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Work in Progress: Institutional Context and the Implementation of the Redshirt in Engineering Model at Six Universities

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Emily Knaphus-Soran is a Research Associate at the Center for Evaluation & Research for STEM Equity (CERSE) at the University of Washington. She works on the evaluation of several projects aimed at improving diversity, equity, and inclusion in STEM fields. She also conducts research on the social-psychological and institutional forces that contribute to the persistence of race and class inequalities in the United States. Emily earned a PhD and MA in Sociology from the University of Washington, and a BA in Sociology from Smith College.

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Ann Delaney graduated in 2016 with her Masters in Materials Science & Engineering with an interdisciplinary emphasis in Public Policy and Administration from Boise State University. Her thesis was entitled, "Nanomanufacturing Outside of the Lab: An Academic-Industry Partnership Case Study." She also received her B.S. in Materials Science & Engineering from Boise State in 2014. In the Spring of 2016, Ann was recognized as part of the first cohort of University Innovation Fellows at Boise State, and has worked as a Fellow to collect and incorporate student feedback into future plans for makerspaces on the Boise State campus. As an undergraduate and graduate student, she has been involved with the Society of Women Engineers, and also taught a materials science laboratory course as a graduate teaching assistant. She has volunteered at numerous STEM outreach activities on and off of the Boise State campus throughout her time as a student and is passionate about increasing diversity in STEM and helping girls and women to recognize that STEM is a path that is open to them if they want to take it.

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Katherine directs the Washington STate Academic RedShirt (STARS) program at Washington State University. She holds a Master of Science in Mathematics with a Teaching Emphasis.

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Pamela C. Cosman received the B.S. degree with Honor in electrical engineering from the California Institute of Technology in 1987 and the Ph.D. degree in electrical engineering from Stanford University in 1993. In 1995 she joined the faculty of the Department of Electrical and Computer Engineering, University of California, San Diego, and is currently a Professor. She has published over 250 journal and conference papers in the areas of image/video compression and processing and wireless communications. She served as Director of the Center for Wireless Communications (2006-2008), Associate Dean for Students of the Jacobs School of Engineering (2013-2016), and Editor-in-Chief of the IEEE Journal on Selected Areas in Communications (2006-2009). Her awards include the 2016 UC San Diego Affirmative Action and Diversity Award, and the 2017 Athena Pinnacle Award (Individual in Education). She is a member of Tau Beta Pi and Sigma Xi, and a Fellow of the IEEE.

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TANYA D. ENNIS is the current Engineering GoldShirt Program Director at the University of Colorado Boulder's College of Engineering and Applied Science. She received her M.S. in Computer Engineering from the University of Southern California in Los Angeles and her B.S. in Electrical Engineering from Southern University in Baton Rouge, Louisiana. Her career in the telecommunications industry included positions in software and systems engineering and technical project management. Tanya taught mathematics at the Denver School of Science and Technology, the highest performing high school in Denver Public Schools. She is a PhD student in the School of Education at University of Colorado Boulder studying Learning Sciences and Human Development.

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Beth A. Myers is the Director of Analytics, Assessment and Accreditation at the University of Colorado Boulder. She holds a BA in biochemistry, ME in engineering management and PhD in civil engineering. Her interests are in quantitative and qualitative research and data analysis as related to equity in education.

Dr. Jana Milford, University of Colorado, Boulder

Jana B. Milford is professor of mechanical engineering and faculty advisor for the Engineering GoldShirt Program at the University of Colorado at Boulder. She holds a Ph.D. in Engineering and Public Policy from Carnegie Mellon University and a J.D. from the University of Colorado School of Law. Her research and teaching focus on atmospheric chemistry and transport modeling and air quality management.

Dr. Donna C. Llewellyn, Boise State University

Donna Crystal Llewellyn received her BA (major in Mathematics and minor in Economics) with High Honors from Swarthmore College in 1980. She went on to earn an MS in Operations Research from Stanford University in 1981 and a Ph.D. in Operations Research from Cornell University in 1984. After 30 years at Georgia Tech in a variety of roles, Donna became the Executive Director of the new Institute for STEM and Diversity Initiatives at Boise State University in January 2015. Donna's current interests center around education issues in general, and in particular on increasing access and success of those traditionally under-represented and/or under-served in STEM higher education.

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 Diversity and Access in the College of Engineering, Professor of Electrical Engineering and Director of the ADVANCE Center for Institutional Change. With ADVANCE, she works on mentoring and leadership development programs for women faculty in SEM. 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, the 2006 WEPAN University Change Agent award, the 2006 Hewlett-Packard Harriett B. Rigas Award, and the 2007 University of Washington David B. Thorud Leadership Award. She is a Fellow of the IEEE.

Dr. Janet Callahan, Boise State University

Janet Callahan is Chair and Professor of the Micron School of Materials Science and Engineering at Boise State University. Dr. Callahan received her Ph.D. in Materials Science, M.S. in Metallurgy, and B.S. in Chemical Engineering from the University of Connecticut. Her educational research interests include retention, mathematics and materials science teaching and learning, first-year programs, accreditation, and faculty development.

Prof. Kevin Pitts, University of Illinois, Urbana-Champaign

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Dr. Michelle Ferrez, University of California, San Diego

Michelle is currently the Director of the IDEA Engineering Student Center at UC San Diego, Jacobs School of Engineering (Inclusion-Diversity-Excellence-Achievement). Dr. Ferrez has twenty three years of experience on diversity in STEM access, retention, and success programs in higher education (4 year and community colleges), K-12 and graduate student pipeline programs, and the role of four-year minority serving institutions in creating educational equity in STEM. Her primary interest centers on postsecondary success for minoritized women and men in STEM fields. Following this interest, she has conducted research in several areas including the intersectionality of race and gender in engineering; including understanding the culture, climate, and infrastructure of an engineering program (policies, organizational

norms, interactions with faculty & peers, etc.) that may reinforce racial and gender stereotypes, engender feelings of racial and gender subordination, and disproportionately validate and privilege members of some racial groups at the expense of others.

