Developing Recruitment and Retention Strategies through "Design4Practice" Curriculum Enhancements

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Abstract - Northern Arizona University’s (NAU) College of Engineering and Technology (CET) has an energetic program to identify pre-degree student populations, bring educational resources to these populations to enable recruitment into the NAU CET learning environment, and retain these students throughout the CET degree programs through graduation. The program, the Engineering Talent Pipeline, builds upon the student-oriented Multicultural Engineering Program (MEP) and the “Design4Practice” (D4P) design curriculum. A study was undertaken to understand successful recruitment and retention efforts of other universities, in order to apply the best practices to the D4P curriculum. This paper will primarily address the information gathered from best practices research that lead to our current D4P curriculum enhancement efforts. The D4P courses provide all engineering majors with interdisciplinary, team-based design projects throughout their four-year program. Also determined were evaluation metrics that demonstrate improvement in recruitment and retention; these metrics were considered for integration into the assessment reports associated with the future curriculum enhancements. We present our findings of the above activities and preliminary strategies for enhancing those D4P courses which most impact our recruitment and retention: The freshman and sophomore design courses.

Index Terms - Student retention, design education, engineering education.

INTRODUCTION

The College of Engineering and Technology (CET) at Northern Arizona University (NAU) is renovating the way it recruits, educates and graduates engineering students. With the aid of the William and Flora Hewlett Foundation, CET is actively assessing its regional recruitment resources for incoming freshmen, as well as re Structuring its courses to excite and encourage enrolled students to stay in engineering. The college has received freshmen primarily from the southwest region through the general NAU recruitment program office and word-of-mouth advertising through alumni and faculty. NAU is the smallest of three Arizona universities offering undergraduate engineering education programs. While the larger University of Arizona and Arizona State University (ASU) enrollments have increased since 1998, NAU CET enrollments has remained flat.[1]

Enrollment must increase in order for the CET to maintain a vital education program and to increase CET’s availability to students from under-represented and ethnic populations. We subsequently applied for and received a five-year grant under the William and Flora Hewlett Foundation Engineering Schools of the West Initiative to aid in increasing enrollment. Several initiatives are addressed under the program; in this paper we will address the work accomplished in the past year associated with 1) identifying “best practices” in recruitment and retention of engineering students, and 2) preliminary strategies for improving student recruitment and retention in CET.

PROJECT OBJECTIVES

One primary objective of this project was to identify “best practices” discovered by engineering educators, with respect to improving recruitment and retention of undergraduate engineering students. Within this objective, a primary motivation was to search for those practices that worked particularly well in recruiting, retaining and graduating students who were from under-represented population groups in engineering.

Another primary objective was to develop a preliminary strategy for improving curriculum offerings, so they could be used to both 1) recruit new freshmen and 2) retain those enrolled beyond their first academic year. The result of this work showed clearly that the freshman and sophomore classes were critical in retaining students.

A third objective was to target first and second year courses for development into educational products which could be “exported” to high schools and community colleges. Such exporting serves as a recruiting pool of incoming students: These courses could be “modularized,” so that

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portions of the courses could be offered in summer recruiting and bridge programs already in place.

**OVERVIEW**

We reviewed academic literature for best practices in retention and recruitment efforts; the review and compilation was accomplished over the summer of 2003. Investigating recruitment and retention is a vast undertaking—in order to scope the project, the review of best practices was limited to primarily western regional institutions. We also restricted the search to engineering student population research—the Science, Technology, and Engineering Program (STEP) student population is larger and relevant, but investigating in that more general realm would be more time-consuming than was feasible. Lastly, the publications were limited to the last 10 years of publications, with some prominent exceptions. The rationale was to concentrate on the latest timeframe with technology innovations. However, technology was rarely mentioned as a factor in recruitment or retention; most issues focused on social connotations or basic sciences preparation.

**GENERAL OBSERVATIONS**

The National Center for Education Statistics (part of the U.S. Department of Education) published a report that studied the entry and persistence of underrepresented groups in college engineering and science.[2] Their conclusion regarding who would enter engineering and sciences was startling: Gender and minority influences could not be proved statistically; rather, the exposure of any student to environmental influences were the primary indicators. Likely engineering and science candidates included (bullets quoted): [2]

- students who had taken advanced science courses;
- students who were self-motivated to study science;
- students who had parents with relatively higher levels of educational attainment; and
- students who had parents with high expectations for their children’s college education.

