AC 2009-1248: ESCAPE TO ENGINEERING: A SUMMER BRIDGE PROGRAM FOR WOMEN IN ENGINEERING

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ESCape to Engineering:
A Summer Bridge Program for Women in Engineering

Abstract

The ESCape program is designed to support incoming female engineering students as they make the transition from high school to college in a number of ways. Some of the elements that may inhibit the retention of a female engineering student include lack of support from home, feelings of inadequacy with regards to mathematics performance, feelings of isolation, homesickness, and lack of connection within a large university. Incoming first year female engineering students are invited to attend the ESCape camp based on math SAT scores. The desired attendance is approximately fifty students, so students with lower scores are invited to apply. The week long camp includes elements of how to succeed in college math, three dimensional visualization skills, trips to local manufacturing plants and visits with their entire female engineering staff, parent programs, social programs, introduction to the campus computing environment and more. Reunions are held throughout the year, and the students are tracked in terms of academic performance, campus involvement, retention and other factors. This paper will present detailed camp content together with the supporting research and assessment data.

Introduction

The Women in Engineering Program in the College of Engineering at North Carolina State University developed and implemented its first ESCape Summer Program in August 2008. It was designed to help rising first year women in engineering transition into the College of Engineering and bridge the gap from high school to college. Only women who scored a 640 and below on the SAT math section were invited to attend this 5 ½ day residential summer program. This was intentional due to data that show a strong correlation between retention of students in the College and the grade they receive in their first math class. The camp was made possible by a generous donation from John Deere, therefore the participants were offered an incentive of receiving a campus bookstore gift card after completion of the program.

In addition to helping participants transition into the University and College of Engineering, other goals of the summer program included preparing them for mathematics and entry level engineering courses, exposing the students to faculty and staff within the College and University, having them participate in hands-on activities and learn about various departments within engineering, and to build social networks and support systems with each other as well as upper class peers and faculty and staff.

Approximately 204 of the female students admitted to the College of Engineering were invited to attend the summer program which was held the first week of August. Of those invited, forty-four accepted, and thirty-four attended the program. (Some could not attend due to the fact they were participating in summer enrichment program aimed at underrepresented minority students which conflicted with the ESCape Program.) Approximately twenty-four percent of the ESCapees were underrepresented minorities.

Design of the Experience

Nationally, women continue to exit STEM majors at a higher rate than men[1,2,3]. In the College of Engineering at NC State, this trend has slowed to the point where women are actually retained and graduated in the College at a higher rate than men, as indicated in figure 1.

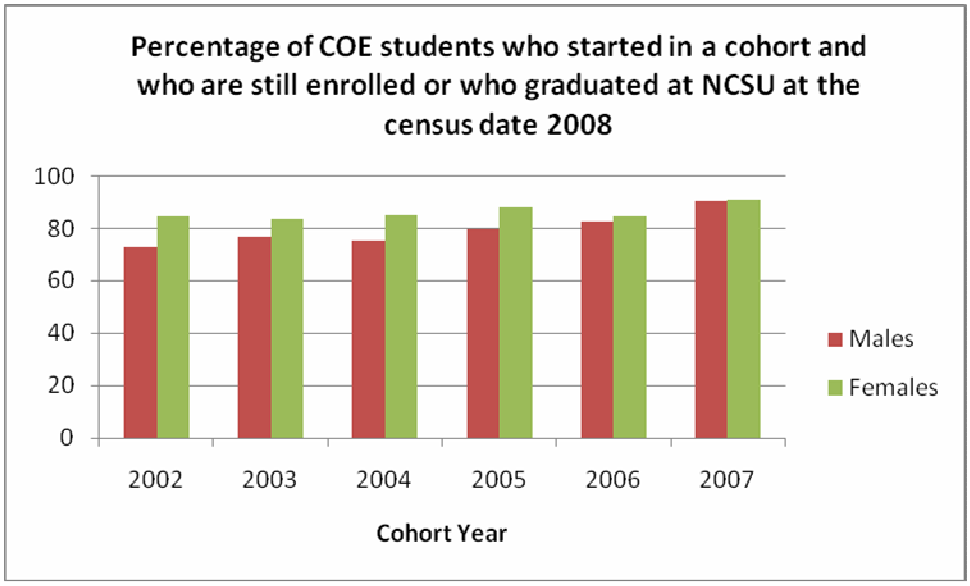

Figure 1: Students who entered in a cohort year who are still enrolled in or have graduated from Engineering

