

The Washington State Academic RedShirt (STARS) in Engineering Program

Mr. Jeremy Kingma, Washington State University

STARS Director M.S. Material Science & Engineering B.S. Mechanical Engineering

Prof. Eve A. Riskin, University of Washington

Eve Riskin received her BS degree in Electrical Engineering from M.I.T. and her graduate degrees in EE from Stanford. Since 1990, she has been in the EE Department at the University of Washington where she is now Associate Dean of Academic Affairs in the College of Engineering, Professor of Electrical Engineering and Director of the ADVANCE Center for Institutional Change. Her research interests include image compression and image processing, with a focus on developing video compression algorithms to allow for cell-phone transmission of American Sign Language. She was awarded a National Science Foundation Young Investigator Award, a Sloan Research Fellowship, and the 2006 Hewlett-Packard Harriett B. Rigas Award. She is a Fellow of the IEEE.

Dr. John B. Schneider, Washington State University

John Schneider is the associate dean for undergraduate programs in the College of Engineering and Architecture at Washington State University (WSU) and a faculty member in WSU's School of Electrical Engineering and Computer Science (EECS). He has taught courses ranging from introductory programming at the freshman level to advanced electromagnetics at the graduate level. He is a Fellow of the IEEE and has been selected as the WSU EECS Researcher of the Year and the School's Teacher of the Year.

Dr. Robert G. Olsen, Washington State University

Associate Dean of the College of Engineering and Architecture for Undergraduate Programs and Student Services and Professor of Electrical Engineering at Washington State University. He received the BS degree from Rutgers University and the MS and Ph.D. degrees from the University of Colorado all in electrical engineering. He is a Life Fellow of the IEEE, and an Honorary Life member of the IEEE Electromagnetic Compatibility Society. He is past Associate Editor of the IEEE Transactions on Electromagnetic Compatibility and Radio Science. As Associate Dean he is responsible for the accreditation process, recruitment and retention of students, community college visitation, management of the scholarship program and services to university and state committees. In addition to these activities, he has created the Harold Frank Engineering Entrepreneurship Institute in cooperation with the College of Business that exposes engineering students to the realities of the business aspects of engineering and better prepares them to work in the changing global marketplace. This work resulted in the 2008 Kauffman Foundation award for contributions to entrepreneurship education. Given the global nature of the economy, he has also worked to make it possible for engineering students to get general education credit for the study of foreign language. Finally, he has (with NSF support and in conjunction with the University of Washington and several community colleges) begun a major effort to recruit students into engineering who have not traditionally considered or entered the study of engineering.

Ms. Sonya Cunningham, University of Washington

Ms. Dawn Wiggin, University of Washington

Mr. Kirk A Reinkens, Washington State University

Scott Winter, University of Washington

The Washington State Academic RedShirt (STARS) in Engineering Program

Abstract

Retention of economically and educationally disadvantaged students in engineering disciplines is a challenge facing all engineering programs across the nation. In Washington state, this issue is critical as 35% of its high schools have over half of their students receiving free or reduced priced lunch, an indicator of the challenge schools face in preparing students for the rigor of college study in an engineering field. Leveraging an opportunity afforded by the Washington state's legislature mandating an increase of 225 engineering degrees a year, the Washington State Academic RedShirt (STARS) program was conceived to increase the number of economically and educationally disadvantaged students who graduate with engineering degrees from both the University of Washington and Washington State University. This program couples Washington's two leading state universities in a partnership where best practices and lessons learned are shared with the goal of retaining students not previously likely to have completed an engineering program.

The STARS program, modeled after the University of Colorado Boulder GoldShirt Program, can be likened to the redshirt year used to develop talented athletes in college athletics. In this first redshirt year, STARS students are offered intensive support, preparing them with the academic and learning skills required to be successful in engineering the following four years. The academic focus of the STARS program is on bringing the student's math skills and efficacy up to levels required to successfully pass Calculus I, an early indicator of future success in an engineering program. Additionally, connecting students in a supportive academic and social community is emphasized. Overall, a high touch approach is being used to create an environment of growth and development not previously offered to these talented and motivated students. We present results from the first year of the programs as well as lessons learned in supporting at-risk students in engineering.

Introduction

Engineering majors are challenging and typically require a significant background in math and science prior to beginning the curriculum at college. Completing the requirements for graduation in four years is difficult, even for students able to begin the program in the first semester. Students unprepared to begin engineering curriculums face an even greater challenge, especially in completing the series of math courses required for all disciplines. Unfortunately, students unprepared to begin the engineering curriculum are found disproportionately from economically and educationally challenged backgrounds. In fact, Reardon finds that the income achievement gap (the difference in standard test scores and grade point averages between children from families in the top 10 percent of the income distribution and those from families in the bottom 10 percent) continues to widen¹.

