Scholarship Program Initiative via Recruitment, Innovation, and Transformation

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The National Science Foundation's funded ($625,179) SPIRIT: Scholarship Program Initiative via Recruitment, Innovation, and Transformation at Western Carolina University creates a new approach to the recruitment, retention, education, and placement of academically talented and financially needy engineering and engineering technology students. Twenty-Seven new and continuing students were recruited into horizontally and vertically integrated cohorts that will be nurtured and developed in a Project Based Learning (PBL) community characterized by extensive faculty mentoring, fundamental and applied undergraduate research, hands-on design projects, and industry engagement. Our horizontal integration method creates sub-cohorts with same-year students from different disciplines (electrical, mechanical, etc.) to work in an environment that reflects how engineers work in the real world. Our vertical integration method enables sub-cohorts from different years to work together on different stages of projects in a PBL setting. The objectives of the SPIRIT program will ensure an interdisciplinary environment that enhances technical competency through learning outcomes that seek to improve critical skills such as intentional learning, problem solving, teamwork, management, interpersonal communications, and leadership.

Support for the student scholars participating in this program incorporates several existing support services offered by the host institution and school, including a university product development center. This paper will discuss several aspects of the program including participant selection and initial cohort demographics; implementation of the vertical-based cohort model in PBL; program and student assessment models; and associated student activities and artifact collection used to foster student success in the program and after graduation. Successful implementation of the SPIRIT program will create a replicable model that will broadly impact 21st century engineering education and workforce preparedness.

Keywords: NSF Scholarship Program, Project-Based Learning (PBL), Engineering, Engineering Technology.

Introduction

The National Science Foundation (NSF) SPIRIT Scholars program at Western Carolina University (WCU) provides undergraduate students in engineering and engineering technology an opportunity to participate in a new approach to the recruitment, retention, education, and placement of academically talented and financially needy students. The SPIRIT (Scholarship Initiative via Recruitment, Innovation, and Transformation) Scholars program establishes a transformative learning environment that fosters the development of professional skills and increased technical competency through interdisciplinary project-based learning (PBL), undergraduate research, peer-to-peer mentorship, and focused institutional support services.[1-8] WCU is classified as a regional comprehensive masters-granting university and was awarded the Carnegie Community Engagement classification in 2008.[9]

During the Fall academic semester of 2014, twenty-seven students were recruited into the program and have subsequently contributed to a diverse and academically promising learning

environment. With the induction of these students into the program, the four program directors have primarily focused on collecting student demographics, measuring preliminary student attitudes and perceptions, partnering with institutional support services, establishing peer-to-peer mentorship circles, and facilitating academic undergraduate research projects with participating faculty fellows. During the Spring academic semester of 2015, the student scholars will participate in a vertically integrated interdisciplinary PBL core of courses ranging from freshman-level to senior-level courses.

The unique nature of this program has produced several interesting preliminary observations. As to inform other institutions wishing to engage in similar work, the current paper will discuss the overall structure of the SPIRIT Scholar program, current scholar activities, future program activities, and preliminary observations of program efficacy.

SPIRIT Program Overview

Program recruitment of students was coordinated by the four program directors and partnering offices across WCU's campus including: Admissions, Financial Aid, and the Honors College. Each office assisted the program with data, outreach, and guidance in targeting potential program recruits. From the list of potential candidates, the program directors reviewed 72 application packets which included both demographic data as well as written application statements.

The selection criteria focused on the students' talents and financial needs, but with emphasis on the students' academic merits. Other factors such as alignments with program needs, and students' demography were also considered. In general, to become a SPIRIT scholar, a student must have met the following qualifications:

- Competitive Intellectually and Academically - The competitiveness can be measured by the student's standardized test scores (SAT, ACT, or GRE for graduate students), GPA, and other relevant performance superiorities observed by the faculty.

- Commitment and Interests - These can be gauged by the student's activeness of participation in classes, understanding of the program, and persistency of application for admission into the program.

