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Lessons Learned from an ECE Recruiting and Retention Program that Increased Undergraduate Enrollment Over 60% in Four Years

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Abstract:

This paper builds upon past works that were published in the ASEE Conference proceedings in 2011 and 2012. In response to a severe decline in undergraduate enrollment from 2004 to 2008, a corrective action program was implemented in our Electrical & Computer (ECE) department at the University of Oklahoma (OU). During this time, our undergraduate enrollment dropped by 36% (387 in 2004 to 246 in 2008). The goal of our corrective action program was to return our enrollment to a target number of 350 students and produce structures and processes to help sustain our enrollment in the future. In the fall of 2012, all program goals were met as our enrollment numbers increased to 399 students and several sustainment measures were put in place. This paper focuses on the lessons that were learned during these four years where we experienced a 62% increase in enrollment with a very modest financial investment.

Early in the process, student surveys were used to gain insight into what inspired students to select ECE as a major. These data were used to shape the focus of our recruiting and retention program and to create a structure that our students would be interested to participate in. We later learned that student participation in the program was a necessity for it to be effective and sustained. Initial survey responses from several students who are now leaders in our recruiting and retention programs will be shared along with their thoughts on how participating in the program benefited them. Analyses of the recruiting methodology we used and the practices we found most cost effective are also shared in this paper. Time is considered an integral factor in the cost effective metric. Early in the program, it was apparent that many activities that took an enormous amount of time were ineffective and detracted from activities that are effective. The goal of this paper is to share our experiences as a means to provide suggestions for other engineering departments that are trying to reverse declining enrollments.

I. Introduction:

In response to a severe decline in undergraduate enrollment from 2004 to 2008, a corrective action program was implemented in our ECE department. During this time our enrollment dropped by 36% (387 in 2004 to 246 in 2008). The goal of our corrective action program was to return our enrollment to a target number of 350 students and produce structures and processes to help sustain our enrollment in the future. As of the fall 2012 reporting period, the number of undergraduates enrolled in ECE was 399, as shown in Figure 1. 261 of these students were majoring in Electrical Engineering and 138 were majoring in Computer Engineering. The second plot on figure 1 is the ASEE national ECE undergraduate enrollment data between 2004 and 2011. 2012 data was not available at the time of publishing this paper.

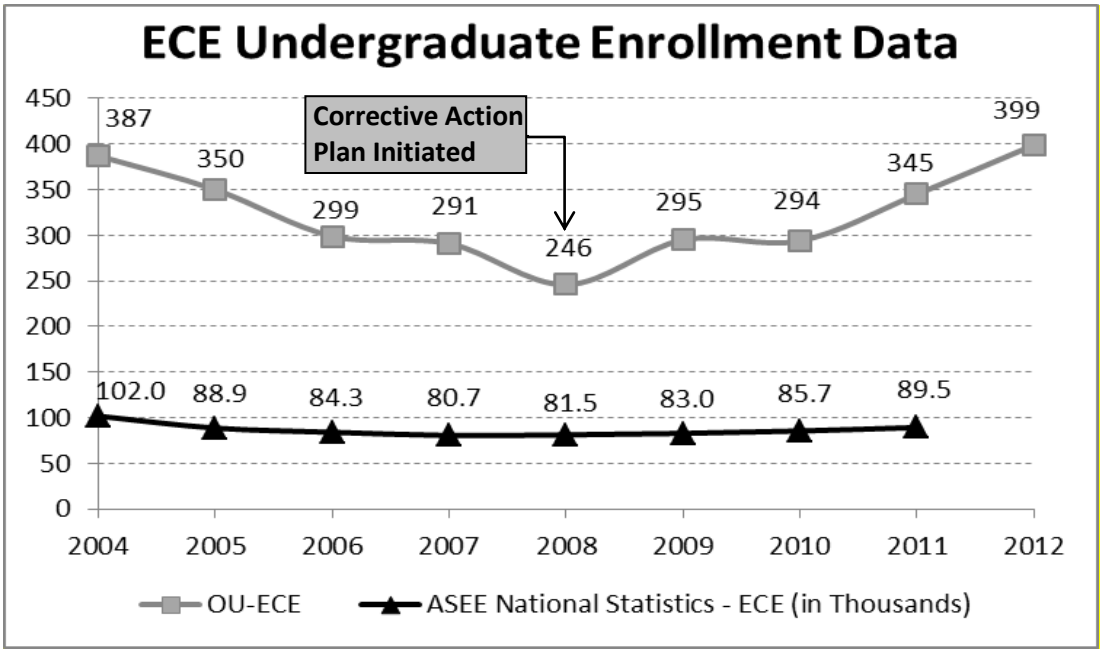

Figure 1: ECE undergraduate enrollment over the last nine reporting periods.

