Using Board Spectrum Technological Projects to Introduce Diverse Student Populations to Biological & Agricultural Engineering

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Dr. Carol S. Stwalley, P.E. joined the Minority Engineering Program team in the fall of 2007 as Recruitment and Retention Analyst. She earned her Bachelor of Science, Master of Science, and Ph.D. from Agriculture and Biological Engineering at Purdue University. Dr. Stwalley has more than 20 years in diversity work, with considerable background working with K-12 students from the Women in Engineering Programs at Purdue. Her current capacity is as Recruitment and Retention Data Analyst for the Minority Engineering Program at Purdue, where she aids the organization assisting historically underrepresented groups of students in engineering. Her work with the Rising Scholar NSF S-STEM program includes the collection, analysis, and management of the data pertaining to the outreach, recruitment, retention and graduation of the Rising Scholars students, as well as serving as the program interface with the undergraduate participants.

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Dr. Robert M. Stwalley III, P.E. joined the Agricultural & Biological Engineering department as a faculty member in the fall of 2013. He earned his Bachelor of Science in Agriculture and Biological Engineering (ABE) and his M.S.E. and Ph.D. from Mechanical Engineering at Purdue University. Dr. Stwalley is the former Director of Professional Practice at Purdue, has more than 20 years in STEM education, and has been a long-term advocate for improving equity in education. He is a long serving public school board member and President of the Indiana School Board Association. In his current capacity as an ABE professor, Dr. Stwalley works on precision livestock instrumentation to improve animal welfare and performance, increasing potable water access in the developing world through tube well utilization, and equity in access to higher education for low socio-economic status students. Dr. Stwalley developed the Rising Scholars program to help demonstrate that access and support are the most crucial elements of success in higher education for STEM majors.

Ms. Virginia Lynn Booth-Womack, Purdue University at West Lafayette (COE)

Virginia Booth Womack joined the Minority Engineering Program (MEP) at Purdue University in 2004 as Director. She earned her Bachelor of Science in Industrial Engineering and her Bachelor of Arts in Psychology from Purdue University. Ms. Booth Womack has over 30 years' experience leading advocacy efforts for historically underrepresented students at a national level and has served as the interim executive director for the National Society of Black Engineers. She is currently a Ph.D. candidate in Engineering Education at Purdue University. Ms. Booth Womack has successfully crafted and maintained the collegiate cultural aspects of excellency in scholarship, fellowship for participants, and assistance to those in need within the MEP. The highly successful, empathetic and high-touch model of student counseling used by MEP was a model for assisting the Rising Scholars cohorts.

Ms. Grace Lynn Baldwin

Grace Baldwin, joined the Rising Scholar NSF S-STEM program in the Summer of 2017 as a Graduate Research Assistant. She completed her Bachelor of Science degree at Purdue University in Agricultural and Biological Engineering (ABE) with a focus in Environment and Natural Resources Engineering. She has worked with the Rising Scholars' Program during the completion of her Master of Science in Agricultural and Biological Engineering and into her current Ph.D. program at Purdue University also in ABE. As part of the Rising Scholars' program, she has helped plan and organize the student recruitment events, align students with summer research experiences and faculty mentors, and conduct student interviews for program analysis and evaluation. Ms. Baldwin has actively contributed to the collection and analysis of data for the Rising Scholars program, as well as the dissemination of information about the progress of the program.

Sarah LaRose, Purdue University

Dr. Sarah E. LaRose joined the Department of Agricultural Sciences Education and Communication at Purdue University in the fall of 2018 as an Assistant Professor of Agricultural Education. She earned a Bachelor of Science in Animal Science and a Master of Arts in Curriculum and Instruction from the University of Connecticut, and her Ph.D. in Agricultural Education and Communication from the University of Florida. Dr. LaRose has over 13 years of experience in agricultural education in secondary and postsecondary settings. Since joining the faculty at Purdue, Dr. LaRose serves as a teacher educator, preparing future agricultural educators to meet the needs of a diverse array of learners in their classes. She teaches coursework in curriculum design, laboratory teaching practices, and teaching methods in agricultural education. Central to all of Dr. LaRose's work as an educator and a scholar is an effort to address inequities in agricultural education curriculum, program design, and recruitment practices.