Work in Progress: Institutional Context and the Implementation of the "Redshirt in Engineering" Model at Six Universities

Abstract

Low-income students are underrepresented in engineering and are more likely to struggle in engineering programs. Such students may be academically talented and perform well in high school, but may have relatively weak academic preparation for college compared to students who attended better-resourced schools. Four-year engineering and computer science curricula are designed for students who are calculus-ready, but many students who are eager to become engineers or computer scientists need additional time and support to succeed. The NSF-funded Redshirt in Engineering Consortium was formed in 2016 as a collaborative effort to build on the success of three existing "academic Redshirt" programs and expand the model to three new schools. The Consortium takes its name from the practice of Redshirting in college athletics, with the idea of providing an extra year and support to promising engineering students from low-income backgrounds. The goal is to enhance the students' ability to successfully graduate with engineering or computer science degrees. This Work in Progress paper describes the Redshirt programs at each of the six Consortium institutions, providing a variety of models for how an extra preparatory year or other intensive academic preparatory programs can be accommodated. This paper will pay particular attention to the ways that institutional context shapes the implementation of the Redshirt model. For instance, what do the Redshirt admissions and selection processes look like at schools where students are admitted directly to engineering from high school versus schools where students are admitted after one or two years taking engineering prerequisites at the university? What substantive elements of the first-year curriculum are consistent across the consortium? Where variation in curriculum occurs, what are the institutional factors that produce this variation? How does the Redshirt program fit with other pre-existing academic support services on campus, and what impact does this have on the Redshirt program's areas of focus? Program elements covered include first-year curricula, pre-matriculation summer programs, academic advising and support services, admissions and selection processes, and financial aid. Ongoing assessment efforts and research designed to investigate how the various Redshirt models influence faculty and student experiences will be described.

Introduction

Students from low-income backgrounds are underrepresented in engineering and are more likely to struggle in engineering programs. Such students may be academically talented and perform well in high school, but may have relatively weak academic preparation for college compared to students who attended better-resourced schools [1]. Four-year engineering and computer science curricula are designed for students who are calculus-ready, but many students who are eager to become engineers or computer scientists need additional time and support to succeed. The need for an extra year of targeted support to prepare highly-motivated but underprepared students drove the creation of the Engineering GoldShirt Program at the University of Colorado Boulder (CU-B) in 2009. The name was derived from the practice of "redshirting" in college athletics - providing athletes with an extra performance-enhancing year to prepare them to compete at the college level [2]. The NSF-funded Redshirt in Engineering Consortium was formed as a

collaborative effort to build on the success of three existing "academic Redshirt" programs (including the GoldShirt Program at CU-B) and expand the model to three new schools. The goal of the program is to enhance the students' ability to successfully graduate with engineering or computer science degrees.

The Redshirt consortium is currently in its second year. In its first year, Redshirt programs at the three existing Redshirt institutions (ERIs) expanded their programming to include second-year students, and supported the three new student success partners (SSPs) in planning for the implementation of their own Redshirt programs (see Table 1). In the second year, SSPs welcomed their first cohort of Redshirt students. Since the launch of the consortium with a kickoff meeting in September 2016, consortium members have participated in bi-weekly conference calls to share best practices and work through challenges. Ongoing communication across the consortium has been helpful for finding ways to successfully adapt the model to fit the needs of students at six different schools.

Table 1 Redshirt in Engineering Programs

	Redshirt Institution[1]	**Redshirt Program Name**	**Year Program Began**
Existing Redshirt Institutions (ERIs)	University of Colorado, Boulder (CU-B)	Engineering GoldShirt Program	2009
	University of Washington (UW)	WA STate Academic Redshirts (STARS) Program	2013
	Washington State University (WSU)	WA STate Academic Redshirts (STARS) Program	2013
Student Success Partners (SSPs)	Boise State University (BSU)	SAGE Scholars Program	2017
	University of California, San Diego (UCSD)	Academic Community for Engineering Success (ACES) Program	2017
	University of Illinois, Urbana-Champaign (UIUC)	Academic Redshirt in Science and Engineering (ARISE) Scholars Program	2017

The Redshirt model is comprised of seven main programmatic components aimed at improving the engagement, retention, and graduation of students underrepresented in engineering. These components include: "intrusive" academic advising and support services, intensive first-year academic curriculum, community-building (including pre-matriculation summer programs), career awareness and vision, faculty mentorship, NSF S-STEM scholarships, and second-year support.

This work in progress paper describes the implementation of the Redshirt program[2] at each of the six Redshirt in Engineering Consortium institutions, providing a variety of models for how an

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[1] For brevity, we will use the acronyms listed in this table in place of the full names of the institutions throughout the paper.

extra preparatory year or other intensive academic preparatory programs can be accommodated. This paper will pay particular attention to the ways that institutional context shapes the implementation of the Redshirt model.