When analyzing the enrollment increases for OU-ECE, the ECE enrollment numbers from the ASEE data is used as a baseline. The ASEE data shows that national ECE undergraduate enrollment declined from 102,012 to 81,501 between 2004 and 2008. This 20.1% decrease was lower than the 36.4% decrease experienced by OU-ECE. After the ASEE national ECE enrolment data decline leveled off between 2007 and 2008, it experienced an average annual increase of 3.3% between 2008 and 2011. The OU-ECE undergraduate enrollment far exceeded that figure at an average annual increase of 15.5% between 2008 and 2012.

Prior work[1, 2, 3] details our methodology, which is focused on advanced engineering technologies, innovative demonstrations, and hands-on activities at a level that the individual student can understand and appreciate. On the surface, this statement might sound like a vague generalization that every engineering department does to some extent. However, most departments that we have observed miss the mark when they try to implement these principles. They are often done sporadically, ineffectively, and not engrained into every aspect of their program. Most importantly, students in their program are usually not the driving force behind the program. Our corrective action program was initiated by the faculty, but now it is being led by students.[3] Later in the paper some, of the details of our corrective action program will be highlighted. The way in which each part of the program was designed to improve specific metrics (shown in Table 2) will also be discussed. To avoid repetitious and non-descriptive words, "student" will be used for those that are in college and "pupil" will be used for those that are K-12. Our university has separate Electrical Engineering and Computer Engineering majors. Since our goal is to increase the sum of the enrollments in these two majors, the term ECE will be used to include either an Electrical or Computer Engineering major.

II. Corrective Action Plan Background

There are three factors that shaped our corrective action program. First, we studied the things that motivate students to select engineering. The Center for the Advancement of Engineering Education (CAEE) has published an abundance of information on this subject. In the Academic Pathways of People Learning Engineering Survey (APPLES), six motivators were analyzed. The results of the survey are shown in Table 1.[4,5] The focus of all aspects of our corrective action program appeals directly to the top two motivators; intrinsic behavioral and intrinsic psychological.

Table 1. Motivators for Selecting Electrical Engineering

Motivator	Description provided in the APPLES Technical Report	Men Value	Women Value
Intrinsic Behavioral	Motivation related to practical and hands-on aspects of engineering, e.g., "I like to figure out how things work," "I like to build stuff."	86.5	86.1
Intrinsic Psychological	Motivation to study engineering for its own sake, to experience enjoyment that is inherent in the activity.	81.4	87.3
Social Good	Motivation to study engineering due to the belief that engineers improve the welfare of society.	76.2	83.1
Financial	Motivation to study engineering due to the belief that engineering will provide a financially rewarding career.	66.1	72.6
Mentor Influence	Motivation to study engineering due to the influence of mentor(s) while in college.	35.5	39
Parental Influence	Motivation to study engineering due to parental influences.	15.8	19.6

The second reason for this focus was driven by the interest level from the pupils in some of the workshops ECE has directed in the past and observing the success of existing programs, such as Botball and FIRST. The common theme of both of these programs is that they are focused on the creation of a technologically advanced robot and framed into a fun competition that engages pupils. They have found a great way to leverage the intrinsic behavioral and intrinsic psychological motivators. The merit of this recruiting methodology was reinforced while serving as a mentor in the FIRST Robotics Competition. The level of pupil enthusiasm at the FIRST Robotics Competition regional competition was surprising and worthy of replicating by other organizations seeking to promote engineering [6].

The third factor resulted from feedback to surveys given in the first ECE course taken by the students at OU. 151 surveys were received early in the formation of our program[2]. When asked "what reasons do you attribute for choosing your major" the largest response was that it was "fun", "exciting", or "interesting". Additionally, many students listed specific ECE topics such as: computers, video games, programming, circuits, electronics, technology, and robots. These results were what we were attempted to emphasize as we implemented our program. The central focus of our outreach and recruiting activities is to create fun, exciting, and interesting demonstrations and hands-on activities that are related to the specific items listed by the students in the surveys. Most of these are created by ECE students. In this way the students can see the

types of things they will be capable of doing if they choose ECE as a major. Another survey question asked the students to state "what impressed them about the experience" (if they were exposed to our outreach or recruiting activities). The most popular response to this question was related to seeing the student projects. Looking back at some of the responses to this question from students that are now leaders in our outreach and recruiting program, they all specifically listed these projects as something that impressed them. These students are now creating and presenting the demonstrations and hands-on activities for pupils. We are beginning to see a cyclic effect that has good potential for sustainment. Once OU-ECE students are capable of creating impressive projects, they are eager to show them off at our recruiting events.