Despite this encouraging trend, the numbers of female students enrolled remains lower, around 250 out of a class of approximately 1200 for each of the listed years. To increase the numbers of successful female engineering students, efforts are in place to bring in more women and to retain them at an even higher rate.

One of the most effective ways to retain women in STEM fields is to encourage and support women in these fields while in college[1]. A study by the University of Washington showed that women who were most likely to be retained in engineering had voiced that the women in engineering program and faculty had a "positive influence on them during their first year in college"[4]. Many colleges and universities have implemented summer programs for rising freshmen designed to "bridge" the road from high school to university life[5]. In fact, NC State College of Engineering has two summer bridge programs that have been held for several years, one aimed at minority students and one for female students participating in our Women in Science and Engineering living and learning community. These bridge programs have been successful in accomplishing their goals and are fairly traditionally designed.

The critical difference in the creation of the ESCape bridge program involves using research to intentionally design a different experience. ESCape was designed through a return to first principles and reference to existing literature on factors that influence the retention of female engineering students in combination with results from internal research at NC State that yielded information about the success of our own students. (For example, previous studies at NC State

College of Engineering have demonstrated that students who do not matriculate into their engineering majors have poor math skills[6,12].)

The committee that designed the camp started with several areas of concern, some of which were based on simple cumulative experience as advisors and some based more firmly in institutional research from studies of the student population over the course of several previous years. The primary areas of concern were:

- Computer skills (based on anecdotal data from females leaving the College about first computing class being discouraging)
- Math bridge support (based on reports from college mathematics and engineering faculty about weaknesses)
    - Math study skills
    - Weaknesses in trigonometry knowledge
    - Lost art of finding more important material to study/picking teachers' brains about what will be on a test
- Need to build personal connections
- Need to build beginning College of Engineering identity
- Delivering coping mechanisms/armoring students against discouragements of first year
- Importance of parents to college success

The above focus areas were further refined by seeking support in education literature and then defining specific actions and/or content for camp sessions to directly address areas of desired emphasis. The table below lists some of the camp content connected with the relevant research. The first column lists the research or experience-related background. The center column lists the camp goal that was written by the planning committee to address that idea, and the last column lists the camp session and/or content that was designed to address the goal. The research-based ideas are referenced if they came from outside publications, and they are not if they came from the experience of NC State faculty and staff.

Table 1: Correlation between camp goals, research and components

Research-based idea	**Goal**	**Action/content**
Parental support important to success[10]	Inform parents about how to support their students	Parent meeting
Need to understand variety in engineering[13]	Expose students to broader variety of engineering than they had seen before	Departmental meetings/tours
Success in first math class strong predictor of success[6,7,12]	Increase student confidence/success in first math class	Math review session
E115 class impediment to retention of women	Increase student confidence in first computing class	Introduction to computers at _____ (E115)
Connecting to what engineers do on the job a strong motivator	Increase student commitment to engineering	Company tours
Selected from experienced advisors	Increase student success in first semester classes	Strategies for success session

Work indicating correlation between engineering success and 3-D[8]	Make students aware of their 3-D competencies	Wii™ games/3-D visualization session
Alternative to campus tour	Help students be comfortable on campus	Walk your schedule
Making connections with faculty[9,11]	Form engineering identity	Faculty luncheon
Making connections with contemporaries[7,11]	Form connections for study groups, increase confidence, form engineering identity	Social events
Making connections with older female students[7,11]	Increase confidence, form engineering identity	Cookout with SWE and AOE

Program Content

Programming for the camp was designed to keep the attendees engaged and busy for most of their waking hours, while meeting the selected objectives. This schedule was deliberate, including evening activities, to reduce opportunities for campers to go off campus or engage in unproductive activities. The students commented that they felt somewhat restricted by the "rules," which only involved attending every session and being in their room by midnight. The camp directors concluded from this that the rules had served their purpose, rather than that they should be changed. The staff felt it necessary to have more rules since the camp was during the summer and the students had not yet matriculated as college freshmen.