Institutional Context

Engineering Enrollments

As shown in Table 1 below, the size of engineering programs varies across the consortium, from 2,611 students at BSU (11% of the University) to about 11,000 students at UIUC (25% of the University). There is also wide range in the competitiveness of programs - at BSU, all students who declare engineering as a major are admitted to the program. WSU is somewhat competitive; any student who is admitted to the university is directly admitted to the engineering and computer science programs, but certification is required for WSU students to begin taking upper division coursework. Most students certify, with GPA requirements ranging from 2.5 to 3.2 (students are automatically certified if they maintain a 3.2 GPA). CU-B has become increasingly competitive -- 38% of applicants to CU-B's College of Engineering are admitted. The UW has changed its admissions policy as of January 2018, but will likely remain very competitive. As of 2017, admission to engineering departments ranged from about 15%-40% of applicants. UIUC and UCSD are highly competitive. At UIUC, only 12% of applicants are admitted, and UCSD ranks in the top 15 of all engineering programs and top 10 among public universities.

Table 2 Engineering Enrollments by Institution

Redshirt Institution	Total University Enrollment	Engineering Enrollment	Engineering as % of Total Enrollment
CU-B	33,246	6,836	21%
UW	40,211	5,650	14%
WSU	25,277	3,468	14%
BSU	20,350	2,611	11%
UCSD	29,286	5,857	20%
UIUC	44,000	11,000	25%

Campus Climate and Support for DEI Initiatives

All six Redshirt programs describe the administration at their university/college of engineering as being supportive of initiatives to improve diversity, equity, and inclusion (DEI) in engineering. While university presidents and engineering deans are generally described as supportive, each school continues to face their own set of challenges. At CU-B and WSU, a great deal of progress has been made in terms of administrative support for diversity over the last decade, but there are still issues with campus climate. At UW, the president is very supportive of diversity initiatives, but it can be challenging to convince other administrators and funders that goals for DEI are compatible with academic quality. Likewise, UCSD has had a hard time securing funding for DEI initiatives even though the administration has voiced support. While

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[2] For the sake of clarity and consistency, the name "Redshirt program" is used throughout this paper to describe the programs at all consortium institutions.

there is still room for progress in supporting DEI initiatives consortium-wide, institutional support is evidenced by the creation of the BOLD (Broadening Opportunity Through Leadership and Diversity) Center at CU-B, the IDEA (Inclusion, Diversity, Excellence, Achievement) Student Center at UCSD, and the Institute for STEM and Diversity Initiatives at BSU.

Engineering Admissions and Selection for the Redshirt Program

Consortium institutions vary in their policies for admission to engineering colleges and majors, which has an impact on the recruiting and selection process for the Redshirt program. At CU-B, BSU, UCSD, and UIUC, incoming students are admitted directly into the College of Engineering upon admission to the University. At two of these schools, BSU and UCSD, students are recruited to apply for the Redshirt program if they have been admitted to the College of Engineering but are behind their peers in terms of academic preparation and have significant financial need. At the other two schools with direct-to-college admissions, CU-B and UIUC, students are recruited to apply for the Redshirt program if they did not meet the qualifications for their selected engineering major and have been redirected to the College of Arts & Sciences or Division of General Studies. For these students, the Redshirt program offers an alternate path into Engineering. At UW and WSU, students express an interest in engineering upon admission to the University, but do not apply to the College of Engineering until their sophomore or junior year. Students are recruited to apply for the Redshirt program if they are eligible based on financial need and have academic backgrounds that suggest they would struggle to meet engineering admissions criteria. At UW, where admission to most engineering majors is highly competitive, Redshirt students are offered guaranteed acceptance into Engineering upon completion of the program. Below, we describe in more detail the engineering admissions processes at each of the six consortium institutions, and how this shapes the recruitment and selection of Redshirt students.

University of Colorado, Boulder (CU-B)

At CU-B, students are admitted to their particular engineering major if they meet the qualifications for the College of Engineering and Applied Science (direct-to-major). If they do not meet these college qualifications, there is a pre-engineering option in the College of Arts and Sciences. The engineering college's Director of Recruiting and Access collaborates with Admissions to identify the pool of students who have not been admitted to engineering but could succeed in engineering through the Redshirt program. Students who are determined to fit the Redshirt profile are sent letters inviting them to interview for the Redshirt program. Redshirt staff also reach out to invited candidates by phone. Interested applicants are required to submit a statement of motivation and to interview on campus. This interview includes a one-on-one interview with faculty or staff and parallel sessions for families, including sessions on financial aid. Students also engage in a simulated engineering design exercise as part of a team to achieve a common goal. The ability to work effectively in teams is assessed through the students' participation in the exercise. Interviews are scored and results are discussed with the Redshirt team to make final selections for offers of admission. Students who are admitted to the Redshirt program gain direct admission to the College of Engineering, contingent on their participation in the Redshirt program including the successful completion of the summer bridge program.

University of Washington (UW)

At UW, prior to the class of 2018, students applied directly to a particular department in engineering after their freshman or sophomore year. Starting in 2018, UW will admit freshmen directly to the College of Engineering (direct-to-college). Freshmen who do not meet the minimum requirements to be admitted directly to the college can still apply for admission to engineering at the end of their sophomore year, but admission is not guaranteed for students in this position.[3] In the past, students who successfully completed the Redshirt program were guaranteed acceptance to Engineering. It is uncertain at the time of this writing how this policy will be adapted for the change to direct-to-college admission at UW.

