Board # 24 : Sustainable bridges from campus to campus: Preliminary results from Cohort 1

Dr. Amy L Freeman, Pennsylvania State University, University Park

Dr. Amy L. Freeman holds a Master of Science degree in Engineering and a Ph.D. in Workforce Education. She has a been a practitioner of engineering education for almost two decades and is a member of several organizations and networks that support her research interest: access and inclusion to STEM education. Dr. Freeman is currently serving as Assistant Dean in the College of Engineering at The Pennsylvania State University and continues to provide administrative direction for the Center for Engineering Outreach and Inclusion through the cultivation of partnerships with corporations, alumni, university constituents and organizational alliances.

Dr. Pradip K Bandyopadhyay, Penn State University (Berks Campus)
Mark Johnson, Pennsylvania State University
Dr. Mikhail Kagan
Dr. Ann Marie Schmiedekamp
Dr. Peter J. Shull, Pennsylvania State University, Altoona Campus

Dr. Peter J. Shull is an associate professor of engineering at Penn State University. He received his undergraduate degree from Bucknell University in mechanical engineering and his graduate degrees from The Johns Hopkins University in engineering science. Dr. Shull's research has two main foci—nondestructive evaluation methods as applied to process control (NDE) and pedagogical methodology. Dr. Shull's pedagogical efforts include meta-cognitive strategy learning to improve student academic success, an interest in women's issues within the engineering environment, integrated, experiential techniques to improve engineering students' social emotional development as applied to teamwork and communication, and program assessment methods that minimize stakeholders' efforts while maximizing the effectiveness of the measurement tool.

Dr. Catherine Cohan, The Pennsylvania State University

Catherine Cohan holds a Ph.D. in Clinical Psychology and has been a research psychologist for over 20 years. Her areas of expertise include engineering education, retention of underrepresented students, measurement, and assessment. She is currently a Research Associate on the Sustainable Bridges NSF IUSE project (Amy Freeman, PI). Previously, she was the project coordinator the the Toys'n MORE NSF STEP project (Renata Engel, PI).

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(NSF IUSE #1525367)

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Abstract

The impetus for the *Sustainable Bridges from Campus to Campus* study is to address the urgent need to expand the pool of Science, Technology, Engineering, and Math (STEM) graduates, especially African American, Native American, and Hispanic students. Long-term improvements in the pipeline of a diverse STEM workforce start with sustaining effective bridge programs that can produce more Engineering baccalaureates. To improve retention in Engineering, this study will conduct academic enrichment programs for racially underrepresented Engineering students at three points in their career at the Penn State—entering freshmen, rising sophomores, and rising juniors. The goals of the study are to (a) increase retention in Engineering among racially underrepresented students in the Penn State system, (b) develop long-term sustainability plans for these enrichment programs, and (c) compare retention rates in Engineering depending on whether students attended a summer academic enhancement program at their local campus or at a different campus and whether they transfer between campuses within the University system. The guiding framework for the summer bridge programs is the Minority Engineering Program (MEP) Model. The study started in January 2016. During summer 2016, we conducted 5 summer bridge programs with the first cohort of freshmen across 4 campuses in the Penn State system. The students in Cohort 1 are currently in the fall semester of their freshmen year. At this early point in the study, our paper can present an overview of the project as well as reporting preliminary data on Cohort 1 after their first semester (Fall 2016). Academic performance data after the first semester include grade point average, math course grades, academic social support, and whether they are retained at the University.

Overview of the Project Goals and Objectives

The current research seeks to accomplish three goals: (1) Increase retention in Engineering among racially underrepresented engineering students by extending a successful summer bridge model and transition program to regional campuses in the Penn State system, (2) Develop long-term sustainability plans for these programs, and (3) Compare the efficacy of three different bridge models. The **primary outcome measure is retention in baccalaureate Engineering majors following the Entrance to Major process at the beginning of the junior year** (i.e., enrollment in a specific major). Secondary outcome measures are retention in STEM majors and retention at the University. This research is generously funded by the National Science Foundation (NSF IUSE #1525367). Please note that any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