The staff for the camp consisted of the Director of Women in Engineering, the Coordinator for K-12 Outreach, the Director of the Women in Science and Engineering Living and Learning Community and one additional advisor from Academic Affairs, all female. Two undergraduate female day counselors and two night counselors, all engineers, completed the team that attended all activities. Most of the female engineering faculty members (about 25) also attended at various times, all at the faculty luncheon and some through departmental visits and industry visits.

Sessions during the camp fell into several categories, as listed below:

Parent Meetings— On the opening day of camp a welcome dinner for parents and students was held, and the Dean of Engineering and the Associate Dean of College of Engineering attended. An introductory session for parents and students was also held simultaneously. A concluding session for parents was held at the end of camp.

Departmental sessions—Departments within the college were invited to participate in the camp. The content and style of these sessions was determined by the department. The departments who participated included Electrical engineering, Nuclear engineering, Chemical engineering, Biomanufacturing, and Textiles (chosen as a representative sample and also for availability of willing faculty members).

Industry Visits/Tours—Visits to two different companies included trips to Burt's Bees and John Deere within 30 miles of campus. Tours were arranged as well as information sessions with women engineers at each company.

Successful navigation/transition—There were several sessions designed to help students with the transition to NC State. Math success @ NCSU focused on a calculus review by the math department. One of the Engineering Undeclared Advisors with the College led a session entitled, "Strategies for Success Freshmen Year" which included upper class women engineers giving advice they wish they had known their first year at school. A two hour session about E115 was held which included installing necessary software on to their personal lap tops. A 3-D visualization session was also held. Finally, students were put in groups with an engineering leader and they walked campus to find their scheduled classes for the fall.

Evening –Each evening structured activities were provided for the students. These social activities were led by the evening counselors and included bowling, pottery painting, cookout/pool party with women student organizations including Society of Women Engineers and Alpha Omega Epsilon, movie night, and Wii™ night (which was actually used for 3-D visualization skills).

Networking—This was an important aspect of the camp and was interwoven throughout the camp. Networking occurred with camp staff, Engineering faculty lunch panel & small group discussion, peers, and upper-class students in Alpha Omega Epsilon (professional engineering sorority) and the Society of Women Engineers.

Assessment

The assessment for the camp includes an online, anonymous survey given six months after the conclusion of the camp. In addition, parents and students were asked to fill out a survey at the end of the week before they left campus after the camp. The six month survey addressed aspects of the camp that are outlined in the table above. Questions in the math and computing areas asked whether students felt prepared for their first classes, and also whether they felt the camp had an impact on their confidence and/or preparedness for those classes. The students were asked whether they were *more aware* of 3-D visualization, since the faculty felt that the short seminar was unlikely to have improved them. However, increased awareness of 3-D issues should also positively impact the students.

The results of the ESCape survey are listed below. The survey had a 50% response rate. The stacked bar graph below enumerates responses by percentages based on a five point scale, strongly agree, agree, neutral, disagree and strongly disagree. The green portion of the bars indicates the percentage of respondents that agree or strongly agree, the red those who disagree or strongly disagree. The intensity of the color corresponds to the intensity of the response, i.e. whether strong or not. The height of the bars indicates the percentage who are neutral, since the neutral percentages are not in the stacked bar. Specifically, the statement about 3-D visualization had the most neutral respondents, since it was the shortest bar.