- Financial Need- Determined by the FAFSA or GANN information and the capability of family contribution.

- Responsive to Dynamic Environments - This quality can be assessed by the students' ability of good time management, team work potential, and ability of prioritizing multiple tasks.

- Motivated to Participate in PBL and QEP - The SPIRIT program requires its scholars to sign scholarship contracts that outline participation in project activities and maintenance of an electronic portfolio.

SPIRIT Scholar Demographics

The selection process yielded a diverse pool of applicants with a wide range of background experiences. The program directors selected 27 scholars from the 72 applicants, yielding a scholar group comprised of 10 freshmen, 9 sophomores, and 8 juniors. Of the 27 scholars, 5 females represent 18.5% and 22 males represent 81.5% of the gender diversity as depicted in Figure 1. In comparison, the Department of Engineering and Technology at WCU reported 8.8% (35 out of 396) female students and 91.2% male students for the Fall Semester 2014.[10] WCU reported 66.4% female and 33.6% male freshman students in 2014.[10] The program experienced a higher than expected diversity in the race of student scholars. Figure 2 compares race demographics for the SPIRIT Scholar group (n = 27) and the WCU undergraduate class (n = 8787) of 2014.[10]
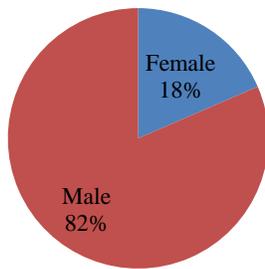
SPIRIT Gender (%)   **Dept. of Engr. and Tech. Gender (%)**
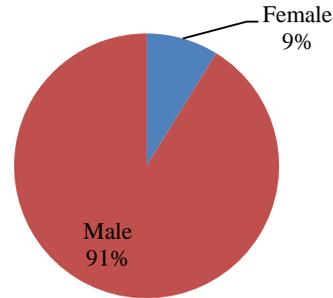
Figure 1: Gender Demographics SPIRIT Program
Compared to Department of Engineering and Technology

SPIRIT Race (%)   **___ Race(%)**
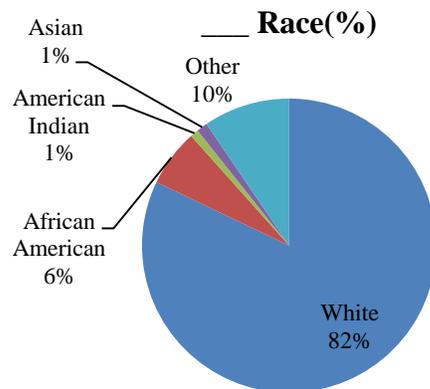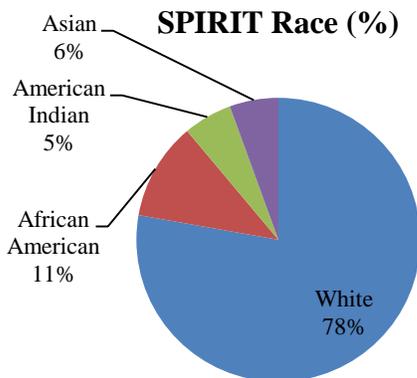
Figure 2: Race Demographics of SPIRIT Program Scholars
Compared to WCU General Student Population

