

AC 2009-321: UNDERGRADUATE RESEARCH EXPERIENCE: A TOOL FOR STUDENTS PURSUING A GRADUATE DEGREE IN ENGINEERING

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Abstract

Many engineering programs across the country have witnessed large numbers of students leaving their engineering programs before graduation. Retention in most engineering programs has become a burning subject due to students' comments on the inaccessibility and unapproachable nature of the faculty. Against this backdrop, we initiated an undergraduate research experience program in the Virginia State University's Center for Biosystems and Engineering (CBE) in order to address and evaluate students' likelihood and performance in the Department of Engineering and Technology to pursue a graduate degree in engineering. We selected students with a cumulative GPA of 2.0 to participate in the program based on their persistence to obtaining an engineering degree. Although GPAs are the strongest predictors of persistence in engineering, our approach focuses on recruiting students who are eager and willing to learn. Along with the willingness to learn "how to learn", the participants must maintain a minimum cumulative GPA of 3.0 and a minimum major semester GPA of 3.5. Students are placed in research teams where they are engaged in self-regulated learning, help-seeking, and peer-learning in all aspects of their engineering education program and conducting research in CBE. The faculty members who serve on the CBE research committee are personally available to students and aid in the transformation efforts of mentoring and retaining students in engineering. We evaluated whether our program was successful at meeting the intended outcomes of increasing the participants' likelihood of attending graduate school and pursuing careers in engineering. The approach used in this study could be employed in other undergraduate institutions, especially Historically Black Colleges and Universities, to increase engineering students' self-efficacy, academic confidence, and GPAs, and retention rates.

Introduction

According to the National Science Foundation, there has been a significant decline in the number of U.S. citizens who are training to become scientists and engineers, whereas the number of jobs requiring science and engineering STEM training continues to grow¹. At Virginia State University (VSU), the retention rate of full-time freshman students in the Department of Engineering and Technology (E&T) is approximately 40%, the retention rate of full time freshman in all units in the School of Science, Engineering & Technology is 30%, and the overall retention rate of freshman at VSU is 29%². As a result, the Virginia State University's Center for Biosystems & Engineering (CBE) conducted a survey of why students fail to return after their first year in order to develop a program to increase the retention rate of its engineering programs. The most important reason why the students leave is due to financial problems. Many reported working significant hours (20-40 hours a week), in addition to registering for a full load of coursework (15-18 credit hours). Other reasons included lack of faculty support (student advising), placed into courses they were unprepared to take, and attending boring classes. These

situations contributed to poor time management and poor study habits, which ultimately contributed to poor grades. It is noted that the majority of students strongly desired hands-on experiences, rather than sitting in a classroom attempting to take notes from a professor's narration of the textbook³.

The current classroom situation is still focused on traditional methods of teaching, insufficient interactions with students ("one way flow" of information), emphasis on theory without any practical application, and notes memorization rather than content understanding. Each of these reasons given by the students closing align with what other researchers found to be the reasons why students do not return after their freshman year⁴⁻⁶. According to a study conducted by Seymour and Hewitt, students decide to leave science, engineering and math because of the intimidating nature of the classroom, the dullness of the lecture model, and insufficient faculty assistance⁷. Confucius wrote, "*I hear and I forget, I see and I believe, I do and I understand.*" This has become the platform for which the CBE is engaging students in engineering. By enhancing the students' ability to acquire new knowledge and truly motivate them to learn "how to learn." They are now prepared to take on subjects with a variety of complexities and remember the content long after the semester is over through constant application of the subject matter in their paid undergraduate research experience in the CBE.

CBE Undergraduate Research Experience

The CBE committee consists of faculty, research faculty, industrial representatives, and graduate students. The committee is committed to retaining students to ensure that there is quality leadership among VSU's next generation of students. Hence, with low retention rates in engineering, faculty and advisors need to give current students an incentive to want to stay in the discipline. The CBE took the opportunity to develop new relationships with the students who were at risk of leaving the engineering program prior to their sophomore year by engaging them in structured paid engineering research programs. Students with a cumulative GPA of 2.0 or less (the majority of the students were second semester freshman) were selected from the computer and manufacturing engineering, electronics engineering, mechanical engineering, and industrial engineering technology programs to participate in the undergraduate research experience to help alleviate the need for them to seek employment from local retail and fast food stores. A good starting salary and a flexible work schedule made the research job seem more palatable to students. This research program provided the students with an opportunity to learn about the faculty members and their research and obtain an applied research experience. The students were given substantive work so that their experience was satisfying and worthwhile.