It may account for the fact that some programs recruiting women and minorities into engineering are only marginally successful; these recruiting programs may be targeting students that are not exposed to the above factors. It also may explain why programs which foster secondary school programs in science and engineering are successful.

A general observation is noted for retention academic publications: Many authors do not account for the “Hawthorne Effect” in their studies. This effect was observed by pioneering industrial research in the 1900’s and is well-known in industrial psychology.[3] Workers under study, knowing they were being studied under different circumstances, changed their performance as different working conditions were changed. The productivity improvements continued even after returning their working conditions were returned to the original situations. These results occurred because the subjects believed they were supposed to improve after each factor change. Similarly, in many studies of new freshman introductory courses, the students were quite aware of their participation in such new courses. It is expected therefore that the students under study would naturally influence them towards improved study habits, increased attention to topics, and so on. These beneficial behaviors would lead them to do better in engineering course work, thereby increasing the likelihood of their retention in that major. A self-fulfilling expectation of the students may well be the influencing the results measured in some educational retention programs.

**RETENTION**

It is apparent that retention programs can be broken up into several categories:

- Remediation
- Social/Cohorts – both general cohorts and cohorts focused on cultural, ethnic or gender
- Course Integration
- Undergraduate Research
- Freshmen introduction

Cross-college course integration may be the most effective method for retaining students as well as improving student performance. The problem is that this approach required whole-hearted commitment from colleges external to the engineering college. Each university that has successfully made this integration path has engineering as one of the largest colleges on the campus. This is not true for NAU, although being a small college may have other advantages in student recruitment efforts.

Recruiting undergraduates into undergraduate research projects appears to be a promising way to retain promising students.[4] However, it should be noted that these undergraduates, selected for research, are already indicated as high performers; otherwise, the faculty would not consider them for selection on research projects. Consequently, their retention in undergraduate studies is typically assured without the undergraduate research application; on the positive side, such an approach appears to keep students interested in graduate engineering school. Another positive note is that the visibility to freshman candidates of these undergraduate students researchers can have a positive recruitment impact.

Freshmen introduction courses which involve active learning and participation by the students also appear promising. These courses are often combined in an overall retention strategy. Many universities, including NAU, utilize a design project approach in their freshman courses. [5, 6, 7, 8, 9] To be successful, however, students need to be instructed on group dynamics as part of the design class. [10] Otherwise, the team design class may foster frustration among some students in the design teams. Considering the preponderance of teams in the engineering workplace, however, this approach may have double benefit. The effects of team dynamics influence not only individual student
attitudes, but also individual and team performance levels and peer evaluations.

It should be noted that the university of Florida utilizes a “laboratory format” design approach, which appears somewhat less successful than the design format.

The least effective as a stand-alone technique may be the 1-hour orientation. Published evidence for this technique shows at best inconclusive changes.

RETENTION INDICATORS

A very rigorous, statistical analysis, performed by the University of Pittsburgh, showed that first year academic probation was a very high indicator of eventual departure from engineering. There are three highly correlated factors that predict freshmen first-year academic probation in engineering: Academic preparation (measured by SAT scores), academic ability (measured by high school academic rank), and confidence in study habits (measured by PFEAS).

Publications utilizing less scientifically rigorous methods abound; they are often based on the results of student self-assessment surveys. A 1994 study showed that female students assessed their top reason for leaving engineering, mathematics or science majors was that these majors “might prove inappropriate;” male students cited their top reason as “poor teaching by faculty.” Beyond these top factors, males and females matched closely in rationale: Inadequate advising, other majors proved more interesting, and loss of interest in engineering/science/mathematics. It is of interest that students in self-assessments do not cite the factors of poor performance as a rationale, yet poor performance is a primary statistical indicator.