At UW, the Redshirt program uses several recruitment strategies. First, they contact high school counselors at schools with 30% or more students receiving free or reduced-price lunch, using a list is received from the College. The UW Redshirt program also sends information to community partner organizations and staff at local private schools and to the UW Office of Minority Affairs & Diversity and the UW Women's Center. The Redshirt program reaches out directly to UW engineering and computer science applicants who are Pell-eligible or self-report low-income status on the UW application with an invitation to apply to Redshirt via multiple emails. When possible, they also send information about the UW Redshirt program to invited applicants through direct mail. Current Redshirt students also call the Redshirt-eligible applicants to the College of Engineering to encourage them to apply to the Redshirt program. After the application deadline for Redshirt (typically mid-March), applications are reviewed by Redshirt program staff with the assistance of staff from the college's Diversity & Access and Academic Affairs units. Applicants are ranked and top applicants are selected for an in-person interview or a Skype interview. Applicants are offered admission based on holistic review of all application materials, including essay and interview responses.

Washington State University (WSU)

At WSU, admission to the College of Engineering and Architecture occurs after students complete their general education courses. Students express an academic interest in engineering when they are first admitted to WSU and apply for certification (formal acceptance) in their specific major during their sophomore or junior year. At WSU, the Redshirt program acquires a list of students who have applied to WSU and have expressed an interest in engineering. This list is narrowed down to students who are Washington residents, then sent to Financial Aid Services to identify Pell-eligible students. Prospective Redshirt students are sent emails and postcards inviting them to apply to the program. Invited students also receive calls from current Redshirt students. The Redshirt advisor speaks to all eligible students one-on-one during first-year orientation. Students are interviewed once they apply to the Redshirt program, and are accepted or denied admission to the program based on the determination of the WSU Redshirt director, assisted by the Redshirt advisor.

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[3] Computer Engineering will fall under the new direct-to-college policy, however Computer Science degrees at the UW are awarded through the College of Arts and Sciences, and will not participate in the new direct-to-college policy.

Boise State University (BSU)

At BSU, students are admitted directly to an engineering major if they choose to declare one, or enter the College of Engineering as "Engineering Undecided". There are no minimum requirements to be admitted to the College of Engineering itself, though Calculus I (Math 170) is a co-requisite for Introduction to Engineering, which is the lowest-level Engineering course required for engineering majors. Some engineering departments have more complex admissions requirements beyond those for admission to the college. At BSU, eligible Redshirt students are sorted from lists received from admissions, as well as from the Boise State Scholarship application. In the program's first year, students who qualified for the Redshirt program were emailed an invitation to apply. Brochures were also distributed during the campus visit day for new and prospective students. Recruitment for the Redshirt program continued through most of the summer, with the program director promoting the program during new student orientation advising sessions and information fairs. In future years, the recruiting and admissions timeline has been moved earlier in the year so that decisions are made in time for the summer programs.

At BSU, students who completed the brief application to the Redshirt program were invited to interview with the program director and/or other leaders of the Redshirt program. This interview covered topics such as interest and motivation in engineering, future career goals, and overcoming challenges. Admissions decisions were made by the Redshirt program leadership team after these interviews. In some cases, conditional offers were made contingent on completion of certain deliverables (such as work in an online ALEKS math course).

University of California, San Diego (UCSD)

At UCSD, students are admitted direct-to-college and declare their major during the admissions process. The Redshirt program receives data from the admissions office after students have been offered admission to the College of Engineering. Recruitment largely targets students who participate in programs that bring students to campus, including the IDEA Engineering Student Center Overnight Program, which overlaps significantly with the desired student population for Redshirt. The marketing plan for recruiting Redshirt scholars also includes distributing flyers at UCSD's Triton Day for admitted students, an email campaign specifically targeting potential Redshirt students, and phone calls from UCSD engineering students. The Redshirt program also worked with UCSD's Summer Success Program to integrate the Redshirt application into UCSD's "Common Application" for all summer programs, since all Redshirt students are required to attend the Summer Engineering Institute. At UCSD, a panel of engineering faculty and staff selects Redshirt students, primarily based on the applicant's financial need and written statement about interest in engineering and overcoming challenges.

University of Illinois, Urbana-Champaign (UIUC)

At UIUC, students must apply to a specific major when they apply to engineering. Students are placed into a major upon admission if they meet the qualifications for that major. Otherwise, they are redirected to the Division of General Studies (DGS), which is an "undeclared" major. The Redshirt program identifies students who apply to engineering majors and have been redirected to the Division of General Studies. These students are offered a chance to apply for

the Redshirt program, then brought to campus for a visit/interview. Offers are made to students admitted to the Redshirt program (with additional scholarship money) before these students accept admission to UIUC. For students who are admitted to the Redshirt program, their admission to Engineering is contingent on their successful completion of the program.

Table 3 Summary of Admissions and Selection Processes at Redshirt Institutions

	COE admission policy	Redshirt-contingent COE admission	Target population	Redshirt recruitment strategies	Redshirt screening process
CU-B	Direct-to-major for those who qualify, pre-engineering in College of Arts & Sciences	Yes	-Not accepted to COE -Meet economic and academic qualifications	-Staff reaches out by phone	-Applicants submit a statement of motivation -Staff conducts interviews and observation of engr activity -Redshirt team makes selections
UW	Up through 2017, apply to College & major in Soph/Junior year. Changing to direct-to-college as of 2018-19 school year	Yes	-Pell-eligible -From HS with high % low-income students -Expressed interest in engineering	-HS outreach -Outreach through community partners -Mail/email low-income applicants interested in engr & CS	-Applications reviewed by Redshirt staff -Selection based largely on essay and interview responses
WSU	Students apply for certification into major (and admission to College of Engr) in Soph/Junior year	No	-Pell-eligible -WA residents -Expressed interest in engineering	-Postcard and email sent to eligible students -Outreach at orientation	-Applications reviewed by Redshirt staff -Selection based on application and interview with Redshirt staff
BSU	Direct-to-major (though some majors have additional requirements for admission to upper division)	No	-Students with financial need -Students meeting academic eligibility based on SAT/ACT, etc	-Email outreach -Outreach at admissions events -Individual outreach	-Students submit short application, reviewed by Redshirt staff -Interviewed by Redshirt staff -Some were conditionally accepted
UCSD	Direct-to-major admissions for those who qualify	No	-Already admitted to engineering -Significant financial need	-Outreach at events for admitted students -Calling campaign -Part of app for summer programs	-Selected by engineering faculty -Application essays about interest in engr and overcoming challenges
UIUC	Direct-to-major admissions for those who qualify, otherwise directed to Division of General Studies (DGS)	Yes	-Redirected to DGS -Low income	-Reach out to eligible students with invitation to apply to Redshirt	-Students fill out application -Invited to campus for an interview -Selected students offered admission to engr and scholarship