Added benefits of the program are that the students are more likely to pursue graduate school, pursue the same type of research area upon graduation, and develop an understanding of current research practices. The CBE retention strategies include setting up a mentoring program to provide the freshman students with opportunities to benefit from the knowledge and experience of senior engineering students and faculty. By understanding the needs of the students, CBE creates a culture that fosters loyalty and hard work. The approach to the undergraduate research experience is to construct learning objectives which incorporates communication (i.e., help seeking), teamwork skills (i.e., peer learning), and project conduct (i.e., self-regulated learning) and faculty assistance. The learning objectives included developing problem solving techniques,

improving communication, working in teams, understanding time management, understanding the impact of problem resolution, understanding the relatedness of multiple engineering disciplines, and developing an appreciation of the courses in their engineering curriculum. We used a multi-tiered undergraduate research approach which incorporated student advising and mentorship, weekly individual meetings (15-30 minutes), a group meeting (1 hour), report writing, and participation in national or local research conferences.

The students were supervised by the CBE committee in conducting scientific research in the areas of biosensors and bioelectronics. The students were given a research topic and were advised to utilize their available resources (e.g., the University's library and the internet) to search for peer-reviewed journal articles pertaining to the research topic they were assigned. A special trip was taken to the University's library, where all the students were trained by the librarian to utilize the resources, such as the databases, search engines, and journal locators. Utilizing ingenuity and problem solving skills, the students tackled the research topic as a team. They constantly sought assistance from the senior research students and committee members in evaluating, organizing, and synthesizing the journal articles they have gathered. Afterward, they were able to generate a research proposal describing their investigative approach based on the review of the literatures. During the weekly group meetings the student team presented their research proposals, their timeline, and the cost of materials.

The students were asked about their progress, decisions, and investigative approach during the individual team meetings. Weekly meetings were scheduled with the advisors and the team is further coached and advised, particularly with regard to problems that have impeded the research progress. Hence, the research conduct is really a procedure for addressing the research problem and providing feedback on teamwork and difficult interpersonal situations, project and time management, effective presentation skills, and alternative procedures to consider as they are conducting their research experiments. Committee members and other researchers were present to answer questions at this session as well as during their office hours. During the students work hours, the students were trained on current equipment and devices. They also conduct their team research project investigation with the research advisor and the committee members. Students were also required to orally present at least a poster or PowerPoint presentation on their research at national research conferences, such as the 2008 HBCU-UP National Research Conference, where all expenses were paid and an allowance was given for food.

Based on the likert scale surveys (1=strongly disagree to 5=strongly agree), all of the students found the experience to be positive. The students rated their improvements in focusing on assigned tasks (4.32), public speaking skills (4.85), project and time management skills (3.78), understanding of application of engineering (4.67), ability to handle criticism (4.35), and learning at a higher level than most of their peers because of their ability to apply the information (3.98). Follow up interviews were conducted in consultation with the VSU Department of Psychology to assess the students' overall experience with the undergraduate research program. It was observed that the participants believed that they received more experience above and beyond the engineering discipline curriculum and grew academically and professionally as a result of their experience in the research program. The students discussed how their time management skills and their ability to focus on studies while ignoring external distractions had

improved over the course of the research program. They also discussed how they developed the courage to ask for help and increased their comfort with public speaking (presentations).

Employment Contracts

Initially, the students were evaluated in their engineering classroom environment to assess their engagement in the course materials during lecture. The students who expressed interest in acquiring applied experience in engineering and engineering technology were selected to meet with the CBE committee to discuss the specifics of the discipline. Primary, second semester freshman students with a GPA of 2.0 were selected to participate in the undergraduate research experience based on a series of interviews to assess their willingness and eagerness to obtain an engineering degree at VSU. After satisfactory interviews, the students met again with the CBE committee and were selected to participate in the undergraduate research program. Since financial hardship exists for minority students, financing has become a big part of the decision making, hence the CBE provided students with monetary aid to enable them to concentrate solely on their studies and research. The monetary aid is of vital importance when it comes to student retention because it has resulted in the reduction of the CBE students need for outside employment at retail or fast-food related industries, thus accelerating their progress toward graduation and pursuit of an advanced degree.