Using Broad Spectrum Technological Projects to Introduce Diverse Student Populations to Biological & Agricultural Engineering (BAE): A Work in Progress

Abstract

This paper is a work-in-progress, focused on the utilization of the Rising Scholars Program to introduce minority students to experiential engineering projects within Agricultural and Biological Engineering. Traditional admissions processes at top institutions predominately utilize standardized test scores when comparing student applications. The equity of these high-stakes tests most severely affects students of low socioeconomic status (SES). The NSF-sponsored program, *Rising Scholars: Web of Support used as an Indicator of Success in Engineering*, was created to investigate whether alternative admission criteria could be used to identify low-SES applicants who would excel within STEM fields in higher education, even if they did not have the superior standardized testing metrics preferred by current admissions processes. The students underwent a pre-selection process to determine their eligibility. The overall experience was designed to enhance student connectivity within the collegiate environment. The Gallup-Purdue Index (2014) found that feeling supported and having learning experiences that illustrated learned principles produced a graduate who would be engaged in their work. The Rising Scholar (RS) program utilized a prescribed path through college designed to enhance these features. These positive experiences are exemplified by the Purdue Agricultural and Biological Engineering (ABE) department and how they approach the overall educational process. Faculty are motivated in their teaching, research, and extension efforts by a focus on meeting the world's grand challenges, in which most college students are also highly interested. The Rising Scholars Program utilized the Vertically Integrated Projects model to introduce their students to real-life projects at the freshman and sophomore level, which could potentially be continued on into graduate school. Several of the RS students have worked with the Purdue ABE Hog Cooling Pad Project and these students have conducted research, prototyping, and design modifications on the pad. They have participated in five experimental bench tests of the design and four consecutive live animal studies related to the pad performance. Within these experiments, Rising Scholars students were able to work on real-life projects, with real-world impact. The preliminary hypothesis question is: Are future graduates of the Rising Scholars Program more likely to thrive in all areas of well-being due to their collegiate experiences?

I. Introduction

The Morrill Act, signed by Abraham Lincoln in 1862, opened the door to establish land grant universities across the United States. In 1890, the mandate was extended to ensure that race was not an obstacle for admissions to the land grant schools. The words "accessible to all" challenge every land-grant institution to achieve and provide an inclusive environment where all have the right to access and the potential to be successful. In the recent past, multiple states have reduced funding to their state-supported colleges, and this has led to out-of-state and international students being favored for admission, due to the tuition levels being higher for these students [1]. This circumstance has resulted in residential (in-state) students with low socioeconomic status (SES), many of whom are underrepresented minorities (URM), to be competing at a distinct disadvantage for admission within the current process. This is especially true within the highly desired science, technology, engineering, and mathematics (STEM) majors. The value of a degree from a top school allows the holder more potential job offers, a higher starting salary, and a wider geographical range of job opportunities, and research shows that the value for low-SES students is even greater [2].

Historically, universities have depended upon standardized test scores as an important predictor of student success, however, high performance on standardized test scores is directly correlated to students that come from families with much higher income status than underserved communities [3]. Admissions decisions that are influenced by standardized test scores can unintentionally penalize URM's and deny them an opportunity to pursue STEM degrees. Potential residential students have to compete against the top students from around the world for these highly coveted openings. If the collegiate admissions processes do not recognize the success metrics that these students possess, then low-SES students are prevented from having the potential to move upward in society. This recognition is critical to changing these potential students' economical social status. It has been shown that high-income families have a 50% greater chance of their children receiving a bachelor's degree by age 25 than low-income families, who only have a 10% probability of obtaining such a degree [4].

However, we know that this does not necessarily have to be the case. Students who have participated in the Minority Engineering Program have demonstrated the ability to persist in engineering across a wide range of standardized test performance. Many students that were denied engineering as their first choice have been able to successfully change their degree objective to engineering and graduate from the College of Engineering with competitive grade point averages. This suggests that there may be other factors that promote student success in engineering that merits further investigation. The Rising Scholars program was developed to explore these additional predictive success factors. Initial data from the program appears to show that RS are performing at a statistically enhanced level in retention and GPA compared with their engineering direct-admit and exploratory studies peers [5]. The value of experiential experiences within the RS program is presented in [6]. This paper concentrates on the cultural aspects of the program borrowed from the close-knit, supportive culture of Biological & Agricultural Engineering departments.

