



Increasing Student Enrollment and Achievement in Engineering and Engineering Technology

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Abstract

This NSF STEM Scholarship program at Vaughn College of Aeronautics and Technology is a five-year project that started in fall 2012. The Project which is titled “Increasing Student Enrollment and Achievement in Engineering and Engineering Technology” is focused on increasing enrollment and retention of talented students in STEM undergraduate education. The project included two cohorts; each cohort goes through a four-year plan. In the first year, all scholarship recipients are engaged in learning communities with well-defined projects in applied engineering such as robot building, truss design, flow visualization and aerodynamics. These hands-on modules are intended to assist students in making connections between math and physics courses and their engineering applications. In the second year, students (now sophomores) received tutor training and provided tutoring in fundamental courses to their fellow freshmen. This practice is intended to give students the opportunity to establish strong links between related courses (statics and mechanics of materials or thermodynamics and fluid mechanics) in their 1st and 2nd year, and to further enhance their hands-on, critical thinking, teamwork and communication capabilities.

The third and fourth year scholarship recipients were involved in research activities to prepare them for the post-graduation. These activities provided students with a unique opportunity to work with faculty members in group research projects. All program participants have the chance to present their projects in the college’s Annual Technology Day Conference in April, and many of these projects are submitted and accepted for presentation and publication in regional, national, and international conferences such as ASEE, ASME, SEM, and LACEEI.

Students in NSF STEM learning communities were encouraged to participate in the engineering seminar series, the industry connection seminar series, industry field trips, robotics and UAV club activities and competitions, and the student chapter of professional societies. They were also encouraged to publish and present at technical conferences. These activities increased the number of students who completed undergraduate research projects under the mentorship of engineering faculty, and this involvement was considered one of the most effective tools to increase enrollment and students’ retention. The program activities also impacted other students outside the program, because student clubs, mostly managed and run by students, created an environment that appealed to their fellow students outside the NSF-STEM program. As a result, the number of active students in clubs’ activities has significantly increased. The details and implementation process of the STEM program and its assessment process will be presented and discussed during the 2018 ASEE Annual Conference Proceedings.

1. Introduction

This NSF S-STEM program (award #11540000) started in the fall of 2012. The program is titled “Increasing Student Enrollment and Achievement in Engineering and Engineering Technology”, and the program included the following objectives:

1. To provide students with mentorship to support them academically.
2. To increase students’ interest on STEM education.
3. To provide students with hands-on skills.
4. To enhance students’ ability to collaborate.
5. To improve students’ communication skills.

Vaughn College of Aeronautics and Technology is a not-for-profit institution serving a diverse student population with 37% Hispanic and 21% Black/African Americans. The high percentage of Hispanic students qualifies the College for designation by the US Department of Education as an Hispanic Serving Institution (HSI). Vaughn College is currently a member of the Hispanic Association of Colleges and Universities (HACU), with participation in HACU’s Capitol Hill Forum and Annual Conference.

2. Program Description

The program is designed to serve two cohorts from freshman year to senior year studying an Engineering or Engineering Technology undergraduate degree program. The first cohort started in fall 2012 with ten students, while the second cohort started in fall 2013 with fifteen students. The number of participants varied at times due to a variety of reasons, including students transferring out of the STEM program. Both cohorts followed a four-year plan. Freshman year was particularly important to build students’ understanding of engineering education by reinforcing the skills related to engineering. Well-rounded learning communities were developed to specifically focus on some of the tools that help students improve their performance in engineering courses and make the connections between physics and math courses and their engineering applications.

The learning communities consist of multiple modules discussed in the following section. In the second year of each cohort, students turn to the course advisor to strengthen their learning by being TA’s at the teaching and learning center at the college. This gives students the opportunity to develop close relationships to the faculty advisors and to enhance their understanding of basic engineering courses such as Engineering Mechanics I (Statics) and Thermodynamics. These connections will further enhance their performance in core engineering courses such as Strength of Material and Fluid Mechanics. The faculty advisors also encourage students’ involvement in STEM club activities at the college; more discussion of club activities and their impact will be addressed in a later section related to students’ after-class activities. In the third and fourth year, each cohort is required to participate in engineering research. The topics are selected by students

and their advisors. All participants are required to present their projects in the annual technology day conference of the Engineering and Technology Department which is held at the college in April of each year.

3. First Year Learning Communities

3.1 Flow Visualization Learning Community Activities

The objective of this activity is to increase students' appreciation of science, physics and math by engaging in competitive, hands-on activity. During this course activity, students are introduced to the methods and applications of flow visualization in Fluid Mechanics. Students learn methods of understanding fluid mechanics using imaging techniques [1] and create their own flow images to explain a variety of flow phenomena [2] [3]. In addition to basic photography tools, students are required to use their creative skills to produce a photograph of interesting fluid and/or solid phenomena using imaging techniques.