Of the current SPIRIT scholar group, program interests were varied with 40.7% of the scholars majoring in the Bachelor of Science in Engineering - Mechanical Engineering Concentration (BSE ME), 25.9% majoring in the Bachelor of Science in Engineering Technology (BS ET), 25.9% majoring in the Bachelor of Science in Electrical Engineering (BSEE); and 7.5% majoring in the Bachelor of Science in Electrical and Computer Engineering Technology (BS ECET). Current undergraduate enrollment in the Department of Engineering and Technology at WCU totals 517 students with approximately equal distributions across the programs, except for Engineering Technology with 203 majors.[10] Figure 3 depicts the distribution of majors in the SPIRIT Scholar group.
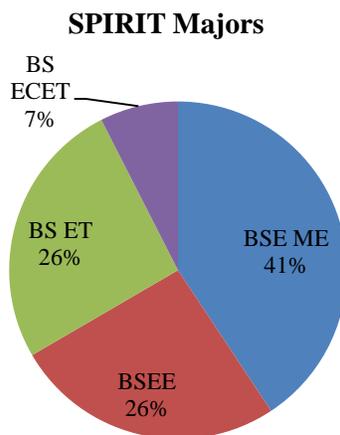
Figure 3: SPIRIT Scholar Group by Major

Prior to the selection process, the Office of the Registrar at WCU provided the program directors with the historical academic data of the scholars.[11] Of the scholars reporting SAT scores, the average SAT Total score was 1600 with a standard deviation (SD) of 177; the average SAT Verbal score was 517 with a SD of 74; the average SAT Math score was 593, SD = 74; and the average SAT Writing score was 490, SD = 68. Of the scholars reporting ACT scores the average ACT English score was 21 with a SD of 6; the average ACT Math score was 26, SD = 4; and the average ACT Comp score was 24, SD = 5. The average WCU GPA for sophomore and junior scholars was 3.72, SD = 0.22.

In comparison, the average SAT Total for students enrolling at WCU in 2013 was 1039, with the average SAT MATH recorded at 512 and SAT Verbal recorded at 504.[12] Average ACT Composite scores for entering students at WCU in 2013 were reported at 21.4.[12] Figures 4 & 5 compare the SPIRIT group SAT/ACT scores with WCU's entering freshman SAT/ACT scores.
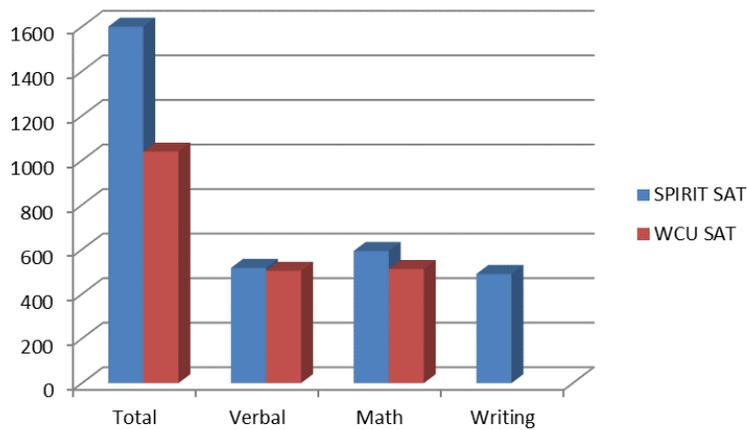
Figure 4: Comparison of SPIRIT Scholars SAT Scores
with WCU Freshman SAT Scores
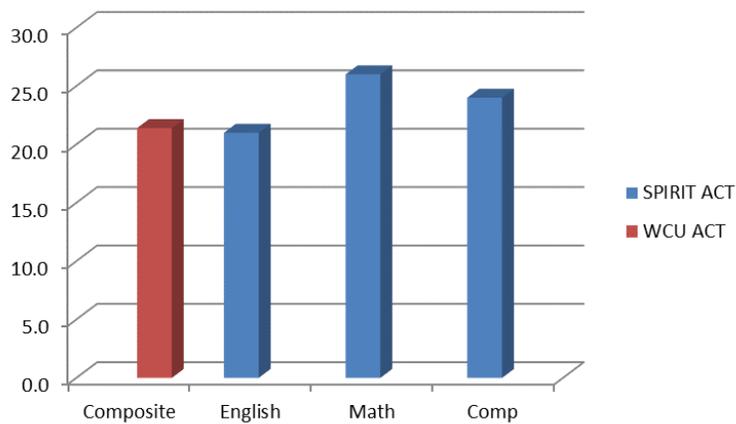
Figure 5: Comparison of SPIRIT Scholars ACT Scores
with WCU Freshman ACT Scores

The Office of Financial Aid at WCU reported the average unmet financial need of the scholar group at $2561 with a SD of $4591.[13] Further, qualitative statements from the scholar's application documents support the financial need data. Multiple scholars not only expressed a strong desire to participate in the program, but indicated an imperative nature of receiving additional financial assistance for college.

