CSU Bakersfield, Antelope Valley College won an NSF grant to establish a Teacher's Pathways program to increase the number of certified math and science teachers in the valley and increase subject matter competency among credentialed teachers of math and science. The Teaching Pathways grant ended in 2005. A co-operative grant between the AVEP and the local community college from Title V has been in place since 2007 to increase the college-going rate among underrepresented ethnic groups and to increase transfers from the community college to baccalaureate degree programs especially in math, science, engineering, and teaching of math and science. Efforts are continuing with an endeavor to bring engineering and technology programs to local middle schools by coordinating grants and donations from industry and government sources. The presence of Project Lead the Way in Valley High Schools has already been mentioned. The outreach activities of individual companies and government agencies on the part of engineering education have been significant.

Conclusions:

The Engineering 11 course has been successful in recruiting high school students with the ethnic diversity representative of the local population without special recruiting mechanisms or acceptance criteria. The students in this outreach class tend to be in the top 20% of academic performance in their high schools. Because of its popularity with students and perceived student satisfaction with the learning outcomes, Engineering 11 can be considered a model course for University College of Engineering outreach activities.

Female students continue to be underrepresented in Engineering 11, but not to the extent they are in the professional engineering population. These gender statistics may imply that current high school based engineering interest programs, while helpful, are still not reaching female students in the appropriate numbers. However, gender issues in engineering recruitment were not a subject of this study.

Future Work:

Once a program like Engineering 11 exists and becomes established, it becomes a platform for development in many aspects of engineering education. Pedagogical research to understand the efficacy of different project and application types in recruiting students into engineering could be conducted. Understanding the influence of service-learning projects on engineering career choice would also be valuable. Targeting curriculum to reach particular gender, ethnic, or other socio-economically marginalized populations would also be an interesting endeavor. Two efforts that require work are creating a follow-up class based on computational methods in engineering and design, and packaging the Engineering 11 course for export to local community colleges. The AVEP relies on a network of community colleges to provide qualified transfer students for its engineering curriculum. Creating arrangements to have Community College instructors and other volunteers vetted as Fresno State professors so they can provide, not only the Engineering 11 content, but also the three credits of CSU credit will require administrative support.

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