Consortium-Wide Practices

At all six institutions, applicants to Redshirt programs are evaluated based on essays and/or interviews in which they describe topics such as their interest in engineering, challenges they have overcome, commitment to pursuing a career in engineering, and overall motivation and academic potential to succeed. While eligibility is determined based on financial and academic need, selection is based on Redshirt staffs' impressions of students' motivation and commitment.

One major difference in the way students are admitted to Redshirt programs across the consortium is whether or not students have already been accepted to engineering prior to their invitation to join the program. For students at CU-B, UW, and UIUC, participation in the program opens up an opportunity to enter an engineering program - for some students, this could greatly influence their decision about whether or not to attend these schools. At WSU, UCSD, and BSU, admission to engineering is not contingent on their participation in the Redshirt program, but participating in the program increases their chance of success. Table 3 summarizes the admission and selection processes at the six schools.

Program Elements

Staffing and Administrative Support

Staffing and administrative support for Redshirt programs varies widely across the consortium, particularly between ERIs and SSPs. At CU-B, where the Redshirt model originated and the Redshirt program has been running for over 9 years, there are three full-time Redshirt staff (a director and two assistant directors). Additional part-time support is provided by faculty, staff and student workers from the College of Engineering's BOLD Center, the Dean's office and instructional staff in the Engineering Plus and Applied Math departments. The CU-B Redshirt program also has a peer mentorship component, which is mostly staffed by second year Redshirt students. In the BOLD Center, two student assistant positions are designated to support the Redshirt Program. Individual departments in the College of Engineering and Applied Science at CU-B support the program in a number of ways. For example, the Integrated Teaching and Learning Lab (ITLL) hires Redshirt students for the technical staff positions; the Engineering Plus department hires students as TA's for the first-year engineering design courses. Also, Redshirt students are hired as Learning Assistants (LAs) for the Applied Math courses.

The UW, in the fifth year of its Redshirt program, has five staff members (a director, two academic counselors, an operations manager, and a math and study skills instructor), one part-time workshop facilitator and several student workers: 4 graduate TAs, 8 undergraduate tutors, and 2 work study office assistants. WSU and BSU run their Redshirt programs with one full-time staff , UIUC has one half-time staff member, and the UCSD program is run by two part-time staff and two faculty members. WSU does have a dedicated advisor from the college of engineering for Redshirt students who provides part-time support. While there is a great deal of variation in the amount of staff support between Redshirt programs, there is not a direct relationship between staffing levels and amount of programming for students. Some Redshirt programs make use of activities provided for other programs within their universities, such as

partnering with LSAMP (Louis Stokes Alliance for Minority Participation) summer bridge programs.

Program administrators at CU-B, UW, WSU, and UIUC all have backgrounds in educational administration, student support, or teaching/learning. The CU-B administrator also has a degree in engineering, as do program administrators at UCSD and BSU. At WSU, the program administrator has a background in mathematics education. The skill sets associated with these varied backgrounds provide a somewhat different experience for students - a background in education/student support can provide students with a resource for deep knowledge regarding topics like study skills, and a background in engineering can provide students with a resource for deep knowledge regarding the application of engineering concepts. Across all six programs, program administrators work hard to incorporate both engineering-specific skills and knowledge and more general study skills, academic support, and career preparation in their programming. For example, though the WSU program administrator initially faced challenges teaching engineering concepts for the WSU Redshirt program's introductory mathematics for engineering application course, the support of other engineering educators at WSU has allowed for rapid growth in the administrator's engineering knowledge. Collaboration across the consortium also provides opportunities for program administrators to share knowledge with each other and provide students with a well-rounded experience. SSPs have worked to incorporate best practices learned from the ERIs that can be applied regardless of administrators' background knowledge or areas of expertise.

First-year Curricula

One of the central components of most Redshirt programs is the first-year course or seminar that Redshirt students are required to complete. Some commonalities among programs include a study skills course or seminar, math and science preparation courses, and supplemental tutoring or problem solving sessions. The first-year Redshirt curriculum prepares students to succeed in the standard engineering curriculum on a level that is on-par with their peers.

At CU-B, Redshirt students take a 1-credit course each semester focused on self-management strategies, leadership & professionalism, and introductions to departments and resources. Placement and math and science courses are determined during the Redshirt Summer Bridge Program where students are individually evaluated on their best course placement. Students who are not yet prepared for the General Chemistry course enroll in an Introduction to Chemistry course; furthermore, students who are not yet prepared for the Physics 1 course enroll in the Engineering Explorations through Physics course which is lecture and lab based. Math workgroup enrollment corresponds to the pre-calculus or calculus course in which the Redshirt student is placed. The Redshirt program funds and restricts small sections of calculus 1 for Redshirt students in the fall and spring semesters to support a more productive learning environment. Other coursework is flexible, but depends on the level of preparedness of each student.