> Scholar 1023 stated, "*The learning opportunities that are provided through this program, such as project based learning and teamwork, will help to better prepare me for life after college. The financial relief this program provides will also be very helpful to me as I proceed through college and beyond. I am paying for college by myself and without the help of my parents, while their assets factor into my eligibility for financial aid, I do not*

receive any financial help from them. As a result I am having trouble financing my education and will be in a substantial amount of debt after college."

Scholar 1095 stated, *"Even though I have applied for financial aid and have received assistance, this scholarship will be a great help for me to accomplish my goal of graduating from WCU's Department of Engineering and take some of the burden off of my mother who is solely responsible for our financial responsibilities. I am an only child and have always lived alone with my mother. I intend to continue my history of academic achievement to achieve my goals. If I receive this scholarship, I will not disappoint you. I am hoping not only to make my mother proud of me, but also to maintain pride in myself as my mother often encourages me to do." Of important note, Scholar 1095's mother passed away in November, 2014 and she currently has no family support structure or continued financial support. The program directors and directors of student support services are working closely with 1095 to ensure she receives strong support."*

Scholar 1103 stated, *"The price of college has put an increased financial burden on my family and me. With four younger siblings and my father being disabled with a lung condition these burdens are quite significant. I have coped with these financial pressures by striving to reduce costs, taking out loans when needed, and doing work on the side when I can. The SPIRIT scholarship would greatly reduce these financial pressures, allowing me the freedom to devote more time and energy into coursework."*

SPIRIT Program Requirements

Upon selection, SPIRIT scholars were required to sign a contract which delineated certain standards and milestone achievements designed to foster their progress toward the goals of the SPIRIT program. The following stipulations were contained in the contract:

1. maintain a cumulative GPA of 3.25/4.0 or higher;
2. maintain full-time enrollment in a degree program within the Engineering and Technology department at the host institution;
3. maintain good citizenship and good standing at the host institution;
4. fully participate in all SPIRIT meetings, events and symposia;
5. complete at least one extracurricular assignment or project per semester (these were permitted to overlap with those required by the host institution's Honors College);
6. prepare and present some aspect of their academic work;
7. submit at least one scholarly paper to an academic conference or journal during the course of their degree;
8. undergo a per-semester assessment of the student's level of commitment, delivery quality, and progress in these requirement areas.

In particular, requirements 5-7 are designed to afford the scholars exposure to intentional learning opportunities in pursuit of their degrees. Activities in these areas are expected to produce a cumulative benefit by allowing the scholars to learn deeply by pursuing a topic of interest with the help of mentorship by faculty and fellow scholars.

SPIRIT Program Activities

The SPIRIT scholars were required to meet with the program directors as a group each week during the Fall 2014 semester. The initial weekly meetings were dedicated to introducing the program, establishing mentorship relationships between the different student groups, and to assessing the students' potential academic support needs. Subsequent meetings sought to inform the scholars about institutional and departmental student support services, faculty sponsored undergraduate research, and project based learning opportunities. The SPIRIT scholars were required to complete a semester project and presented their work during the last semester meeting.