II. Background on the Rising Scholars Program

Admissions processes at top institutions predominately utilize test scores in comparing student applications. The SAT and ACT test scores are typically used to provide a set of common metrics from which these applicants can be compared. The inequity of these high-stakes tests most severely affects students of low-SES. Students with this profile, pursuing a degree in higher education, have become known as 'Rising Scholars' (RS) [7] [8]. The 2016 National Science Foundation S-STEM program, #1644143 *Rising Scholars: Web of Support used as an Indicator of Success in Engineering*, was created to investigate whether alternative admission criteria could be used to identify low-SES applicants who would excel in STEM disciplines within higher education, even if they did not have the superior standardized testing metrics favored by the current collegiate admissions process. The program utilized a prescribed path through college designed to increase students' opportunities for professional networking. It incorporated best practice experiential programs on campus, an industrial internship, and a four-year renewable $6,500 annual scholarship, along with additional opportunities to earn money during the research and internship segments of the program. The authors have provided a detailed description of the selection process that successfully brought 21 students into the pilot program [9].

Potential students for the RS program underwent a pre-selection process that evaluated their previous high school's rigor, the standard collegiate application essays, a specialized written survey to determine their web of supporting adults, and an on-campus interview with the program selection committee. The selected students had the following demographic characteristics:

Gender: 9 - female and 12 - male;
Residency: 18 - residential and 3 - non-residential;
Ethnicity: 14 - Hispanic (1 with American Indian identity);
Race: 3 - Black or African-American;
4 - Two or more race (3 with Black and 1 with American Indian identity); and
First Generation: 11 students.

The final selected students' academic performances were compared with a similar pool of engineering and undecided students to determine if there were differences in the pools selected by the RS committee for admission into the program and those selected by the admissions office personnel for engineering. It was established that statistically the RS students had significantly diminished averages of the desired admissions metrics compared to the general pool of engineering students. Longitudinal studies using matched pair comparisons will examine whether long-term differences in retention, performance, and major selection continue to exist.

As part of the program, each student participated in a minimum of one semester of faculty-directed research through the Louis Stokes Alliance for Minority Participation (LSAMP). The LSAMP experience allowed students to work with a faculty member on their own specific element of a project within the faculty member's ongoing research program. Some of the students were introduced to Agricultural & Biological Engineering (ABE) projects through this partnership opportunity. These students were paired with an ABE faculty member in their research area to conduct their initial project in a university setting. RS students were then allowed to direct a project of their choosing within the Multi-disciplinary Engineering Research Fellowship (MERF). The MERF opportunity provided students with a self-directed project to help prepare them for their senior capstone project within their discipline. Students were required to document their projects and formally write-up their experimental results. The LSAMP and MERF projects provided valuable experiential components to the RS students' overall collegiate experiences that introduced them to both project management and technical documentation, two essential skills for professional job seekers [10] [11] [12] [13] [14] [15].

III. Nature of an ABE Department

The Agricultural and Biological Engineering faculty members of Purdue University are highly respected within the institution, as they have received top ABE program ranking in the *U.S. News and World Report's* annual listing of top undergraduate engineering programs for the sixth consecutive year [16]. ABE has one of the broadest ranges of instructional and research areas of any engineering program, and ABE activities include elements from all traditional engineering disciplines [17] [18]. The department has a long history of being a nurturing, high-touch academic home for students, composed of small class sizes (10-25 students) and intentional professors who work very hard to get to know each student within their classes. This culture of

friendship and community is a hallmark of ABE. A department's culture unquestionably influences the quality of education and students' value of their college education [19] [20].

The Gallup-Purdue Index found that there were six positive experiences that are the most important in creating graduates who are engaged at work, but also thrive in all areas of wellbeing: purpose, social, financial, community, and physical. These include: (1) having a professor that cared about them, (2) having a mentor to encourage them in their goals and dreams, (3) having a professor that made them excited about learning, (4) having a job or internship that let them apply what they learned in the classroom, (5) becoming active in extracurricular activities and organizations, and (6) working on a project that takes longer than a semester to complete [19]. These attributes have long been a staple of ABE at Purdue, and the design of the RS program was heavily influenced by these elements.