III. Corrective Action Plan Implementation

Initially, the goal of all of our activities was to appeal to the top three motivators listed by CAEE (1-intrinsic behavioral, 2-intrinsic psychological and 3-social good). More recently, the primary focus has been shifted to the top two motivators. As more survey data were obtained from our students, social good was not very highly rated. Furthermore, requiring a "social good" element to all recruiting activities was more difficult to implement and required an additional time investment. Instead, we emphasize the social good aspect of ECE prominently in our recruiting literature and mention it verbally during the presentations or hands-on activities when there is a straightforward connection to be made. We have found that the social good motivator is more effective to college-age students than pupils. This is one reason that we have been able to gain such strong support from ECE students in our recruiting activities. Many of these ECE students have indicated that they believe they are benefiting society if they can lead pupils to pursue a major in engineering. The recruitment coordinator for OU-ECE strives to mentor these students and tries to instill this philosophy in them. One ECE student leader stated that his goal is "to inspire younger students in the same way that upperclassmen had inspired me."[3]

With ECE course loads being very difficult and time consuming, getting students to sacrifice time for recruiting is likely a difficult proposition for most universities. When our corrective action program was initiated in the fall of 2008, there was very little involvement in recruiting and outreach from ECE students or with ECE student organizations. Now we have so many

students wanting to participate that we rotate them in shifts. To achieve this level of involvement, we initially focused primarily on the ECE student groups. There are multiple student organizations and competition teams at OU that are made up primarily of ECE students. The IEEE student chapter president in 2012 commented that "after first volunteering for on campus events, most members enjoy the experience and gladly volunteer for later events."[3] We believe the reason the students enjoy these activities is due to the methodology we chose. Showing off cool projects that they (or their classmates) created is a fun activity for most students majoring in ECE. It also gives them a sense of accomplishment and resolution. They feel that they have arrived to the point that they can show others what ECE is all about and feel good about giving back. One ECE student that switched his major from physical therapy to EE because of these recruiting activities stated that he wants to inspire others to major in ECE in the same way he was inspired.

As detailed extensively in previous work[1,2,3] the format and venue of our recruiting and outreach activities vary by event. In attempt to maximize the fun (intrinsic psychological motivator), outreach events for younger pupils are usually hands-on activities that are framed as a competition with prizes. A recent example occurred in the summer of 2012 when several ECE students led an outreach event where middle school pupils created their own laser tag system and competed against each other. The inspiration behind this hands-on activity was an ECE class student project from the spring 2012 semester that had been turned into a demonstration for recruiting. This outreach event for female and underrepresented minorities was very well received. It occurred during a summer camp at OU where many different disciplines had a session. The ECE session gained special notoriety and was even highlighted in the local newspaper.

Recruiting events for high school pupils are usually more focused on small groups that are shown ECE projects and allowed to get their hands on them. Some of the student projects that have been shown recently are:

- LabView Joystick Video Games
- Magnetic Levitator
- Electromagnetic Particle launcher – Safely propels a piece of iron at a target when fired.

- Mind Control Device – Moves a needle when you concentrate.
- Tesla Coil
- Electronic Musical Instruments
- Guitar Amplifiers and distortion pedals.
- IR transmit/receive modules that flash the receiver when the transmitter is shot at it.
- Virtual games and musical instruments using the Kinect sensor module in the Xbox 360.
- Remote controlled lady bug modified to act autonomously. (Designed for Females)
- Large microcontroller based robots that move around on the floor.
- Small line following or light seeking robots that move around on the display table.
- Analog electronics based walking robots and sumo wrestling robots.
- Remote controlled helicopters used for controls research.
- The Electric Go Cart Competition Team's vehicle (This is taken to local high schools)
- The IEEE Robot Competition Team's robot (This is often showed during personal tours)

Video examples of many of these projects and other outreach activities can be found on our youtube channel: www.youtube.com/ECEatOU/ and pictures can be seen at our facebook page: http://www.facebook.com/pages/OU-Electrical-and-Computer-Engineering/167607003291905