The contracts were distributed to students who met CBE criteria. The criteria require students to remain in good academic standing (i.e., GPA requirements), maintain fulltime enrollment, and demonstrate commitment to their research and academic success. The employment contracts were issued and signed by all students. The contract is used as a binding tool between the student and the university through the CBE. Students quickly took ownership of their research and academic commitment upon signing the contract. The CBE has set up a student referral program for research. It is like hiring hundreds of in-house recruiters of the research as well as the engineering program. The program is new to VSU, and the rumor around campus is one must have “a TOUGH SKIN” in order to participate in the undergraduate research experience because during the individual meetings “they (the committee) will break you down and make you want to quit but its really just constructive criticism.” It is clear more students want to join the program where they can grow and learn, personally and professionally. Many of the students in the program feel a sense of being part of a group of scholars. Hence, the CBE plans to set up more training programs to teach and prepare future leaders in the CBE.

Mentoring/Advising Sessions

Academic advising has been shown to be the cornerstone of student retention, especially during the first year of a student’s college/ university career⁸. The CBE committee works with the first year students to develop their undergraduate curriculum through a one-on-one interaction with the students. All advising sessions for the CBE students were recorded in each student’s file. The CBE committee members took full advantage of student advising to introduce themselves to the students, establish a rapport with the students, assess the needs of the students, and make the necessary adjustments to the student’s academic or work schedule. Upon the receipt of midterm grades, an appointment was set to meet with students to review their academic performance. Students with grade report of “C” or less were mentored by senior students in order to assist the

student with boredom and indecision of the discipline, as well as any transitional problems. The faculty and student mentors provided the student with realistic expectations, address the social and academic environment issues the student might be experiencing, provide rationale for the content of the coursework, and help students to become better prepared.

Advising plays a critical role for the CBE students by navigating them toward successful completion of their engineering degree. The CBE students who took similar courses (i.e. Calculus, Physics, Chemistry, etc...) were encouraged to study together. In addition, when the CBE students encountered difficulties in their courses, the committee advisors and the senior student mentors developed strategies with the students to resolve the difficulties through a structured tutoring session in the course to improve their educational experiences and establish a foundation of success as they face social pressures. The CBE mentorship and advisement programs allowed the students and the faculty to maintain close contact and it allowed the CBE to monitor student progress more closely. The CBE undergraduate research experience program has developed into a family affair, where there is constant communication between the faculty, students, and the parents of the students in regards to the academic and professional developments of the students. This type of relationship has allowed students and parents to establish a point of contact with University personnel. All in all, this mentoring and advising program has helped students to enhance their academic performance in a variety of courses with the participants being able to maintain a 3.0 overall GPA at the end of each semester.

Student Participation in Research Conference

Having the CBE students attend regional and national research conferences is another method used by CBE to help retain students in the engineering program. Full funding is provided to CBE students in order to support and encourage them to participate. These conferences, especially the HBCU-UP National Research Conference, are specifically tailored to undergraduate student research, where the engineering students participate in oral and poster presentations about their research, and they network with more than 700 students, faculty, and administrators. It also provided the students with undergraduate research programs, graduate school programs, fellowship opportunities, and faculty research programs available at other institutions as well as providing faculty and administrators with institutional strategies to enhance the quality of undergraduate STEM education and research at HBCUs.

Participation in these conferences has increased the students' exposure to research in their respective engineering disciplines, their problem-solving skills, and their exposure to other engineering students from various universities conducting research. This has enhanced the students' knowledge and motivated them to complete their degrees and pursue an advanced degree program in graduate school. Clearly, student participation in conferences provides them with life-long learning experience in which they can appreciate classroom knowledge and its application to real-world situations. The students' involvement in research conferences has proven to be priceless for retaining the CBE students, especially those who are freshman.

Conclusions

The likelihood of undergraduates pursuing a graduate degree in engineering aids in retaining underrepresented student populations in engineering, which is a critical concern. To increase the likelihood that engineering students would attend graduate school and complete their undergraduate education in engineering at VSU, the CBE has implemented various strategies to help address academic and social pressures that their students encounter throughout their academic career. The undergraduate research experience program developed by the CBE is aimed at making the college experience less stressful and improving undergraduate retention rates. The CBE has developed various strategies retaining minorities in engineering and engineering technology education programs. Some of the strategies described herein include early exposure of students to engineering research, paid research experience during the academic year, mentoring/ advising, and student participation in national research conferences. The CBE undergraduate research experience program has focused on changing the negative, preconceived notions about research in engineering so that the students will pursue a graduate degree in engineering.

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