Excluding economically and educationally disadvantaged students from the engineering workforce has national economic and social implications. Strutz, Orr and Ohland state that "Not only does engineering lose the diversity of experiences that students from different

socioeconomic backgrounds bring, but the field commits a social injustice by systematically excluding people from a lucrative profession².” Because engineering offers well-paying job opportunities that can change the socioeconomic status of a family, it is important that low-income students be provided access to an engineering education.

Engineering in Washington state is particularly vital. The state of Washington ranks first nationally in its concentration of science, technology, engineering, and mathematics (STEM) jobs, but between 2012 and 2017 approximately 30,000 jobs in Washington will go unfilled due to the lack of qualified STEM candidates³. To help fill this deficit of qualified employees and narrow the income achievement gap, the Washington State Academic RedShirt (STARS) in Engineering Program was conceived to increase the number of engineering and computer science graduates from the University of Washington and Washington State University.

“Redshirt” programs are common in athletics; in these programs, an athlete is given a year to prepare to compete in athletics at the university level. Following this model, the Washington STARS in Engineering Program provides bright and highly motivated students from economically and educationally disadvantaged backgrounds the opportunity to build the required foundation to be successful in an engineering curriculum. They are provided with the academic and community support that has often been absent from these students’ education. Curriculum has been specifically developed and faculty singularly focused on preparing these students for the rigor of studying engineering. This paper introduces the Washington STARS in Engineering Program in its first year from both the University of Washington and Washington State University.

Washington STARS in Engineering Program Components

The Washington STARS in Engineering Program focuses on incoming freshmen to 4-year institutions. Due to the higher number of underrepresented minorities prevalent from disadvantaged backgrounds, these students are sought during recruitment. The Washington STARS in Engineering Program is designed with the following goals:

- To reinforce the students’ academic preparation and learning skills
- To connect the students to a supportive academic and social community
- To provide personal and effective academic advising and counseling
- To build a clear and compelling understanding of the engineering profession
- To provide significant financial support

The program is modeled after the University of Colorado’s Engineering GoldShirt program, where so far the program reports an impressive 72% retention rate for their first three cohorts with over 65% of students coming from Under Represented Minority (URM) backgrounds^{4,5}. Given the success in Colorado, the GoldShirt model was adapted by each respective Washington campus, paying special attention to the challenges faced by economically and educationally disadvantaged students. Each university targeted enrolling 32 STARS students. The WSU and UW STARS programs have common components as outlined below, but are tailored to each individual campus:

- First Year Curriculum: STARS staff designed the first year curricula at both universities to advance STARS students' academic preparation, primarily in mathematics; develop their learning skills; and help them complete some required coursework. The specific curriculum for each university is described separately below.
- Academic Advising: Each STARS student is required to meet with an academic adviser at least six times per year for academic planning and to address any academic or personal challenges the student may be facing. Each university has a team of culturally competent advisers with extensive experience working with students from diverse backgrounds and socio-economic levels.
- Residential Living-Learning Community: Research at WSU shows that living in a Living-Learning Community (LLC) yields a 25% better retention rate in STEM disciplines than other residence halls⁶. Both WSU and UW have LLCs in Engineering. All STARS students are encouraged to live in an Engineering LLC
- Career Awareness and Vision: Activities designed to promote STARS students' understanding of the engineering profession and a vision of themselves as engineers are integral to both the curricular and extracurricular components of STARS.
- Financial Aid: At WSU, the 2012-2013 budget for an on-campus student is \$27,302, of which \$12,300 is for tuition and mandatory fees. At UW, the 2012-2013 budget for a student who lives on campus is \$26,066, of which \$12,383 is for tuition and mandatory fees. Fortunately both universities are strongly committed to provide access to low-income students and guarantee full tuition and fee scholarships for Pell Grant-eligible Washington State residents. At WSU, this program is called the "Cougar Commitment" and at UW it is called the "Husky Promise."
- Leveraging Diversity Programs on Campus: The UW's Office of Minority Affairs & Diversity (OMA&D) and the Louis Stokes Alliance for Minority Participation (LSAMP) provides advising, tutoring, supplemental instruction, and experiential learning, including programming for students in STEM, underrepresented minority and educationally and economically disadvantaged students. Staff from OMA&D and LSAMP work collaboratively with STARS staff on student selection and support.