The activity includes a demonstration to students of modern tools such as digital imaging, stereo imaging and high-speed imaging and how these techniques can be utilized to investigate complicated science phenomena in fluid mechanics [4], [5]. The concepts of digital resolution of DSLR cameras and high-speed cameras are currently used in engineering research for purposes as varied as predicting weather using satellite imaging to designing micro mechanical systems. In the final project, students were divided into groups where each group was required to come up with their own photo ideas while creating an experimental setup to obtain "the right image". Students also were trained to utilize image filtering and enhancement techniques to extract valuable scientific information using image analysis software. At the end of the four-week class, each group presents their work to the class.

3.2 Introduction to Aerodynamics and Wind Tunnel Testing

In this module, students were introduced to aerodynamics design as an example of applied engineering. They learned the basic formulation of fluid mechanics equations, which lead to application of continuity and Bernoulli's equations. Students had an opportunity to verify these equations through hands-on projects and direct measurements in the thermo-fluid laboratory. Also, students were introduced to basic force analysis on aerodynamic vehicles, with an emphasis on lift generation airfoils, and they were also given an opportunity to use simulation tools to better understand flow properties and their effect on the aerodynamic loads.

Throughout this module, students were introduced to both theoretical and experimental topics related to Bernoulli's and continuity equations, aerodynamics of airfoils, wind tunnel testing and measurements techniques utilized in wind tunnels. In the final weeks, students worked with a faculty mentor to develop a project related to aerodynamics using simulation tools available at NASA website such as TunnelSim and FoilSim [6].

3.3 Introduction to Structure Analysis (Truss Bridge Design)

The main focus of this module was to give students a brief introduction to the structural side of engineering with simple design and hands-on application.

During the four weeks of this course, students were given an introduction to basic mechanics concepts such as stress, strain, deformation and Hooke's law as used in mechanical engineering. Application of these concepts was then introduced to students who studied and analyzed a basic Warren truss bridge, after looking at the various types of bridges and mechanisms involved in their load distribution.

During the final two weeks of the course, students were given an opportunity to design and build a simple Warren truss bridge which was required, according to the worst case scenario, to support a heavy truck driving over the bridge. During this design process, students made use of a simple truss analysis and Excel software. As part of the class, students were required to write a short report explaining their design process and to build a small bridge based on their design.

3.4 Introduction to Robotics

This module of the NSF-STEM program is intended to introduce fundamentals of robotics to students. Students are involved in programming robots and in practically building a mobile robot. At the end of the module, students can understand the basic concepts of robotics and can assemble and program a robotic system with the logic controller, DC motors and a ultrasonic sensor. The schedule of the program is as follows:

Week1 - Introduction to robotics. Test and program a single DC motor. Week 2 and Week 3- Test and program a single ultrasonic sensor; program the DC motor that can respond to the input of the ultrasonic sensor. Assemble the robot body, including two DC motors as motor drives, a VEX logic controller, and an ultrasonic sensor. This is followed by programming the assembled mobile robot to detect an obstacle and choose a trajectory to avoid the obstacle. In week 4, students provide group presentations with their learned knowledge related to DC motors, ultrasonic sensor and programming a robotic system to avoid the obstacle.

4 Students' on-campus activities (after-class activities)

The project moderators have always believed students' activities on campus are a strong tool to increase student academic performance and skills, thus enhancing student retention and graduation rates. During the implementation of this project, emphasis was placed on the

encouragement of students to participate in STEM based student clubs and to attend the two-seminar series hosted by the Engineering and Technology department.

One of the program requirements for students in this program is to participate in some form of on campus activity. This requirement includes STEM club activities as well as engineering and industrial seminar series. During this program, the robotics club has seen more than 300% increase of its active members. As a result of students’ active after-class involvement in robotics club activities, the club was able develop robots to win VEX U robotics world championship in 2016 and finished third place in 2017 VEX U world championship. In 2014, the Unmanned Aerial Vehicles (UAV) club was established, with a majority of students from NSF-STEM cohorts, and this club went on to qualify for the AHS Micro-UAV students’ competition for 2016 and 2017, and achieved the 2nd place in the AHS competition in 2017. Other clubs were also established such as SWE (Society of Women Engineers) and Engineers Without Borders.

Additional activities within the program:

Field trips to Brookhaven National Laboratory, Cradle of Aviation museum, Sikorski Aircraft Facility in Startford, CT., Curtiss-Wright Manufacturing Facility in Long Island, NY, and the Intrepid Air and Space Museum

5 Results and Analysis

The focus in measuring the effectiveness of the program was on the achievement of program objectives. The following table shows the average GPA of students in the program compared with the GPA of all students in degree program at Vaughn College of Aeronautics and Technology. The understanding is that the project is inherently selective in terms of the students’ academic performance; however, it was important to measure this integral tool in order to track the overall effect of the program on the students’ academic performance.