Initially, we focused more on recruiting and outreach than retention because retention methods took more time to develop. In keeping with the focus of OU-ECE's overall program, the most keenly-sought new retention program was a continuous mechanism to present advanced engineering technologies, innovative demonstrations, and hands-on activities to students in their first year. A recent publication from the American College Testing Program provides the results of research that lists the top practices that make the greatest contribution to retention.[7] A first-year seminar/university course that is taken for college credit is listed as the number one practice by a large margin.[7] Past work describes in detail how OU-ECE applied its new retention program into first-year seminar/university courses.[2] At OU, all engineering majors are required to take a freshman engineering orientation course. The primary goal of these courses is to increase retention by providing the students with an engineering experience. By having ECE-led sections, we are able to increase the exposure and excitement in our discipline in much the same way we do in outreach and recruiting events. The number of students in ECE led freshmen orientation sections has increased significantly since we initiated the program. In the first two

years (2009-2010) there were 234 students in the sections and 322 in the last two years (2011-2012). We plan to continue this level of ECE led freshman orientation sections to help sustain our enrollment numbers.

IV. Performance Metrics

Figure 1 shows the primary goal of our program was achieved, but to study the effectiveness of different aspects of the program a lower level analysis was performed. Table 2 shows a detailed breakdown of metrics that are important to determine our level of success. Freshmen with less than 24 hours are classified as U.C., which stands for University College. At OU, students officially move into the College of Engineering (CoE) when they reach 24 credit hours. "New students in U.C." are those that come to OU with less than 24 hours of college credit. Most of these students come to OU directly from high school. "New students in CoE" are those that transfer from other colleges or current OU students that change their major to ECE. The "% of U.C. students retained the next year" metric is the percentage of U.C. students that initially declared ECE as a major and were still majoring in ECE in the next fall reporting period.

Table 2. Detailed enrollment and retention data

Totals	Fall 2008	Fall 2012	% Increase
Number in U.C. (< 24 credit hours)	66	89	35%
% Female in U.C.	12.1%	14.6%	2.5%
Number in CoE (≥ 24 credit hours)	180	310	72%
Combined Retention GPA (CoE Students)	3.11	3.15	1.3%
Number of Students Reporting ACT score	179	274	
Average ACT score	26.6	27.1	1.9%
Number of Students Reporting SAT score	72	120	
Average SAT score	1240.6	1261.6	1.7%
Number of National Merit Scholars	11	41	273%
Averages	Fall 04 to 08	Fall 09 to 12	% Increase
New Students in U.C. per year	59	79	34%
New Students in CoE per year	66	87	32%
% of U.C. students retained the next year	38.4%	53.6%	15.2%

a. Metric 1 – Student Quality

The potential negative consequence of reducing student quality was a significant concern in our attempt to increase enrollments and something we strived to avoid. Table 2 shows all student quality metrics (GPA, ACT, and SAT scores) have increased. Additionally, the number of National Merit students in ECE at OU has dramatically increased. To achieve these results, we emphasized high quality students, especially National Merit Scholars. Providing VIP personal tours for highly sought after pupils was the primary technique used to improve this metric. Personal tours are something offered to any student or pupil, but if he/she is a National Merit or other distinguished scholar, then more time will be invested to take it to a higher level. Some of the things that can be included are multiple student project demos, visiting a research lab to see the advanced technologies our students are working on, touring student and competition team labs, and additional tours with ECE student leaders. We plan to continue this practice to help sustain our enrollment numbers and student quality.

b. Metric 2 - Increase the number of U.C. students that declare a major in ECE

Table 2 shows that 89 new U.C. students declared ECE as a major in 2012. This is a 10 year high for OU-ECE. We have averaged 34% more annually in the four years following the corrective action plan than the five years before it was initiated. Personal tours for high school juniors and seniors were likely a contributor to this success. Another technique that was designed to target this metric was to participate in recruiting events with substantial ECE student participation. These recruiting events often involved setting up a table display. At nearly every event witnessed in the last four years, many of which had multiple universities and disciplines present, our table had the most impressive demonstrations and hand-on activities. Evidence of this is the multiple awards we have won for the best table display at the Shell Fall Festival OU recruiting event. Examples of student projects that are included in our table displays are listed in the previous section. Furthermore, we usually had many more students present than others. The primary goal of these events is to inspire pupils to think about majoring in ECE, but we also sign up prospective pupils for personal tours on our campus.