In studies of a new freshman engineering course at Arizona State University (ASU), they determined that a highly reliable indicator of first and second-year retention was student self-assessed confidence in graduating college. This aspect of “confidence” was also reported by Levitz and reinforced in other related publications. It is not clear whether indicators of retention such as confidence are inherent in students or whether they were infused via active academic interventions. Assuming that confidence can be infused, a possible method of doing so may be through team-oriented recitations (workshops) in the freshmen and sophomore fundamental courses. ASU’s Minority Engineering Program promotes such voluntary classes to new students; an overwhelming majority (97%) of the student participants self-report that these recitation sessions “improve grades.”

RECRUITMENT

Recruitment programs are varied; however, some general categorizations can be made.

a. Website development
b. College “engineering days”

1. Student recruitment
2. Retention
3. Placement

A significant K-12 effort (essentially, eighth-grade through twelfth-grade) initiative was undertaken by San Jose State University to recruit more engineering students to combat a 16% decline in enrollment from 1993 to 1994.

The Hewlett Packard Foundation funded a program to encourage minority and women engineering enrollment at that university. The results of their DEI (Diversity in Engineering Initiative) were enrollment increases of 10.9%, 11.8%, 17.9% and 8% in 1995, 1996, 1997 and 1998, respectively. This program involved increasing secondary school science fair participation by the college, training of high school teachers for specific course modules, and employment of a full-time and part-time director for DEI student recruitment.

The University of Texas at El Paso (UTEP) developed a strategy integrating both recruitment and retention activities. UTEP has a unique situation of being primarily a commuter university with a large Hispanic population. Their strategy impacts several areas: Entering freshmen students, enrolled student support, undergraduate research, and faculty development. There is an emphasis on development of a “learning community” for the students. There is also a unique “Academic Center for Engineers and Scientists,” a resource center offering tutoring, study areas, and laptop checkout services. This center is “run by students for the purpose of serving students.”

ASU appears to have multiple “pathways” established that 1) recruit, 2) retain, and even 3) place students throughout the engineering education process. The key concept is to define and target a process (strategy) rather than target pieces of the problem.

The need for strategy in recruitment and retention is emphasized by Manchester University. They note that a strategy could be divided into four parts: secondary-school motivation, recruitment of high school students “of appropriate calibre,” student induction (introduction) to engineering, and ongoing student support.

FRESHMAN ENGINEERING PROGRAMS

Cross-college course integration may be a most effective method for retaining students as well as improving student performance. Though larger universities were noted as examples, smaller universities also conduct engineering/science/mathematics integrated programs, such
as Drexel University with their E³ program and Rose Hulman Institute of Technology with their IFYCSEM program. [25]

A specific example of an integrated, freshman cohort program is given by the University of Alabama, “TIDE.” Cohort freshmen groups of 4 students are created; the university has rearranged chemistry, math, physics and engineering offerings for better integration. Additionally, new computer-equipped classrooms were provided for TIDE. Reported of the TIDE participants were improvements of 14% for those calculus-ready and 16% for those pre-calculus-ready. [25]

University of Colorado offers the first year engineering design course, GEEN1400, as part of its overall Integrated Teaching & Learning Laboratory (ITLL). [26] A 6.38% increase in 1st-to-2nd-year retention was observed upon implementation (1997 – 1999). However, there was no differentiation as to whether the design aspect of the course, the team interaction, the “service learning” component, or the fact that a brand-new, design-oriented building was opened during the ITLL implementation achieved the increase. All of these factors were apparently introduced simultaneously with the ITTL concept.

“Service Learning” is also proposed as a recruitment tool for engineering education in the University of Puerto Rico.[27] A network of day-or-week-long workshops and programs are provided via student volunteers and faculty to secondary education students and teachers. It also appears to be a useful recruiting mechanism for delivering information about engineering college to the K-12 community. The Engineering Projects in Community Service (EPICS) program that started at Purdue has found that women students show a preference for EPICS coursework which infers a positive impact on their retention.

Recruitment-Specific Programs

Trinity College has a high school recruitment program, organized around industry-organized, problem-solving workshops: The United technologies/Trinity college Engineering Initiative (UTCEI).[28] After five years, it is estimated that 80% of high school participants went on to enroll in engineering or science in college.

ASU has a Summer Bridge Program for high school students[29] that brings students into the university environment for two weeks. The students are exposed to simulated university projects including a design project competition. Scholarship/awards are distributed to participants, based in part, on their level of success to the projects.