Table 1: Average GPA of students in the program compared with overall GPA of students in Vaughn College

Academic Year	Average GPA for students in the program	Average GPA for overall students in Vaughn College	Ratio of increase of the student in the program to the overall students (%)
Fall 2012	3.63 (n=10)	2.85	27.4%
2013/2014	3.51 (n=21)	2.87 (n=421)	22.3%
2014/2015	3.47 (n=21)	2.65	30.1%
2015/2016	3.49 (n=23)	2.64	32.2%

In terms of graduation rate, out of the nine students that remained consistently in the first cohort seven graduated after four years, the other two students finished their degree requirements in four and half years. For Cohort II, out of twelve students, one graduated in three years, eight

students graduated in four years and two students are projected to complete their program requirements in the current year (fifth year). It's worth noting that the reason students remained in the program beyond four years was due to their personal choice to change their degree major during the first or the second year of study.

In terms of job placement and acceptance within graduate programs, sixteen of eighteen (88.9%) of the graduated students are employed in the STEM field. Three of these students are currently enrolled in graduate studies in the STEM field (mainly engineering), one of whom received a full scholarship from the U.S. Army.

In terms of students' academic activities on and off-campus, there was a major increase of STEM oriented student club activities, such as the robotics club and the establishment of the UAV club, in addition to five other student chapters such as AIAA, SWE, and IEEE. There was an increase in the robotics club active members by more than 100 %, one year after the program was established, and currently, the club holds its highest active members count. UAV club has seen a strong interest from students. Currently, three years after it was established by students from the program, the UAV club has more than 20 active student members. Both clubs participated and won in many regional, domestic and international competitions such as VEX international, and American Helicopter Society Micro-UAV competition.

Students worked in research projects in their third and fourth year of the NSF-STEM program. Many of these student projects have advanced to professional conferences and received top awards such as 2nd place SME students' competition in 2016 ASEE Annual Conference, Innovation award in 2017 ASEE Annual Conference, and second place in 2017 LACCEI International Conference.

6 Conclusion

Both NSF-STEM cohorts have been successfully implemented, and students of this program had better performance through their discipline of study than those who were not part of NSF learning community cohorts. The benefits of the scholarship program have been reflected in students' graduation and job placement rates; Students involved in the NSF-STEM program have the highest rate of graduation within 4 years and the highest rate of job placement.

In addition to the success stories of after-class professional activities, NSF-STEM students were engaged and involved in Robotics and UAV club activities. As a result, many of these students were able to participate in regional, national and international competitions and received top place ranking [7]. As an example, NSF-STEM students designed and developed two robots for the 2016 VEX U world championship. Their innovative robotics design and advanced

autonomous programming allowed Vaughn's Robotics team to be the 2016 VEX U Robotics World Champion.

Also, NSF-STEM students were active participants of UAV design and club activities. In 2016 and 2017 Vaughn's UAV team was selected as one of the finalists beside Georgia Tech, Penn State, North Dakota State University, University of Maryland, and Concordia University to participate in AHS annual Micro Air Vehicle (MAV) student challenge competition. This is a tough and challenging competition that only the top teams with proven supporting documents and videos demonstrating that their drones can complete the tasks were invited as finalists to compete in the Annual American Helicopter Society Micro Air Vehicle (MAV) competition. In 2017, Vaughn's NSF-STEM students have done an incredible job in competing against these teams and they received second place in this challenging competition [8].

Student involvement in scholarly activities is the other direct result of the NSF-STEM learning community. From 2014-2017, many first and second cohorts of NSF-STEM students participated in national and international conferences, and their research papers received top place awards in both student paper and poster session competitions [8]. The development and implementation of Vaughn's NSF-STEM learning community and its connection with student accomplishment will be discussed in detail at the ASEE Annual Conference.

7 References

- [1] Van Dyke ed., An Album of Fluid Motion, (1982), Parabolic Press.
- [2] Hertzberg, J. and Sweetman, A. "Images of Fluid Flow: Art and Physics by Students," by Journal of Visualization, Vol. 8, No. 2 (2005)145-152
- [3] Flow visualization, a course in the physics and fluid of fluid flow, <http://www.colorado.edu/MCEN/flowvis/index.html>
- [4] Elzawawy, A., "Time resolved particle image velocimetry techniques with continuous wave laser and their application to transient" PhD thesis,565 CUNY, New York, 2012.
- [5] Pierides A, Elzawawy A, Andreopoulos Y (2013) "Transient force generation during impulsive rotation of wall-mounted panels" J Fluid Mech 721:403–437. doi: 0.1017/jfm.2013.52.
- [6] NASA, Glenn Research Center, <https://www.grc.nasa.gov/www/k-12/TunnelSim/index.htm>
- [7] Rahemi, Hossein, "Ninth Annual Vaughn College Journal of Engineering and Technology", Vaughn College, New York, April 2017.
- [8] Rahemi, Hossein, "Tenth Annual Vaughn College Journal of Engineering and Technology", Vaughn College, New York, April 2017.