These positive collegiate experiences are exemplified by the manner that the Purdue ABE Department treats their students. Faculty members serve as mentors and advisers both in and outside of the classroom setting. Faculty are inspired in their teaching, research, and extension efforts by focusing on meeting the World's Grand Challenges [21]. Faculty use this motivation within their classes to promote and encourage student learning. Students participate in undergraduate research and summer internships at all levels. These experiences often lead to follow-up opportunities for continuing their work in the form of undergraduate employment during the normal semester, another internship the following summer, or a formal job offer. Students engage in a broad range of professional societies within the department, including: American Society for Agricultural and Biological Engineers (ASABE); American Association of Pharmaceutical Scientists (AAPS); American Institute of Chemical Engineers (AIChE); American Society of Mechanical Engineers (ASME); Fluid Power Society (FPS); Institute of Food Technologists (IFT); Purdue Society of Professional Engineers (PSEF); Society of Automotive Engineers (SAE); National Society of Black Engineers (NSBE); Society of Hispanic Professional Engineers (SHPE); Latinos in Science and Engineering (MAES); and Society of Women Engineers (SWE). Within these organizations, students often participate in professional, service, and outreach activities that help form connections to other students, faculty from other departments, alumni, and working professionals in their area. These student clubs also provide platforms for students to obtain a variety of student leadership roles.

All undergraduate students in ABE participate in the department's senior capstone program. This series of classes teaches project management and execution through assigning student teams to solve and execute solutions to real world problems, similar to what a new STEM graduate employee would be tasked with in an industrial position. Students work closely with the instructor, departmental staff, the project client, and a technical mentor who has specific expertise in the area of their specific project. By participating in the capstone program, every student has been involved in a project lasting one to two semesters prior to graduation. Through their capstone projects, these students are exposed to the six positive collegiate experiences that contribute to overall well-being and make them more likely to thrive upon graduation.

IV. Rising Scholar students involved in ABE work

The Rising Scholars Program tried to utilize the Vertically Integrated Project (VIP) model in getting students involved in on-campus projects [22]. Similar to the reoccurring work experience sessions in Professional Practice, students returning to the same overall research group do not have to repeat the steep end of the learning curve becoming familiar with the overall project. In this educational pathway, undergraduate students at the freshman or sophomore level become involved in projects that they can continue to work on into graduate school, if they so desire. As part of the RS program, some of the students worked on such projects within ABE. A primary example has been multiple RS students continued involvement with the research, prototyping, and design improvement of the Purdue Hog Cooling Pad. Although faculty-conceived this device began its development in Purdue ABE as an undergraduate capstone project [23] [24].

The rationale for this innovative thermo-fluid machine involves both improved production metrics in swine culture and increased animal welfare. Selective breeding for increased litter size and increased milk production has caused a sizable divide between the optimal conditions for a sow and her piglets. If a sow is kept in temperatures above 25°*C*, her milk production, daily feed intake, fertility efficiency, and survival rate all decrease. However, piglets with lower birth weights cannot prosper below an ambient temperature of 25°*C* [25]. The Purdue Hog Cooling Pad, shown in figures 1 and 2, attempts to solve this mismatch of optimal environmental conditions for animals within a farrowing barn and can be retrofit within a traditional farrowing crate.