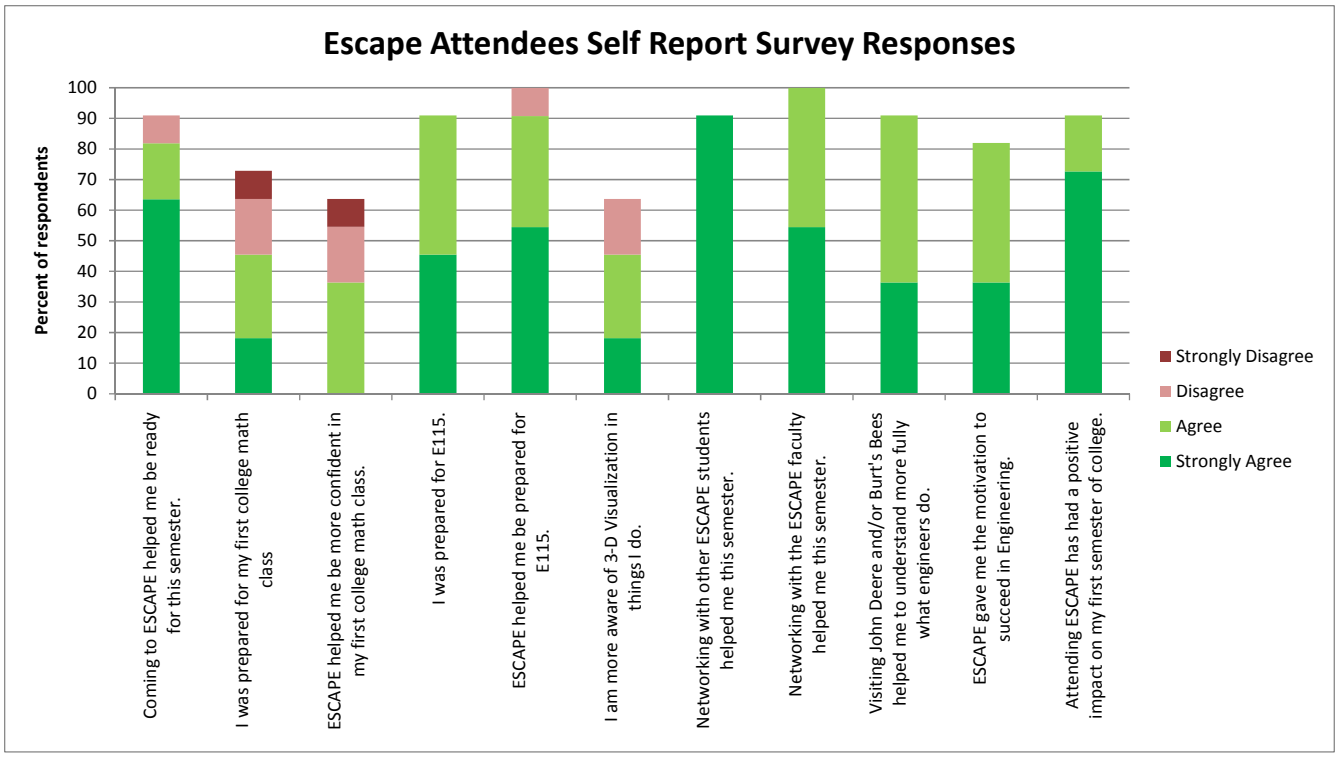

Figure 2: Percentage of respondents agreeing/disagreeing with statements about ESCape camp

The responses indicated the degree to which, at least from the perspective of the students, the camp goals had been met. The students indicated that they felt prepared for their first computing class (E115) and credited ESCape for that feeling. Sixty-three percent of the students felt prepared for their first math class, with fifty-six percent saying that ESCape positively influenced their confidence in the class. The camp faculty feels that the review class presented in the camp, because it was presented as a review and was intimidating to some students who did not recall having learned the information, was less effective. The faculty was surprised, in fact, at the number of students who stated that they did not remember being taught the trigonometry that was included in the review.