The **Intellectual Merit** of this research is two-fold: examine variation in Engineering retention for three models of bridge programs and produce a series of workshops on Engineering bridge leadership, funding, and sustainability strategies for Engineering summer bridge programs. The goal of each math-intensive bridge program is to provide academic, social, and geographic exposure for groups of 15 to 30 incoming students. The three models differ by students' transfer status (native or transfer student) and bridge location (assigned campus or campus different from assigned campus). For Model 1, incoming students at the flagship University Park campus attend the summer bridge at that campus (~25 students) and do not make a campus transition. For Model 2, incoming students (~30 students) from approximately 16 regional campuses attend a summer bridge at the University Park campus, complete the first two years at their regional campus, and transition to University Park as juniors. For Model 3, incoming students at 3 regional campuses attend a summer bridge at their own campus (~15 students per campus), complete the first two years at that campus, and then transition to University Park as juniors. The three models are applied to five bridges. As part of a comprehensive program, all participants will also be offered professional development seminars during freshman year, an additional math-intensive 4-week summer bridge for rising sophomores (Calculus II, Differential Equations, Physics II), and transition programming to assist in acclimating to the University Park campus for rising juniors. Bridge programs are successful for only as long as they exist. Sustainability of summer bridge programs is a significant challenge because of their annual expense and the ongoing need to raise university, industry or external funds to support them. We propose to develop a learning community among the regional campus Engineering bridge leaders and conduct a series of workshops on fund-raising and sustainability strategies for the 3 regional campuses with new summer bridge programs for incoming underrepresented Engineering students.

The **Broader Impact** of increasing the retention of students in baccalaureate Engineering majors is derived from the urgent need to expand the pool of STEM graduates, especially racially underrepresented students (African American, Hispanic, Native American). That need is documented in a series of monographs by major government and scientific councils. Penn State is comprised of the flagship University Park campus and 19 regional undergraduate campuses. About 60% of Penn State students opt for the “2+2 plan” by completing the first two years of their education at a regional campus and then transitioning to the University Park campus for the last two years. For over 20 years, Penn State has offered a traditional Engineering bridge program for underrepresented students who start their education at the University Park campus. For 11 years, a second Engineering bridge program at the University Park campus has served underrepresented Engineering students who will start their Penn State education at one of 19 regional undergraduate campuses. Historically, the regional campuses have not offered local summer bridge programs. Based on preliminary success starting STEM bridge programs with predominantly white, first generation populations at 3 regional campuses (NSF-STEP Toys’n MORE project #0756992), the research implements 3 new bridge programs at the regional campuses with the largest populations of underrepresented Engineering students in the Penn State system. Because these regional campuses have not had summer bridge programs, they do not have a sustainability plan or bridge program staff. Long-term improvements in the pipeline of a diverse STEM workforce starts with sustaining effective bridge programs that can produce more Engineering baccalaureates. Sustainability starts with understanding the funding process at each campus.

National Retention in Engineering

The broad rationale for this proposal is derived from the national need to retain and graduate more baccalaureate Engineering students, especially underrepresented students. To remain competitive in the global marketplace, the President’s Council on Jobs and

Competitiveness (2011) called on American universities and employers to collaborate to graduate 10,000 more students with a baccalaureate degree in Engineering *each year*. To meet this goal, American colleges and universities will need to double the annual increases of the past several years by adding 5000 to 6000 more engineering graduates each year. Where will those successful engineering students come from? There are two sources. The incoming pipeline of Engineering students from high school can be increased or student retention in college Engineering programs can be increased. Research on the pipeline for Science and Engineering students is rather discouraging, with 1 to 2.5% of middle and high school students showing interest in STEM professions (Mau, 2003; Tyson, Lee, Borman & Hanson, 2007).

Increasing the retention of Engineering students who already have an expressed interest is the focus of this proposal to increase the number of Engineering graduates. Studies with large samples of Engineering students show that approximately 60% of college students who intend to major in Engineering do complete an Engineering degree (National Science Board, 2012; Ohland et al., 2008). One way to make strides toward achieving the goal of 10,000 Engineering students is to boost retention among racially underrepresented students. They enter STEM majors in college at similar rates as white and Asian American students, but have much higher rates of attrition (American Council on Education, 2005). Racially underrepresented students earn approximately 12% of the baccalaureate degrees in Engineering, less than half of their representation in the population (28%; National Science Foundation, 2013). The problem of low numbers of racially underrepresented individuals in STEM fields was described as "urgent" by the Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline (2011).