The UW Redshirt curriculum is very similar – Redshirt students take a seminar course for credit each quarter which focuses on study skills, wellness, time management, faculty engagement, and engineering and computer science pathways and careers. There is little flexibility for UW

Redshirt students with regard to their coursework during the first year. Students are required to take a math problem-solving class and a chemistry problem-solving class. Additional problem solving workshops are offered (e.g. physics).

At WSU, Redshirt students take a 2-credit course during the first semester that continues as a 1-credit seminar during the second semester of their first year. This course focuses on study skills, career identity, and professional development. Redshirt students also take an introductory mathematics for engineering applications course. In addition, students must attend problem solving sessions each semester where math and chemistry tutoring are offered.

AT BSU, Redshirt students are required to take an introduction to engineering course sequence (2-credits each semester) which incorporates academic support and study skills content with introduction to engineering. Redshirt students are required to complete Calculus I by the end of their second semester in the program.

At UCSD, Redshirt students are required to participate in small discussion groups with the program administrator. These groups meet weekly during the fall quarter, and twice during the winter and spring quarters. The Redshirt students follow the same course plans as other first year engineering and computer science students.

At UIUC, Redshirt students take a course for credit that focuses on academic support, study skills, and engineering projects. This course is similar to an introductory engineering course taken by all first year students, but has a stronger focus on academic and professional development. Students are also required to take a writing course, introductory chemistry course, introductory physics course, and a math course.

Pre-matriculation Summer Programs/Community-Building

All Redshirt programs have a required pre-matriculation summer program to help students get a jump start on their academics and begin bonding with their Redshirt peers, though these programs look quite different from school to school. At CU-B, UW, UIUC, and BSU, all or most of these summer programs are designed specifically for Redshirt students. At WSU and UCSD, summer programs for Redshirt students are conducted in collaboration with other programs. At WSU, Redshirt students participate in a 4-day bridge program co-hosted by LSAMP (the Louis Stokes Alliance for Minority Participation). Redshirt students at UCSD participate in a 5-week summer engineering institute that is open to all incoming freshmen engineering students. At BSU, Redshirt students are required to attend a 2.5-day bridge program with an optional 3-day rafting and hiking trip, which is also open to other incoming freshmen STEM students. Similar to WSU, the BSU summer program is a collaboration between the Redshirt program and LSAMP. Redshirt students at UW are assigned summer homework to complete before the school year starts, with additional transition week programming right before school starts. CU-B Redshirt summer programing consists of a 2-week program with academic workshops, community-building activities, and advising/registration. Redshirt students at UIUC take part in a 2-day orientation event at the beginning of the summer, and a 3-day early move-in event before school starts. Pre-matriculation summer programs are generally funded by the college/university and grant funds, but some programs rely heavily on private gifts or other state funding mechanisms.

Academic Advising

All the Redshirt programs provide academic advising to the students, both in terms of required advising meetings and as-needed appointments, beyond the regular levels and types of advising provided to engineering students in general at each institution. All programs have at least two required advising meetings per term with the designated advisers for the Redshirt programs, and these meetings include midterm grade checks and discussion of study habits, and may include input directly from instructors and TAs. The designated advisers in some cases are Redshirt program administrators and in other cases are a subset of the regular engineering academic advisers. Redshirt students generally also get advising from departmental advisers for their majors, but advising provided through the Redshirt program tends to be more holistic.

Faculty Mentoring

All Redshirt programs have a faculty mentor program.[4] The faculty mentors are recruited largely by word of mouth and by information circulated by email. The pairing between students and faculty is generally done along departmental lines, although students at some schools are also asked for their preferences. In some cases, attempts are made to pair students identifying as women with faculty who are also women. Faculty are encouraged to include their participation in this mentorship program in their academic personnel files, to be considered as part of their contributions to diversity and inclusion. Since students may be shy about asking for mentoring meetings, and faculty are busy and can overlook the need to set up meetings, the responsibility for initiating and scheduling the meetings is frequently taken by the Redshirt staff. Redshirt staff also facilitate events to encourage interaction and networking between students and mentors. Across the different programs, the number of required meetings between students and their faculty mentors ranges from one to five times per term. These sessions include discussion of study habits and grades, but also tend to also delve into questions of career choices, focus areas within the major, and how to get involved in research.

Two of the programs have set up a peer mentoring program, in which first-year students are matched with second-year (or older) students, and the remaining programs are intending to implement this. Though peer mentoring can involve a small cost (for example, providing gift cards to mentors so they can take mentees out for coffee), they facilitate both social support and a transfer of detailed experiential information to new students.

Support Services

Each campus has existing academic support services that complement Redshirt programming. For example, the BOLD Center at CU-B provides support for Redshirt and non-Redshirt students of color in engineering. UIUC and UCSD also have existing programs to support students from diverse backgrounds in engineering, which overlap somewhat with the Redshirt program and widen the circle of peers that Redshirt students interact with. Programs that reach beyond engineering, like LSAMP (the Louis Stokes Alliance for Minority Participation), Smart Start,

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[4] At CU-B, the faculty mentor program is currently available only to students receiving the S-STEM scholarship, not to all Redshirt students.

and CAMP (College Assistance for Migrants Program), also serve some Redshirt students. At UW and WSU, Redshirt students participate in supplemental workshops/first year courses that are similar to classes offered to all engineering students. There is some overlap between the academic support that Redshirt students receive from the Redshirt program and other support programs in which they participate. However, this is seen as a benefit, as many Redshirt students pass on the knowledge and wisdom they receive from the Redshirt program to students in other programs. Each Redshirt institution works closely with other support programs on campus to avoid redundancy.