WSU Program

While the central components of the STARS program are common to both universities, there are different ways in which these are implemented at each campus. A primary difference between the two universities is that WSU is on the semester system while UW is on the quarter system. This played a critical difference in recruiting for the first cohort for WSU as the STARS program was not funded until after students had finalized most of their financial and living arrangements for their upcoming school year. With this in mind and classes beginning in three months, enrollment was accomplished by meeting the students during their summer registration and orientation session. WSU uses a math placement assessment administered through Assessment and Learning in Knowledge Spaces (ALEKS) and is a fully automated, adaptive system that covers material from basic Mathematics through Precalculus. Most students targeted were those found to be on the border between Prealgebra and College Algebra. During this recruiting phase, students who were Pell Grant Eligible were especially encouraged to participate in the program. By the first day of classes, 33 students were identified and enrolled in the program. Half of these students were Pell Grant Eligible and all were placed at the same level in math resulting in a cohort of students starting from a uniform mathematical ability.

The first semester of the WSU STARS in Engineering Program incorporates an enhanced MATH 106/116 College Algebra course, which is a five-credit version of college algebra developed at WSU⁷. This course includes extensive tutoring that is part of the recently developed WSU Math Emporium program (modeled after the successful Math Emporium at Virginia Tech⁸). The class uses ALEKS as an enhancement that tests students on their mastery of all the topics and tailoring problems that fill in any deficiencies they may have. Additionally, there is a Math Learning Center that is open throughout the day and into the evenings that is staffed with teachers and TAs knowledgeable and available to tutor students in any math subject. The first semester also includes ENGR 101 Success in Engineering Study, an engineering study skills and time management course with engineering challenges. The course is based on Ray Landis's *Studying Engineering* text⁹. The remainder of the first semester consists of a science course that meets general education requirements but does not require a math prerequisite, and general education credits.

The second semester includes ENGR 107 Introductory Mathematics for Engineering Applications, a laboratory-based "engineering mathematics" course (developed with support from an NSF Phase III CCLI grant) that teaches mathematics in the context of engineering applications and laboratory experiments. This course was originally developed by Wright State University and has had a significant positive impact on the retention rate for underprepared engineering students¹⁰. Studies of students taking ENGR 107 at WSU show that they have significant improvement in their math efficacy¹¹. Additionally, WSU STARS will take MATH 108 Trigonometry, the prerequisite for the first calculus course required of engineers. The remainder of the second semester is CHEM 101 Introduction to Chemistry (preparation for college chemistry), ENGR 120 Innovation in Design (a project-based introduction to engineering course), and general education credits. After two semesters, students will have completed four courses required for graduation, lightening the load in the subsequent four years, while also preparing them for the rigor of calculus and chemistry in the process.

Results of the STARS program at WSU are mixed after completing the first semester. Six students have left the program for reasons ranging from inability to successfully complete the math requirements to inability to afford the expense of college at a four-year institution. Additionally, 15 students of the original 33 enrolled in the program failed to pass MATH 106/116 with a 'C' or better, which is required to move on to MATH 108. Positively, the STARS program has been able to engage with these struggling students and identified paths forward. Many of them surely would have left the field of engineering without this high touch approach. Comments from students regarding the ENGR 101 class include "The most effective part of this course I think is that it really helps me grasp what it is like to take on an engineering degree. I was a little scared at pursuing an engineering degree, but this class has helped me realize that I am capable of doing it" and "This course prepares me for what to expect in my next five years of schooling at WSU so that I know what I'm getting into and that I have committed myself to my major. Also, this course was really effective in explaining good study habits and what we should do to do better in school and so forth."

UW Program

As mentioned earlier, UW is on the quarter system. This allotted additional time for recruitment of the first cohort of the STARS program. The recruitment process began by identifying all incoming engineering students who were found to be Pell Grant Eligible and who attended under-resourced high schools. These students were notified of the benefits of joining the STARS program and resulted in a pool of 90 applicants. After some time of reviewing applications and interviewing candidates, 30 participants were selected for the first cohort.

The first quarter of the UW STARS program includes a new 4-credit Math Problem Solving course designed in collaboration with staff from the College of Engineering Academic Center and the Mathematics department. The course has four primary objectives: 1) To solidify algebra skills; 2) To develop the ability to read and write within a mathematical context; 3) To develop the ability to represent mathematical information visually; and 4) To apply mathematical concepts to problems within engineering and the sciences. The focus of this class is on developing the ability to thrive in a high level university math course by being able to manage time, form mathematical questions, and develop mathematical efficacy by solving additional problems. Students' initial math placement will be determined after eight weeks using the UW Mathematics Placement Exam in consultation with STARS staff. Math placement resulted in approximately one third placed into MATH 120 Precalculus, one third into MATH 124 Calculus I, and one third into Math 125 Calculus II. Additionally, each quarter, students will register for a 1-credit academic workshop connected to the specific math course. The academic workshops will continue to build on the mathematical problem solving skills developed in the fall quarter in ENGR 105.