c. Metric 3 - Increase the number of new CoE students in ECE

Table 2 shows that we have averaged 32% more new CoE students annually in the four years following the corrective action plan than the five years before it was initiated. Recruiting events that are designed for OU freshmen play a large role in our strategy to improve this metric. OU-ECE has a table display at these events along with all of the ECE student groups and competition teams. Freshmen are presented with a variety of impressive ECE student projects that often lead many students to change their major. For example, a student came to OU as a National Merit Scholar majoring in another field and visited one of these events the weekend before the semester started. He was quite impressed and signed up for a personal tour on the first Monday of classes. On the next day he switched his major to Electrical Engineering and is now one of the top students in our program. The key factor in improving this metric is thriving ECE student groups and competition teams. Non-engineering students and those majoring in other disciplines are attracted to the major through these students. OU-ECE has seen a dramatic increase in student group involvement since the inception of our corrective action program.[3]

d. Metric 4 - Increase the number of U.C. students who persist in ECE into the 2nd year

Table 2 shows that we have averaged a 15.2% annual improvement in this retention metric for the four years following the corrective action plan than the four years before it was initiated. Since our plan began in the fall 2008 semester, the new fall 2008 U.C. students that persisted in ECE into fall 2009 is included in the post-plan percentages. We will not have retention data for the fall 2012 class (our largest class of new U.C. students in 10 years) until fall 2013. Active ECE student group and competition teams play a large factor in this metric. Students are compelled to stay in the major in the same way non-ECE students are attracted to the major. The ECE-led freshman orientation sections that were previously discussed are another method we have successfully used to increase our retention rates.

e. Metric 5 - Increase the number of female and underrepresented minority students

Table 2 shows that the percentage of females in our new U.C. class in fall 2012 was 14.6% compared to 12.1% in fall 2008. Since race reporting is optional at our University and many students choose not to fill out this information, the underrepresented minority data will not be included in this paper. This modest increase in female students is encouraging, but the strategies we have utilized will not be realized until further in the future. This is due to two factors. First, the primary technique used to increase female and underrepresented minority enrollment is outreach to pupils, mostly middle school aged. These pupils are beginning to reach college, but the program has not been in effect long enough to see the full result of these efforts. The reason to focus our outreach on females and underrepresented minorities is to reach them at the age that is the most crucial in determining whether a pupil will choose to go into a math or science related field.[14] Furthermore, from recent experiences in dealing with pupils, it is evident that ECE is not well understood and therefore outreach is essential.

The second factor that has not been in effect long enough to show results is a new student group called Women in Electrical and Computer Engineering (WECE). This group started in the fall of 2012 at OU and is growing in numbers. They recently had a very encouraging turn out at an event to teach female ECE students to solder by making fun, flashing LED Christmas presents. We hope this student group has the same effect on our female population that our other vibrant student groups have had on the total OU-ECE population.[3]

f. Metric 6 - Low Financial Investment

We were able to reach our target enrollment goal in four years with a small financial investment. In 2008, we allocated $25,000 for recruiting materials and travel expenses and as of 2013 these funds have still not been fully depleted. Another investment was selecting a faculty member to be the recruitment coordinator. In the 2008 academic year, this position carried a 25% load. In 2009 through 2012 the position carried a 12.5% load. In summary, over the last four years a total of five courses were removed from the recruitment coordinator's normal teaching load. No scholarship incentives or any other investments were included. Maintaining this position is of vital importance to sustain our enrollment numbers.

This position can be made less demanding and carry a smaller load by reducing the number of low-profile events in our recruitment strategy and by encouraging ECE students to continue to take on more of the responsibility.

V. Lessons Learned

This paper concludes with reflections on lessons that were learned over the last four years while attempting to perfect our outreach, recruiting, and retention programs.

a) Don't Lecture - Engage!

This simple piece of advice was found early in the implementation of our program in an online article by Seelman.[8] We interpreted this statement as talk less and show more. The pupils will likely not remember your words, but they will remember the interesting things you show them.

b) Don't Spam the Pupils

There is nothing more time consuming than written and verbal correspondence. After initially putting considerable efforts on these activities, we started to realize that there was little response or evidence that it made much of an impact. We were able to achieve successful results with little effort spent in this area over the last three years. Responding to emails or calls initiated by the pupils should definitely be placed as a top priority, but being the initiator of the correspondence did not appear to be a good use of time in our case. In today's age of rampant spam and telemarketers, some pupils might be turned off by phone calls, emails, and letters.