Housing

The programs differ substantially in their approaches to student housing. At CU-B, the students are housed together in an "engineering quad" building. At UIUC, the students are housed together, although not in a building specifically for engineers. At UW, the students are housed together for 2 years. At the other three schools, the Redshirt students are not required to live together (although WSU encourages them to do so, and UCSD houses the Redshirt students together for the initial 5-week summer program). Having all Redshirt students living together definitely facilitates the delivery of academic support services as well as social activities. However at some schools there are institutional difficulties with providing joint housing. At UCSD, the division of the university into six residential colleges with six sets of general education requirements means that requiring students to be housed together would also remove their flexibility in choosing among the sets of general education requirements.

NSF-scholarship/Financial Aid

Each university distributes scholarships differently, with some schools providing scholarships only through NSF funds, while others provide scholarships through a combination of NSF funds and university funds.

CU-B's Redshirt Program provides a scholarship as long as students meet program participation and academic requirements. The Redshirt scholarship increases over five years from $3000 to $4000. Recently, for the fall 2017 cohort, the GPA requirement was changed to 2.7 from GPA requirements that increased from year to year for previous cohorts. Additionally, as an effort to reduce attrition, Redshirt students are offered an additional $500 each semester (the GoldShirt Academic Achievement Award) the following fall semester for earning a 3.3 GPA. A subset of students who have financial need also receive an additional S-STEM scholarship. S-STEM scholars received $2500 for the first 2 years, layered on top of their Redshirt scholarship.

In the UW STARS Program, scholarships are disbursed at the end of students' second year based on their successful completion of program requirements. Successful completion of program requirements includes earning a cumulative GPA of 3.00 by the end of both the first and second years and attaining at least a 2.5 in all graded courses and credit in credit/no-credit courses. Upon completion of the program all students are awarded a $2,000 scholarship. Students have the opportunity to earn an additional $500 by earning a 3.0 or higher in MATH 126. They can earn an additional $900 by earning a 3.0 or higher in PHYS 121 (if physics is required for the major)

or a 3.0 or higher in CHEM 152 (if physics is not required). Thus, students have the opportunity to earn $1,400 in scholarships on top of the guaranteed $2,000.

At WSU, no scholarships were provided to Redshirt students until the second year of the program, with $2000 awarded to students through $500 chunks based on performance in math courses. This support was provided through College of Engineering scholarship funds. Currently, WSU is able to provide $4000 to Redshirt students throughout their first two years (an average of $1000 a semester as long as the student maintains a 2.5 GPA). This support is provided solely through NSF. Once WSU students are close to their junior year, they are encouraged to seek out scholarships from their engineering or computer science department.

At BSU, scholarships are disbursed based on the individual's successful completion of their first two semesters in good standing with the Redshirt program. This means that they have fulfilled all requirements in the contract they sign when they join the program, which include meeting conditions for behavior and participation, meeting S-STEM eligibility criteria, continuing to pursue engineering, and earning a grade of B or higher in first year math and engineering courses. Students are eligible for up to $8000 in scholarship funding, based on financial need. Redshirt staff work with the financial aid office to determine the students' level of need.

Redshirt students at UIUC are offered a five-year renewable scholarship supplemented by funds from the Engineering Visionary Scholarship Fund. The supplemental funds allow them to offer an amount significantly higher than available through the NSF award. Specific amounts are based on financial need, and can be used for all items that feed into cost of attendance (tuition, room, board, books, fees, etc.).

Initial Evaluation Findings

The Redshirt in Engineering Consortium builds on the success of the Engineering GoldShirt at the University of Colorado Boulder and the STARS program at the University of Washington and Washington State University. The GoldShirt Program has contributed to improved rates of retention among students who enter college underprepared for engineering - of students beginning the program in 2014, 89% returned to engineering in fall of 2015 [3]. The WA STARS program has also been extremely successful at retaining retaining students in engineering - 82% of WSU STARS students and 99% of UW STARS students from the first four cohorts who completed a full year of the program returned to engineering in fall of their second year [4].

Assessment of the Redshirt in Engineering Consortium will include a student-level analysis of the academic performance and retention of Redshirt students across all six universities. We will also analyze surveys comparing change over time in engineering identity, commitment to engineering, confidence in abilities, and perceived level of preparation for engineering coursework among Redshirt students and their peers who have not taken part in the program. While longitudinal survey results and student-level data are not yet available for all six consortium institutions, baseline survey results for students beginning in Fall 2017 indicate that Redshirt institutions are reaching the target population: students highly motivated, confident in their abilities, and committed to engineering, but underprepared for engineering curriculum.