Other classes required of UW STARS include a one credit seminar offered each quarter. This seminar incorporates many elements including those found from The Guaranteed 4.0 Learning System¹² and also Ray Landis's *Studying Engineering* text⁹. The primary focus will be on learning skills, along with activities to educate the students about the engineering disciplines and profession as well as developing a sense of community within the cohort. Additional classes taken are geared towards preparing students for future success. Courses to build academic background include ENGL 109 and 110 – Introductory Composition I and II, a two-quarter English composition sequence to build writing skills; CHEM 110 – Introduction to General Chemistry, a course for students who did not take high school chemistry; PHYS 114/117 – General Physics, an algebra-based course for students who did not take high school physics; and CSE 120 – Computer Science Principles, an introduction to computer science and computational thinking.

Following the first quarter, results of the UW STARS program are also mixed, but encouraging. Early on, one student left the University due to a personal family matter. A few other students may not continue in the program for other reasons. Several important areas where students identified lessons learned are the benefits of studying in groups, strategies for eliminating procrastination, and being more comfortable asking for help. Overall, the majority of the STARS students are on track to complete the first year of the STARS curriculum and enter an engineering department.

Conclusion

The first 6 months of the Washington STARS in Engineering program has resulted in many lessons learned, both for the students and for the administrators of the program. First, working with students in a high touch capacity is beneficial, especially when times get difficult due to a poor result on a test or when facing financial difficulties. This may result in the student leaving the program, which may be in the best interest of all parties, but is the end result of a deliberate decision process that first-year students are just beginning to learn how to do. Second, placing students in a cohort with common classes is incredibly important to building a cohesive program. It allows students to bond and build a sense of community; it lets them realize they are not alone in their hopes and dreams. Finally, students will make mistakes and will fail, but they are also resilient when given the support and resources needed to succeed. This was epitomized after one student's failure to passing to the next level of math by responding with the following: "I'll push through this."

The UW and WSU STARS faculty and staff want to thank the University of Colorado's Associate Dean of Inclusive Excellence Jacquelyn Sullivan and GoldShirt Program Director Tanya Ennis for their guidance and encouragement during the launch phase of the Washington STARS in Engineering Program.

This material is based upon work supported by the National Science Foundation Graduate 10K+ STEP Grant under Grant No. 1317246 & 1317349.

Bibliography

- [1] Reardon, S. F. The Widening Academic Achievement Gap Between the Rich and the Poor New Evidence and Possible Explanations, 2011. <http://cepa.stanford.edu/content/widening-academic-achievement-gap-between-rich-and-poor-new-evidence-and-possible>
- [2] Strutz, M. L., Orr, M. K., Ohland, "Low Socioeconomic Status Individuals: An Invisible Minority in Engineering," in Engineering and Social Justice: In the University and Beyond, edited by Caroline Baillie, Alice L. Pawley, and Donna Riley, 157-180. West Lafayette, IN: Purdue University Press, 2012.
- [3] Washington State Higher Education Coordinating Board (2011), A Skilled and Educated Workforce - 2011 Update.
- [4] Ennis, T. D., J. B. Milford, J. F. Sullivan, B. A. Myers, and D. Knight. "GoldShirt Transitional Program: First-Year Results and Lessons Learned on Creating Engineering Capacity and Expanding Diversity." American Society for Engineering Education, 2011. <http://www.asee.org/public/conferences/1/papers/2141/view>
- [5] Interview with Tanya Ennis, University of Colorado GoldShirt Program Director on November 15, 2012.
- [6] Internal WSU study of STEM retention in the science and engineering living learning community.
- [7] WSU – Department of Mathematics: <http://www.math.wsu.edu/math/Application/Math106/>
- [8] VirginiaTech Math Emporium: <http://www.emporium.vt.edu/>
- [9] Landis, R. B., Studying Engineering: A Roadmap to a Rewarding Career, Discovery Press, Los Angeles, CA.
- [10] Klingbeil, N.W., K. A. High, M. W. Keller, I. M. White, B. J. Brummel, J. S. Daily, R. A. Cheville and J. Wolk, The Wright State Model for Engineering Mathematics Education: Highlights from a CCLI Phase 3 Initiative, presented at the ASEE 2012 meeting in San Antonio, TX.
- [11] Brown, S., and J. Burnham. (2012), "Engineering Student's Mathematics Self-Efficacy Development in a Freshmen Engineering Mathematics Course," International Journal of Engineering Education Vol. 28, No. 1, pp. 113–129.
- [12] Guaranteed 4.0 Learning System: <http://www.guaranteed4.com/>