Engineering at Penn State

An overview of the structure of Penn State and the process for Engineering students is important for understanding the research. Penn State is comprised of 19 regional undergraduate campuses across the Commonwealth that offer 2- and 4-year undergraduate degrees or 2-year curriculums which tie into terminal programs at other Penn State locations. Penn State's College of Engineering at University Park (the flagship campus, 46,000 students), offers a selection of 13 Engineering majors (including computer engineering and computer science) and has one of the largest Engineering colleges in the United States (Yoder, 2012). With a Fall 2013 undergraduate Engineering enrollment of 9,941 across 20 campuses, Penn State offers the largest variety of Engineering degrees in the U.S., primarily through the College of Engineering at University Park, with newer programs evolving at several regional campuses. One reason to focus on racially underrepresented Engineering students at the regional campuses, in addition to the University Park campus, is because over half of incoming racially underrepresented Engineering students begin at a regional campus.

The overall 6-year graduation rate in the Penn State College of Engineering among students who begin at University Park (55%) is similar to the national average. However, it is more difficult to retain students who start at regional locations and transfer to University Park in the junior year. Overall, their 6-year graduation rate in Engineering is 32%. A great percentage of these regional campus students are first-generation students, women, racially underrepresented students, and students with differences in ability. The University Park campus has several retention programs that are designed to enhance the first-year experience and retain women and racially underrepresented students who start at this large campus. But there are fewer resources for those who start at the regional campuses.

The Sustainable Bridges project seeks to apply and compare bridge solutions to first- and second-year populations who participate in one of five bridge programs depending on the campus where they start their Penn State education. The guiding framework for these bridge programs is the Minority Engineering Program (MEP) Model (e.g., Astin & Astin, 1992; May & Chubin, 2003). The MEP Model strives to increase student academic achievement by increasing student engagement through activities such as formal freshmen orientation, clustering students in core curriculum, and study groups.

The regional campuses that will offer new bridge programs include Penn State Abington, Altoona, and Berks. Penn State Abington is a commuter campus located 15 miles north of Philadelphia with 3,600 students. Penn State Altoona is a residential campus in central Pennsylvania 45 miles from the University Park campus with 3,800 students. Penn State Berks is a residential campus located in Reading, 55 miles northwest of Philadelphia with 2,700 students. Each institution's bridge program will address the unique audience and culture it serves at that campus location. Across the Penn State regional undergraduate campuses, these three campuses have the largest populations of racially underrepresented Engineering students (45% of the total). Table 1 shows the numbers of racially underrepresented Engineering students in the Penn State system.

Table 1. Racially Underrepresented Engineering Students in the Penn State System

Campus	Total Students in Engineering	Racially Underrepresented Students in Engineering	
		#	%
Abington	257	41	16
Altoona	486	37	8
Berks	391	48	12
All 19 Regional Campuses	2721	280	10
University Park	7220	429	6

The Entrance to Major Process in Engineering at Penn State

To understand the timing of the interventions and the retention data presented in this report, it is important to understand the process of being admitted to a major at Penn State. When students enter the Penn State system, they are assigned to a college based on their *intended* major. Students enroll as an Engineering *pre*-major for their first four semesters. During the fourth semester, typically the spring semester of the sophomore year, students apply to be admitted into a specific major. To become an Engineering major, students must typically complete 6 required core courses with a grade a "C" or better during the first four semesters, including Calculus I, Calculus II, Differential Equations, Chemistry I, Physics I, and Physics II. In the spring semester of the sophomore year, undergraduates complete the Entrance to Major process whereby they formally apply to a specific Engineering major in the College of Engineering (e.g., aerospace, chemical, mechanical). Their overall grade point average after three semesters determines their eligibility for an Engineering major. Students may use the spring semester of their sophomore year to complete the 6 required Entrance to Major courses.

Eleven out of 13 Engineering majors at Penn State have enrollment controls with GPA requirements of 3.0 or higher to qualify for the Entrance to Major. Students who complete the 6 required courses with a "C" or better *and* have GPAs above the 3.0 cut-off (or as determined by each Engineering department), are officially admitted into an Engineering major by the end of their sophomore year. Students with GPAs below the cut-offs established by each department are only admitted in descending GPA order based on space availability. If not admitted to an Engineering major, these students can remain at the university but must choose another major or leave to pursue an Engineering degree elsewhere. Therefore, retention data regarding students' majors in the freshman and sophomore years reflect their pre-major status or *intentions*. Retention data regarding students' junior year majors reflect the major they were *admitted* into after going through the Entrance to Major process.