Table 4 Summary of Program Elements at Redshirt Institutions

	Curriculum	Summer programming	Advising	STEM diversity center	Students housed together	Scholarships
CU-B	1-credit per semester course, focus on self-management, leadership & professionalism, introductions to departments and resources. Individual course plan developed based on placement.	2-week program with academic workshops, community-building activities, and advising/registration	Redshirt-specific Engineering advisor, program director, assistant directors	Yes	Yes	$3000-$4000 each year for 5 years, plus additional $2500 in first 2 years for S-STEM students and $500/semester for earning a 3.3 GPA
UW	1 credit/quarter seminar, focus on study skills, wellness, time management, faculty engagement, and engineering careers. Structured course plan with mandatory calc & chem problem solving workshops	Summer homework assigned, additional programming during transition week.	Redshirt-specific academic counselors	No	Yes (2 years)	$2000 at end of second year if student receives a 3.0 GPA both years. Additional $1400 available for doing well in select courses
WSU	2-credit seminar first semester, 1-credit second semester, focus on study skills, career identity, and professional development, mandatory applied math course, mandatory problem solving sessions	4 days, co-sponsored with LSAMP	Redshirt-specific engineering advisor	No	Encouraged but not required to live in same residence hall	$1000/semester for 2 years if student earns a 2.5 GPA
BSU	2-credit per semester course sequence, focus on academic support, study skills content, and introduction to engineering. Required to take Calc I in first year.	2.5 day bridge, co-sponsored with LSAMP. Additional 3 day outdoor trip available to other incoming STEM students	Program administrator and professional advisors in College of Engineering	Yes	No	Up to $8000, based on financial need and contingent on meeting program requirements. NSF funded
UCSD	Required not-for-credit weekly discussion groups.	5 weeks (offered to all first year engineering students)	Program administrator and faculty mentors	Yes	No, aside from summer program	Based on unmet need
UIUC	For-credit course, focus on academic support, study skills, and engineering projects. Also required to take writing, chem, physics, math.	2-3 day early move-in program and extended registration event available to other incoming students	Assistant dean who oversees the program, support from program administrator	No	Yes	5-year renewable scholarship based on need, supplemented by college funds

Redshirt students rate themselves as lower in preparation and ability in math and science than non-Redshirt students, but higher in perceptions of self-confidence and most measures of identity as an engineer and sense of belonging in engineering.

The Redshirt in Engineering evaluation efforts also include an observation of consortium-level collaboration. There are two primary ways the Consortium works together as a team to strengthen their individual programs: bi-weekly conference calls and information sharing via a shared Google Drive. In its first two years, the consortium has held 34 bi-weekly conference calls. These calls have been particularly helpful for SSPs in developing and implementing their programs, but have also helped ERIs think through ways to improve their programming and begin new efforts, such as the faculty mentoring component. In the second year of the consortium, these calls have become more topic-driven - providing program staff with a forum to examine specific elements of the Redshirt model and work through challenges. These calls tend to be very well-attended, with most institutions being present on each call. The consortium uses its shared Google Drive to exchange best practices and centralize resources. While some programs use this more than others, SSPs appreciate having access to things like templates for applications and program guidelines.

Discussion and Conclusions

While the Redshirt in engineering consortium is only in its second year, with SSPs currently conducting their first year of student programming, the implementation of the program across six institutions suggests that the Redshirt model can provide strong support for students in a variety of contexts. This type of program can benefit institutions that are having a hard time reaching aspirations for diversity in general. Redshirt programs are most suitable for schools where the College of Engineering has significantly lower percentages of Pell-eligible students entering and being retained compared to the rest of the University -- this indicates a need for better mechanisms to support highly motivated but underprepared students interested in pursuing engineering.

There are several conditions that serve as the program's backbone and are key to its success regardless of context. First, financial commitment from the institution (university administrators and college deans) is important for institutionalizing a Redshirt program, particularly to fund staff positions for program administrators and instructors, and for the programming needed to support students. Furthermore, scholarships are essential in attracting students to and retaining students in engineering. Since this program is focused on improving outcomes for students from low-income backgrounds, scholarship funding is central to its mission and its success.

Also, curricular support is paramount; departments, faculty and staff must be willing to provide resources to deliver instruction, assess the courses, and continue to improve courses for Redshirt students. To implement a Redshirt program, physical space is necessary; this includes instructional space (classrooms), study space, residential hall space, maker spaces, and space for social events. While the specific elements of Redshirt curricula vary somewhat from school to school, all programs have courses designed with the needs of their students in mind. A targeted first-year curriculum is an essential component of the Redshirt model -- a well-rounded curriculum that provides engineering fundamentals, professional development/career

preparation, and study skills is necessary for actualizing the potential of underprepared students who are part of the program. A specialized first year curriculum works best when existing academic/student support services that compliment Redshirt programming are available.

Another important component of the Redshirt model across institutions is Summer Bridge/pre-matriculation programming. Providing students an opportunity to connect with their peers prior to the school year helps to ease the transition to college. While timing and length of Summer Bridge varies across the consortium, it is consistent in its focus on familiarizing students with the university climate and norms, academic advising and coaching, fall course placement and scheduling, community building, and introduction to engineering practices.

Overall, the implementation of the Redshirt program across these six institutions provides promising evidence of the malleability of the Redshirt model. While impacts of Redshirt participation at the three SSPs are not yet available, Redshirt programs at the three ERIs have been highly successful. Ongoing evaluation of the Redshirt consortium will track the success of programs at the SSPs. Together, successful launch of six Redshirt programs and strong evidence of its success at three universities suggest that similar programs geared toward improving the retention of underprepared students from low-income backgrounds could readily be implemented elsewhere.

References

[1] M. Ohland, M. Orr, V. Lundy-Wagner, C. Veenstra, and R.A. Long. "Viewing access and persistence in engineering through a socioeconomic lens, in Engineering and Social Justice in the University and Beyond, 2012.

[2] T.D. Ennis, 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," 2011 ASEE Annual Conference & Exposition, pp. 22.754.1-22.754.15, 2011.

[3] E. A. Riskin et al. "Collaborative Research: The Redshirt in Engineering Consortium," Grant Proposal to the National Science Foundation, 2015.

[4] E. Knaphus-Soran, J. Branstad. "2017 Redshirt in Engineering Consortium: Year 1 Evaluation Report," Center for Evaluation and Research for STEM Equity, University of Washington, August 2017.