SPIRIT Program - Student Support Services

The early meeting sessions were used to establish relationships between the SPIRIT Scholars and directors as well assess potential student scholar support needs. During these meetings, the scholars were divided into groups of 4-5 students where each was issued several discussion prompts. The initial peer grouping of scholars was more methodical with freshmen being equally paired with sophomores and juniors, or purely homogenous groups, while the later groupings of peers were more organic in their formations, containing a mix of demographics. At the mid-point of the discussions, the individual groups would report to the larger group where large-group discussions would follow. The four program directors and four graduate assistants also met as a discussion group and participated in the overall group discussions by sharing our viewpoints and past experiences with the larger group.

Individual outside-group activities were used to reinforce group discussions. A series of weekly journaling assignments (4) focused on the scholars' fears and anxieties about the new program; current and future academic expectations; future academic and career related activities; and mentorship. Weekly journaling prompts were based on themes generated by the individual peer groups during their discussion meetings. In their journals, scholars wrote about their goals for the academic year; obstacles to accomplishing these goals; strategies for overcoming potential obstacles; and professional goals immediately, and five-year after, graduation. The journal entries were used to coordinate a series of focused workshops and discussions.

The first in a series of workshops designed to facilitate support for the students was conducted by the Assistant Director for The Office of Career Services at WCU. The workshop incorporated a discussion on the various in-depth student services provided through their office. Topics such as student employment opportunities, including internships and CO-OPs, resume building,

interview skills and training, and business attire and etiquette were also covered. Additionally, the director discussed the various career fairs and shadowing opportunities available on campus.

The Writing and Learning Commons (WaLC) at WCU conducted two workshops with the SPIRIT group focused on study skills, writing, grammar, associated tutoring services, group work, and teaming. The director of the Mathematics Tutoring Center presented the final workshop on the study methods and the various academic tutoring services available to SPIRIT Scholars. The director also offered future opportunities for the scholars to become tutors for the center. Additional tutoring support for the SPIRIT Scholars was created through the graduate assistance program within the Department of Engineering and Technology.

SPIRIT Program - Undergraduate Academic Research Activities

SPIRIT scholars were required to undertake an extracurricular project or activity of their choosing during the second-half of the semester. This requirement will be recurring throughout the degree program of each scholar. It is envisioned that such projects, each having a research component, will build upon one another so as to afford the scholars an opportunity to benefit from the guidance of a faculty research fellow and to deeply explore an area of their own interest. Several format options were presented to the scholars for their particular project. These options included a research project under the mentorship of a faculty research fellow or course instructor, participation in a student organization including those fielding competition teams, or individualized research topics for students seeking to focus their interests.

During the first semester of the SPIRIT program, faculty researchers at the host institution were invited to deliver short presentations of 5-7 minutes at a weekly SPIRIT scholars meeting. Scholars thus had the opportunity to view the scope of research being conducted in the department in an informal setting and at an accessible level of rigor. Scholars had the opportunity to ask questions of the various researchers so as to discern how their interests might align with the work presently under way. Similarly, scholars were also invited to seek out a course instructor to extend the material of a course beyond its traditional scope. Several students, some working as teams, fashioned their projects in this manner.

Students were also introduced to the competition teams fielded by student organizations. These included the Society of Automotive Engineers (SAE) Mini Baja competition and the Institute of Electrical and Electronics Engineers (IEEE) SoutheastCon Robotics competition. Both of these teams solicit members from mechanical, electrical, and software disciplines in order to compete in annual events. Participation is sponsored by the host department.

Some scholars, typically first year students, had limited exposure to technical coursework in their respective disciplines. For these scholars, the scholarship directors provided individualized advisement on possible project topics. Suitably, several of these students conducted research in career planning and placement, or a topic of personal interest which meshed with their non-technical coursework. A summary of the projects executed by the scholars is given in Table 1.