Benchmarks for Retention

The greatest loss of students in Engineering in the Penn State system comes at the point when students make the transition from sophomore to junior year, after the Entrance to Major process and formally entering a specific major. Table 2 shows the retention rates in Engineering among all Engineering students and racially underrepresented Engineering students who start at either the University Park campus or a regional campus. Retention among sophomores before going through the Entrance to Major process is fairly comparable. The impetus for the Sustainable Bridges proposal is the significant and dramatic loss in retention that comes among juniors after the Entrance to Major, especially for underrepresented Engineering students and those at regional campuses (see Table 2). The other important yardstick for retention in Engineering is the 6-year graduation rate. That rate is also very low for underrepresented Engineering students, especially those who start at regional campuses. The broad goal of the work is to improve the retention in Engineering as juniors so that there is a higher 6-year graduation rate for racially underrepresented Engineering students.

To judge the retention success of the Sustainable Bridges project, our goal is to improve junior-year retention among racially underrepresented Engineering students by 20 percentage points. We selected that goal for two reasons. First, the recently concluded NSF-funded Toys'n MORE project (described below) achieved a *15 percentage point improvement* in junior-year Engineering retention among the sample of primarily white regional campus students who participated in new regional campus STEM bridges for incoming students. Whereas the Toys'n MORE project did not offer follow-up support after the incoming summer bridges, the Sustainable Bridges proposal includes *ongoing* support into the junior year. We expect that additional support will help to retain more racially underrepresented Engineering students. Second, the Penn State College of Engineering strives to meet the national benchmark for diversity in Engineering set by the American Society for Engineering Education (ASEE) by awarding baccalaureate Engineering degrees to at least 130 African American and Hispanic students annually. In 2013, Penn State awarded 74 baccalaureate Engineering degrees to racially underrepresented students. Therefore, our long-term goal is to achieve a net gain of at least 56 Engineering degrees to racially underrepresented undergraduates. If we can improve our junior-year retention for University Park racially underrepresented Engineering students from 43% to 63% (net gain of 86 students, from Table 1: 429 x .63) and our junior-year retention for Abington, Altoona and Berks racially underrepresented Engineering students from 32% to 52% (net gain of 26 students, from Table 1: 126 x .52), then we would be on track to achieve the goal of graduating 130 racially underrepresented Engineers, after accounting for the attrition between junior year and the 6-year graduation point.

Table 2. Undergraduate Retention Rates in Engineering at Penn State Based on Starting Location

	Starting at University Park			**Starting at a Regional Campus**		
Population	**Sophomore Retention (Pre-ETM)**	**Junior Retention (Post-ETM)**	**6-Year Graduation**	**Sophomore Retention (Pre-ETM)**	**Junior Retention (Post-ETM)**	**6-Year Graduation**
All Engineering Students	79%	62%	55%	81%	42%	32%
Underrepresented Engineering Students	75%	43%	35%	75%	32%	12%

Note: ETM = Entrance to Major.

Challenges with Retention

Penn State's challenges with retention are not unique. There is extensive research that identifies the transition from two-year to four-year campuses as a barrier to college graduation. Research also indicates that for STEM degrees, math preparation is a key component to success. The lack of preparation is often associated with economically disadvantaged communities and a lack of educational resources in the student's primary and secondary school community (Freeman, 2009). Academic interventions are critical for these populations to obtain an Engineering degree. At Penn State's regional campuses, the combination of these factors result in low retention and graduation rates for those seeking to acquire a degree in Engineering.