Forty-four percent of the students stated that they had been more aware of 3-D visualization in the things that they do. The activities that addressed this were an evening Wii™ tournament, where students played each other in tennis, fishing and other games that include an element of 3-D visualization skills. The next day's activities included a seminar extracted from Sheryl Sorby's work[8] that included a short quiz that the students took. The goal was to simply help students to be aware of how 3-D visualization skills are used in the classes that they take (including integration in calculus, diagrams in physics, etc.) and that different people have different levels of these skills.

The 94% strong agreement with the networking statements, whether student or faculty, indicate that students felt that these elements had strongly influenced their success in the first semester. In addition, 94% of the students felt that the industry visits helped them to understand engineering. Perhaps most significantly, 88% of the students felt that ESCape had provided them the motivation to succeed in engineering.

The survey had three open-ended questions: 1- List all the ways ESCape helped or positively impacted you that you can think of, 2-What was the best thing about ESCape, 3-What would you change for ESCape next year? Some of the answers to these are reflected in the statement/response questions outlined in the figure above. Many noted some aspect of networking as a positive impact and/or the best thing about the camp. One student listed the best thing about the camp as: "It gave me confidence as a female in engineering. I learned that it's ok to not be "amazing" at math, everyone struggles sometimes." Some selected additional responses are given in the table below.

Table 2: Sample responses to open-ended survey questions

Being introduced to what was ahead in the semester such as being introduced to e115, knowing faculty and being able to see what engineers do in the field.
Walking the campus helped so much! I felt better prepared and more confidant going to class that first week. It also helped me to meet new people and get to know others in a non-classroom setting…being able to say hi to people and go to the gym with a friend was very helpful and made the transition much easier. Also, learning about the different areas of engineering helped me to see what other options I have.
Definitely getting to know some of the girls that were going to be in some of my classes helped. Also, I was really relieved to have a lot of the computer programs already downloaded for E115.
Getting to know campus, instructors, other students. Finding classes knowing other girls.
Knowing people before I came to school.
Getting to know the people. Fellow students and some of the professors and mentors. I really like having a large amount of people to rely on.
Meeting new people so I didn't feel so alone at the beginning of the year.
Getting to know some of my professors and women in engineering. It helped bridge the gap from high school to college. Also the people who were at the camp have become my friends and study buddies!
Engineering confidence; Networking with other women engineers; Mentally preparing me for the obstacles as a first year engineering student; Motivation to succeed; First step in feeling a part of NC State--Making new, great friends
Knowing people, being prepared for classes, people to look to when things get rough...they just really helped pull me through this past semester and one of them is going to be my roommate next year.

I made new friends that I might not have made in just the first semester. I was familiar with campus through exploring campus. I found a week with girls who wanted to be engineers was very encouraging that women can become engineers.
I just felt more confident going into my first semester. I felt like I had a better feel for the campus, what to expect from my classes. Also it was comforting to know that a lot of the concerns I had were the same as the other girls, and that the counselors had them before they came and told us they didn't last long.
I have made great friends thanks to ESCape and going into my first semester of college I was secure in my decision to become an engineer.
I made so many new friends. There's no better feeling like seeing one person that you know in a huge room full of 300 strangers.
Maybe provide a few different nighttime activities.
It would have been nice to hear some of the sophomores give advice and first hand experiences.
... more activities to replace the lectures.

Semester Grade Data

Semester grades were examined for ESCape attendees and compared with a sample of non-attending female and a sample of male students matched on math SAT score and ethnicity. The SAT math scores were matched within 10 points to achieve the match based on ethnicity. The match did not consider economic and social factors since this information was not readily available. The participants of the ESCape program averaged a 2.972 grade point average after their first semester in engineering. The matched sample of non-attendees averaged a 2.912 grade point average after their first semester in engineering. The grade point average for male students was 2.703. Because it is not unusual for female students to perform better than male students, this number is provided as a sanity check. This exercise will be performed each semester for at least three more semesters. The semester grades were not compared with the results of the Student Transition Program (STP), a six-week program for minority students in engineering at NC State. This was due to the fact that the programs are not comparable, as the students in the STP program take summer school classes for credit. In fact, when the SAT scores were matched based on ethnicity, students in the STP program were excluded from the match since they had already attended class at NCSU and been awarded college credit. ESCape was assessed solely on the basis of its own goals.