Table 1: Summary of Extracurricular Projects

Scholar(s) ID #	SPIRIT Project Description
1006, 1031, 1027, 1019	Investigation of gesture recognition techniques for assistive robotics
1003	3D modeling of a cube puzzle
1081, 1014, 1103	Digital design of a Space Invaders game
1015	Mini Baja machining and manufacturing
1040	Hydraulic fracturing
1072, 1037	Air ionization for a moving device (hovercraft)
1033	Establishing and accomplishing career goals
1032	Digital design of a Simon memory game
1051	Investigation of engineering employment opportunities
1061	Mini Baja electrical system
1059	Mini Baja frame assembly
1050	Microcontroller-based pulse detection
1093	Dressing for success
1091	Career research and preparation
1104	Digital design of a countdown timer
1094	Robot assembly programming
1086	Complex 3D modeling
1076, 1023, 1041	3D modeling and CNC machining

Scholars conducted their project over the course of four weeks during the Fall 2014 semester. A mid-project update was delivered by each scholar/team after two weeks of initial investigation and a final presentation was delivered at the conclusion. The brief interval allocated to the projects was due to the time taken by the initiation of the program (introduction to campus resources, group discussions, department faculty research agendas, etc.). It is expected that future projects will take on a stronger research component and span the breadth of the semester with periodic update presentations being required.

SPIRIT Program - Vertically Integrated PBL

The degree programs in the host department include a series of project-based learning (PBL) courses. The PBL component incorporates open-ended problem solving and project management to broaden student involvement in practical scenarios and to prepare students for the challenges of their senior capstone project and professional practice. The PBL sequence consists of five courses, each with expanding levels of autonomy in the execution of class projects.

These courses are: ENGR 199 (freshman year), ENGR 200 (sophomore year), ENGR 350 (junior year), and ENGR 400/450 (first and second semesters of senior year). Vertical integration among SPIRIT scholars is planned with those in alternating years partnering to work on projects. These began in Spring 2015 with students in ENGR 199 partnering with students in ENGR 350.

Similarly, ENGR 200 students will work with seniors in ENGR 450. This paradigm is depicted in Figure 6.
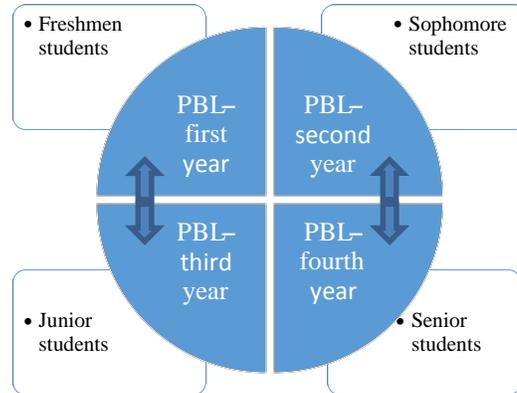
Figure 6: WCU's Vertically Integrated PBL Model & Peer to Peer Mentorship

The logistics of this planned integration was carefully constructed to maximize student learning and the mentoring aspects of having students work with those of other years. Freshman and junior students are provided with a set of project guidelines by the instructor. Juniors are expected to deliver an alpha prototype of a product whose requirements afford multiple design approaches. Freshmen observe and play a supporting role during development so as to obtain an understanding of the concept development process and project planning. Freshmen are evaluated on their demonstrated understanding of the project through a final presentation while juniors are evaluated on the success of the prototype.

For sophomores matched with seniors, the integration is less interactive. Sophomores are required to attend group meetings, customer design reviews, and a final poster session with their senior partners who are working on their capstone projects. Sophomores are required to write a reflection paper which demonstrates their knowledge of the project and the process to its completion. This limited interaction is designed to expose the sophomores to the fully open-ended nature of a capstone project without imposing an undue burden on the seniors to bring their counterparts along in their progress.

Through this mechanism of interlaced vertical integration, a mentorship dynamic is expected to emerge in which older students support the younger students as they experience the anxieties associated with their upcoming challenges. At the same time, older students experience a leadership role in explaining their work to their junior colleagues.