Research on the retention of transitioning students. Penn State's structure is such that many students begin the first two years at one of the regional campuses and relocate in the junior year to complete the Engineering degree at University Park. Over half of racially underrepresented Engineering students start at regional campuses. Students starting at these campuses are also more likely to be first-generation college students, economically disadvantaged, and entering Engineering at the pre-Calculus level. The statistics in Table 2 show an overall 6-year Engineering graduation rate of 55% for students starting at University Park. But it is 32% for students who start at regional campuses, and lower for racially underrepresented students. One of the primary differences between these two groups is the transition adjustment that is borne by students who do not start at University Park. The 2010 report *The Penn State University Task Force on Students in Transition* identified several causes of transitional problems including lack of housing information, academic support, and preparation for the social adjustment at a much larger campus of 46,000 students. Students who transition to a second campus leave behind a support system that took two years to establish and must navigate a new system.

The challenges of Penn State students who participate in the “2+2” model with the first two years at a regional campus and the second two years at another Penn State location to finish their degree are similar to some of the challenges of community college students. Since their creation, regional and community colleges have played a significant role in providing access to higher education for many Americans (Cohen & Brawer, 2003). Community colleges have disproportionately been the primary access point to higher education for underrepresented groups, such as multicultural, female, first-generation, nontraditional, and low-income students. Factors contributing to the selection of community colleges as the access point to higher education include affordability and less competitive admissions requirements (Bailey & Morest, 2006). Extensive research sheds light on low graduation rates of transfer students (Graham & Hughes, 1994). Nationally, 80% of first-year college students at community colleges express an initial desire to transfer to a four-year institution. Out of this initial group, only 40% achieve their desired goal of even being eligible to transfer. Of the transfer-eligible students, only 10% eventually transfer to a four-year institution (Berger & Malaney, 2003). Finally, community college transfer students have a lower likelihood of graduation than students who start at four-year institutions (National Center for Education Statistics, 2008).

Tinto performed a number of studies from 1975 through 2008 on the effectiveness of the learning communities when applied to a wide range of students including those who were new to the college environment (Tinto, 1975; Tinto, 2007; Tinto & Love, 1995). The learning community principle is founded on the idea that students and faculty sharing multiple classes and experiences will assist each other in building positive academic strategies and social relationships. Tinto applied the learning community philosophy to targeted student populations that were underprepared and from low income backgrounds, and found to be equally effective. In addition, precollege academic preparation was also found to increase persistence of students (Engstrom & Tinto, 2008; Tinto, 2007). The learning community principle is a core feature of bridge programs to ease some of the adjustment problems.

Research on math preparation and retention. Grandy (1995) showed that students who do not do well in high school math may not continue in technical majors if retention support systems are not available. Retention support should include community building, encouragement to develop math skills, mentoring and networking with other students in technical fields, all features of bridge programs. Guthrie (1992) found that intensive math review helped students with low standardized math scores to pass college math courses and graduate with bachelor degrees. The summer bridge has proven to be an effective retention tool for incoming students in technical fields (e.g., Lang, 2001; Schrader & Brown, 2008). A typical summer bridge is a 4- to 6-week residential program where incoming first-year STEM students review math and other entry level courses. It resembles the college environment where students are exposed to technical skills needed to succeed in a STEM major. Best practices for retention in STEM fields include summer programs, research experiences, professional development activities, academic support, social integration, and mentoring (Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline, 2011). Comprehensive programs that support underrepresented minorities in undergraduate STEM programs with ongoing and multifaceted support, such as the University of Maryland, Baltimore County Meyerhoff Scholars Program, have demonstrated success in graduating more underrepresented STEM majors (e.g., Hrabowski & Maton, 1995; Maton, Hrabowski, & Schmitt, 2000). The college graduation rate is 90% for that program (Maton et al., 2000). One factor that may contribute to the success of these comprehensive programs is greater student involvement, such as more time committed to studying, more time on campus, and more interaction with faculty and students, which all improve the learning environment (Astin, 1985).

The Current Research

Based on the need to graduate more underrepresented Engineers, the literature, and results of the Toys'n MORE project, the Sustainable Bridges project seeks to address three **research questions**.

RQ1: Can the **retention gap** in Engineering between underrepresented transfer students and native students (those who stay at the same institution for four years) be reduced/eliminated by additional support through the junior year for regional campus students who plan transfer to University Park?
RQ2: What is the size and quality of the first year **academic social network** (i.e., campus peers, faculty, and staff) for (a) racially underrepresented University Park students who bridge at University Park, (b) regional campus students who bridge at University Park and return to their local campus, and (c) regional campus students who bridge at their local campus?
RQ3: What is the **relative contribution** of academic success (e.g., course grades, GPA) and the size of the academic social network to retention in Engineering in the junior year for the three groups?