c) You Need a Recruitment Coordinator

A common practice of engineering departments is to have the chair/director handle recruiting duties on top of everything else they have to manage. From our experience, allocating a portion of a faculty member's load to serve as the recruitment coordinator is an effective process. With fewer things to manage, this person can focus more on these aspects of the department. Selecting a recent PhD graduate or a new faculty member is a good idea because they have more "skin in the game." They will likely equate increasing enrollment with job security, which provides additional motivation. Another key factor is finding someone that is passionate about

promoting engineering to pupils. Finding someone that has served as a mentor for FIRST Robotics or other similar organizations would be a good litmus test. Looking for someone that is a faculty sponsor of a student organization is another good idea because they will have a better chance at getting the students involved in the process. Details of how the recruitment coordinator motivates the students to be ambassadors for the recruiting program is described in prior work.[3]

d) We Have a Math Problem

In past work[3], we concluded that the vast majority of students that switched out of engineering or left OU altogether could not pass the prerequisite calculus courses to get into the engineering courses. This is a difficult problem to solve. This problem would be best addressed by helping pupils at math at much younger ages so they could come to college prepared and not have to play catch-up. A worthy endeavor by anyone interested in promoting engineering would be volunteering to help young pupils improve their math skills so they would have the option to become engineers someday.

e) Students > Professors

When it comes to recruiting pupils, students have a distinctive advantage over professors because they relate to them better. Prior to the initiation of our recruiting program, there were almost no students involved in recruiting or outreach activities. Now, the students do most of the talking and the faculty serves in more of a coordinator/mentor capacity.

f) Best Recruiting Practice = Personal Tours

As previously discussed we have been incredibly successful at increasing the number of National Merit enrollment since we began the VIP personal tours. In past work[2], we tracked 21 National Merit students that were given personal tours and 14 of them ended up coming to OU and majoring in ECE. This is a small sample, but it is an excellent result since students are generally choosing between many schools and various majors. The fact that the number of National Merit

scholars in OU-ECE has increased from 11 to 41 (shown in Table 2) between 2008 and 2012 shows that this practice appears to be working.

g) Student Organizations are the Key to Success

The number one factor in our success was likely the active involvement from student organizations. From our experience, most faculty members pay little attention to the student groups in their department and do not utilize them effectively. Supporting these groups and serving as a mentor or faculty sponsor for them is one of the best ways to keep your department prosperous.

h) How to Find the Projects

Experiential learning is a major focus in OU-ECE, so it is not difficult to find courses that include hands-on projects. The difficulty is capturing these projects so they can be used for recruiting. Preferably, the students and their projects would be used together for recruiting. The project presentation to the pupil is more effective if the student can show them how "they" designed and built the project and specifically how it works. One should strive to work with professors to get them on board with this recruiting methodology. Some may even be inspired to include a hands-on project in their course so they can contribute to the recruiting program and the good of the department.

i) Validation Data is Overrated

As engineers, we tend to try to scientifically validate whether something works or not. In terms of recruiting and outreach, the more subjective validation technique of observing the level of pupil engagement might be more appropriate. It is far more cost effective and might give a more accurate indication of effectiveness than a survey or other more scientifically sound validation methods.

j) Women are From Venus

From our observations, there is nothing more profound than the difference in female pupil engagement when the presenter is a female ECE student instead of a male faculty member. Studies have shown that actively engaging females, especially peers, to help in the recruitment process is highly effective. [9, 10] This has been and will continue to be an emphasis in our program. By supporting WECE, and with the help from our new female faculty member (hired in 2012), we hope to see continued increases in our female population in ECE.

k) Don't Just Put Your Feet in the Water; Dive In!

To implement the methodology defined in this paper, one outreach event periodically is not enough to make a significant difference. We were doing this as our enrollment declined by 57% between 2004 and 2008. This paper and prior work provides many examples of projects that are focused on ECE, but this methodology can be used for any engineering discipline. There are an abundance of papers with great recruiting and outreach ideas that have been validated to be effective.[11, 12, 13] Until a stream of student projects begin to come in, these papers and others like them can be used as blueprints to get things started. Eventually, to maximize the effectiveness of the program, there needs to be a continuous process of students creating new projects to show pupils. This model has led to a dramatic success for OU-ECE and should translate to any engineering discipline if it is implemented effectively and embedded into all aspects of outreach, recruiting, and retention. We hope our successes will inspire others to take the plunge and together we will produce what our nation and world desperately needs: more engineers.

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