SPIRIT Program – Per Semester Scholar Evaluation Review

SPIRIT scholars are evaluated every semester to determine the eligibility to continue in the program. Students who fall below a 3.25 or miss 30% of the required activities will be considered "at-risk," placing them in jeopardy of being placed on probation. Students who fall below 3.0 GPA or miss 50% of the required activities will be placed on probation the following semester. For "at-risk" students, the program administration will work with appropriate units (student support services, the honors college, the graduate school, etc.) to help the students get back on track. Should a student lose the scholarship, a new vacancy is created and a new SPIRIT scholar will be recruited. For Fall 2014 semester, five scholars were determined to be "at risk" and were issued academic action plans and encouragement to seek student support services.

Conclusions

The scholar selection process was labor intensive, but the program attracted and initiated an academically strong and diverse group of students. During the start-up phase the program directors spent a significant amount of time building relations between the scholars and directors and growing a collaborative environment through small group work and journaling assignments. The scholars were made aware of several campus and college student support services, which may be beneficial in the future. The directors required each scholar to participate in a half-semester project focused on a research topic of their choice followed by delivery of a final presentation. The Spring 2015 semester will begin with activities involving the vertical integration of PBL courses. While the performance of a few scholars is of concern, overall the program has been a success. Overall, the program experienced an enthusiastic start and has received positive feedback from the students, faculty, and administrators at the host institution.

Bibliography
1. Bender, W. N., 2012, "Project-Based Learning: Differentiating Instruction for the 21st Century," Corwin Press.
2. Boss, S., Krauss, J., 2007, "Reinventing Project-Based Learning," International Society for Technology in Education, Eugene, OR.
3. Anagnos, T., Furman, B. J., Hsu, P., Backer, P. R., 2013, "How Important is the WOW Factor in First Year Engineering Courses?" AC2013-6417, Proceedings of the ASEE Annual Conference & Exposition, Atlanta, GA.
4. Eris, O., Chachra, D., Chen, H. L., Sheppard, S., Ludlow, L., Rosca, C., Bailey, T., Toye, G., 2010, "Outcomes of a longitudinal administration of the persistence in engineering survey," Journal of Engineering Education, 99, pp. 371-395.
5. Mena, I. B., Zappe, S. E., Litzinger, T. A., 2013, "Examining the Experiences and Perceptions of First-Year Engineering Students," AC2013-6270, Proceedings of the ASEE Annual Conference & Exposition, Atlanta, GA.

6. National Academy of Engineering, 2005, "The Engineer of 2020: Visions of Engineering in the New Century," The National Academies Press, Washington, DC.

7. Baker, J. G., Finn, M. G., 2008, "Can a Merit-Based Scholarship Program Increase Science and Engineering Baccalaureates?" Journal for the Education of the Gifted, 31, pp. 322-337.

8. Wilson, Z. S., Iyengar, S. S., Pang, S., Warner, I. M., Luces, C. A., 2012, "Increasing Access for Economically Disadvantaged Students: The NSF/CSEM & S-STEM Programs at Louisiana State University," Journal of Science Education and Technology, 21, pp. 581-587.

9. Western Carolina University (2014). WCU 2014 FACT BOOK. Retrieved December 12, 2014 from http://www.wcu.edu/WebFiles/IPE_FactBook_2014.pdf

10. Office of Institutional Planning and Effectiveness, WCU (2014). Demographics. Retrieved December 12, 2014 from http://www.wcu.edu/about-wcu/leadership/office-of-the-provost/oipe/institutional-research/fact-books/index.asp

11. Office of the Registrar (2014). Internal Document. Retrieved from Western Carolina University, Assistant to the Registrar, WCU.

12. Office of Institutional Planning and Effectiveness (2014) WCU Quality Indicators. Retrieved December 12, 2014 from http://www.wcu.edu/WebFiles/IPE_FactBook_2014_QualityIndicators.pdf

13. Office of Financial Aid, (2014). Internal Report. Retrieved July 23, 2014 from Western Carolina University, Associate Director of Financial Aid, WCU.