Figure 1 - Purdue Hog Cooling Pad

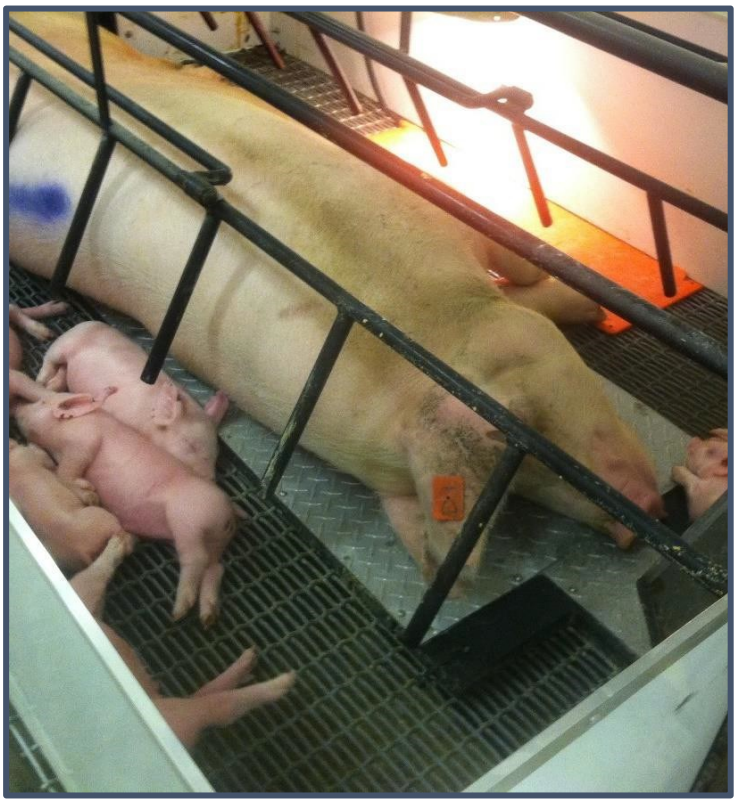

Figure 2 - Sow asleep on Purdue Hog Cooling Pad.

The Purdue Rising Scholars students have assisted with multiple facets of the device development. In particular, several with specific interests in the electrical applications have worked with ABE graduate students on multiple circuit board design prototypes for the pad. Two Rising Scholars, were instrumental in the creation of the first coolant flow controller [26] [27]. A third Rising Scholar executed numerous bench tests on the controller and enjoyed working with the team so much that she returned for another project involving a thermal study of the overall farrowing room [28]. These students and several others have at various stages helped carry-out four back-to-back experimental studies on the cooling effects of the pad for sows under heat-induced stress [29] [30] [31] [32], as well as five experimental bench tests [33] [34] [35] [36] [37].

The bench tests were conducted in three major segments across six weeks. The in-barn studies were carried-out over several months with a variety of sows at multiple parity levels. Within the live animal studies, the cooling pad microprocessor collected system data every six seconds, and physiological data was collected by hand every two hours for every sow. Students helped clean, prepare, and analyze the continuous data obtained from the pads. This live animal data, along with the bench test data the students helped obtain, were used to improve the cooling pad design as the studies progressed. These results have culminated in the most current model, which is under consideration for commercialization by a Canadian firm. Work on the pads at Purdue is ongoing, and some of the RS students, based upon the word-of-mouth from previous students, have recently begun their experiences with the cooling pad research. They have become involved with both ABE and Animal Sciences faculty members, along with a variety of graduate students working on different aspects of the project. The RS undergraduates have become valuable members of the research and development team and have been able to see their contributions manifested in the overall work. Additionally, the RS students have had numerous opportunities to meet and engage with multiple potential professional support network members through the Purdue Hog Cooling Pad project, and some of these people have joined their support networks.

V. Closure

The Rising Scholars Program was created to investigate alternative admission criteria that could be used to identify low-SES applicants who could excel in higher education, despite having unfavorable standardized testing metrics currently used in the generalized admissions process. The students who were selected for participation in the program went through a pre-screening process that emphasized their support networks and desire to succeed. The program utilized a prescribed path through college for the recruited students that provided them with opportunities to meet and work with faculty and staff to enhance their professional support networks. The Gallup-Purdue Index determined that six positive experiences that were the most important for graduates to have that would enable them to thrive in all areas of wellbeing, all of which are hallmark features of the ABE Department and the Rising Scholars program. The VIP model was used to introduce freshman and sophomore RS students to real-world projects that could potentially be carried on into graduate school. These projects were in collaboration with the ABE Department. A primary example of this was some of the RS students' involvement in the Purdue Hog Cooling Pad research, where they participated in prototyping and improving the design of the device. These students also took part in four consecutive live animal studies for the pad, as well as five bench tests. The Rising Scholars program has utilized their partnership with ABE to provide their students opportunities to work on real-life projects, with real impact. These future

graduates will be more likely to thrive in all areas of wellbeing due to their positive experiences within the Rising Scholars program.

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