Retention Programs

(not specifically Freshmen Programs)

In considering retention beyond the first year, tutoring, mentoring and social belonging are often cited as an aid to retention. Women in engineering are particularly targeted for social inclusion in the engineering discipline. The rationale for this effort is fairly obvious: Girls and boys show essentially the same math/science interest and aptitudes in secondary schools, yet only enroll at a roughly 1-to-10 ratio with respect to men in engineering.[30] This ratio is reported with wide variation, as authors frequently report data coming from their specific institutions.

A sampling of recent publications show that a promising method of recruiting requires active camps or workshops for secondary school female students, in order to bolster their self-image as potential engineers.[30, 31, 32]

The Society of Women Engineers (SWE) is a professional organization with a specific agenda of making women feel welcome into the engineering profession. At Baylor University, the proportion of SWE members graduating was shown to be statistically higher than the student population that was not active in SWE.[30] Though this information does not clearly indicate that SWE membership directly affects increased retention (cause verses effect), the organization clearly enables women students to become more confidently integrated into the engineering profession.

Strategies for NAU CET

CET has pursued improving recruitment and retention of underrepresented populations through its MEP program. The Hewlett Foundation funds allow for enhancing these efforts. There are also additional solutions for CET to implement in curriculum and academics that will allow for better visibility to the academic community.

One problem that many smaller universities have is the persistent inability to fund staff positions that support recruitment, retention and placement of students. There are often no designated, “permanent” positions that are specifically authorized for recruitment and retention positions. Only decreases in state funding are seen in CET’s future; therefore, CET is making efforts to support personnel in recruitment-related positions through increased research funding. The overhead allocations from these research efforts can then assist in supporting the necessary recruitment positions in the college.

One well-researched approach to engineering retention, cited earlier, was to offer an integrated Mathematics/Physics/Engineering curriculum. However, This solution is probably not appropriate for most small universities.

It is noted that “service learning,” can be applicable to NAU CET education activities. These activities are prominent in environmental issues (environmental remediation, renewable energy, etc.), which are strongly service-related. CET has several research and education programs in these areas that can be promoted to high school student populations.

Retention solutions should clearly focus on first-and-second-year retention. Part of the problem is associated with the physical and mental disconnect of a freshman from the engineering discipline in the first year. These students are taking calculus and physics courses, with often no direct engineering applications for those important topics.
This problem of disassociation becomes acute for students requiring remediation, particularly in pre-calculus or earlier math courses. One immediate social solution is involvement in engineering student organizations. If students were recruited into engineering student organizations in their freshmen year, they may develop a sustained enthusiasm for the discipline while undergoing their remedial coursework. One example, previously cited, is SWE. Another group is the Society of Automotive Engineers (SAE). They have publicly visible national competitions (Formula Car, Solar Car, Mini-Baja, etc.) that enable new students participation without requiring immediate calculus or physics proficiency. More student organizations could easily be cited; however the college must actively support such groups in their competitions—if not with funding, then at least with moral support.

The D4P EGR 286 course is probably our “flagship” undergraduate design course, where excitement is generated in the process of team design of mechatronic devices. However, this course may actually be offered too late (sophomore year) to be effective in student retention. The novel activities of EGR 286 may be better offered (with some modification) at the freshman level.

Nevertheless, EGR 286 is undergoing a significant review, so that the mechantronics, “robot-oriented” program can be offered more easily at CET by more faculty. This revision will also simplify the course structure, such that portions of the short-term projects (using Legos™ and controllers) can be offered in science fairs and summer high school camps as part of a recruiting process. Additionally, a detailed documentation project is underway to enable course materials to be available to partnering community colleges, as part of pre-engineering programs.

Another curriculum-related approach to the problem of retention is being pursued. A records-tracking system is being developed to identify root causes of retention problems and measure the success of interventions implemented by the Engineering Talent Pipeline efforts. This system will identify students at risk and provide guidance for interventions to help them before they encounter academic or personal problems that could affect their retention. This system will use a wide variety of information about each student obtained from existing NAU student databases, the CET course and teaching evaluation system, and other data sources such as a proposed NAU Retention Management System.[33]

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REFERENCES