Table 3: Semester grade data for attendees versus matched sample

	SAT Math Score	High School GPA	Fall 2008 Semester GPA
ESCape Attendees	590	4.286	2.972
Non-ESCape Females	590	4.303	2.912
Non-ESCape Males	590.30	4.313	2.703

An additional measure of the students' status is retention. Of the 35 students attending the camp, only one left the university and returned to a private college near her home. At this time, none have transferred to another College on campus, however this will be tracked over the next years through graduation. Unfortunately, one of the participants is now deceased which occurred during the fall semester. Semester grade analysis did not include the deceased student. The ESCape community responded to the death of this student in a manner very supportive of one another, meeting to prepare condolence cards for her parents and process this tragedy together.

Examination of the assessment results in this section was then applied in relation to the camp goals:

- Inform parents about how to support their students
  - Parent surveys indicated unanimous approval of the information sessions, particularly those with the Deans of Engineering.
- Expose students to broader variety of engineering than they had seen before
  - Both open-ended questions and Likert questions indicate strong agreement that this goal was met.
- Increase student confidence/success in first math class
  - Fifty-six percent of students said ESCape increased their math confidence. The math session will be reworked for the next camp and couched less as a review of concepts that they should already know and more as a session on how engineers use math.
- Increase student confidence in first computing class
  - More than 90% of the students credited ESCape with increased confidence in E115.
- Increase student commitment to engineering
  - Eighty-eight percent of the students said ESCape increased their commitment to engineering. In addition, the open-ended responses further defined this commitment.
- Increase student success in first semester classes
  - GPA data indicate that students performed fractionally better. The biggest influence on student GPA for this class was in fact chemistry. Students

performed at the lowest success rate in chemistry. Next year's camp will include chemistry sessions conducted in conjunction with chemistry professors.

- Make students aware of their 3-D competencies
    - Almost half of the students felt their awareness was increased. In next year's camp, 3-D awareness will be introduced earlier in the camp week and reiterated as appropriate during activities and other sessions, including the industry tours.
- Help students be comfortable on campus
    - The open-ended responses indicated that ESCape significantly helped students feel more comfortable.
- Form engineering identity
    - Although the survey tool did not specifically seek to measure identity, open-ended responses contained significant amounts of language like "confidence as a female in engineering" and "other women engineers" which indicated that the women were identifying themselves as engineers.
- Form connections for study groups, increase confidence
    - Open-ended responses indicated universal agreement that this goal was met.

The students will be tracked through graduation, as will each cohort of incoming students that attend the camp, modified by the formative assessment results extracted from this survey and grade data.

Conclusion

The assessment of the ESCape summer program has been conducted for only one iteration, but preliminary data indicate that this grass-roots approach to designing the camp has strong potential. Future assessment will track the participants' progress including matriculation rates, grade point average, and retention in the College and at the University. In addition, future work will compare the ESCape camp to camps offered by other universities.

Not only will we conduct future assessment, we will also provide future programming for these participants. A reunion was held mid-semester during the fall for everyone to come together and socialize, for program staff to offer advice and guidance prior to spring course registration, and to mourn the loss of one of the summer participants. Students were also personally invited to a major spring Women in Engineering program, called Passport to Engineering. The ESCape participants will continue to be invited to reunion gatherings each year as well as personally be invited to various events offered by the Women in Engineering Program. The initial findings of the summer program are positive indicating the program provided motivation, confidence, and networking that helped with their overall success in first semester grades. Some critical feedback of the program included the desire for more hands-on activities and fewer structured evening activities. The program will continue to evolve and will incorporate this feedback. Other sessions will be added including a possible chemistry and physics review and a modified mathematics review session that should provide more tools for success and greater confidence.

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