Math-intensive summer bridges are among the most successful STEM retention tools utilized in the nation because they curb the attrition that occurs in the first year at a new institution. The bridges will include the following elements that must be present for a successful summer STEM bridge.

1. **Math-Intensive Curriculum**
   Math skills are critical for students entering STEM fields. Students are not always aware of how their high school skills measure up to those required in college. During a summer bridge program, students establish peer teams and take math review courses (30 hours minimum) to prepare them to enter the fall semester with a realistic view of the work required in college.
2. **Application of Engineering Concepts**
   Successful summer bridges include hands-on or observed application of Engineering concepts. This includes project building, site visits to technical firms, and research projects.
3. **Access to Resources and Information**
   This includes faculty, advisory, and financial support that are readily accessible. When students interact with faculty and other university support staff, they are creating a network of resource information and access to new strategies for college success. When

students are introduced to these areas of support early on, they are more likely to utilize these options if problems arise.

4. **Cohort Community**
   Students develop friendships based on shared experiences and goals. These supportive group relationships continue throughout the college experience.
5. **Ongoing Support**
   Once the summer bridge program ends, follow-up includes mentoring and retention programming through the first year.

The current study implements five bridges encompassing three models that differ by students' transfer status (native or transfer student) and bridge location (assigned campus or campus different from assigned campus). The following are details about the bridge programs with different campus audiences. We propose to implement each bridge program three times to have a sufficient sample size to detect significant results and to follow each cohort through junior year during a five-year funding period.

Campus Location and Population: Penn State Abington
Bridge Program: Abington First Year Success in Engineering Program (AFYSEP)

AFYSEP is a 6-week non-residential summer bridge program with the goal of offering an opportunity for underrepresented and first-generation college students to boost their math, study and collaborative skills before the first fall semester. One third of the campus population identifies as racial minorities. Penn State Abington has been successful in recruiting underrepresented students for another summer math prep course. It is expected that students who successfully complete this program will be ready to start with Calculus I in the Fall or Spring of the first year and be on track with Engineering major requirements. The program will be offered to commuter students four days per week from 10am to 3pm. The target group would be identified by reviewing high school GPA and SAT scores and ALEKS placement scores, if available. These are students who show an interest in the Engineering major but who would place in Algebra II, Trigonometry or even Algebra I, and delay the students in the six required courses for the Engineering pre-major.

The program will employ math instructors and trained peer tutors. The math classes will be project driven with skill-building activities that have been developed to promote problem solving skills and creative thinking. For example, graphing of mathematical functions would be reinforced by a project to construct a picture of a house (for linear functions) or a face (for higher-order functions). A creative competition among students for the best diagram results in lively activity and demonstrated understanding of graphing of linear and higher order functions. Another team project provides an introduction to physical measurement. Students use video cameras and Logger Pro software to discover the equations of motion for objects that are accelerating due to gravity. This hands-on project is applied to parabolic trajectories as well as to the basic trigonometric functions describing by a rolling wheel. Students gain experience with equipment, software and concepts which will be used later in their physics courses during the first year. A student's success in introductory Chemistry, Physics and Engineering courses is highly dependent on their skill in solving word problems. This skill is addressed in our math curriculum by teaching linear programming with two variables. This approach to problem solving in recent pilot classes has resulted in a student success rate of over 90% on solving typical word problems.

In an effort to ease the adjustment to the university, students receive an orientation to student life and study skills from the admissions team. Student performance in AFYSEP will be graded by university standards (e.g. performance, correctness completeness) so that they are not surprised by the expectations and standards of the University. Lunch will be provided each of the four days on campus to encourage the students to form a cohort community. Field trips to nearby Engineering companies (e.g., NASTAR) will be included and a stipend of $250 will be rewarded upon successful completion of the program to offset the income that might have been earned by some students who gave up working hours during this program. The cohort of students from this program will be followed in the first year and we plan to involve these students in Abington's first-year experience program. The peer tutors will maintain a relationship with the cohort throughout the first year. Students in the cohort will be invited to special events involving speakers on Science and Engineering and they will be encouraged to become active in the Engineering club and our undergraduate research program. At the completion of the first year, some students in the cohort will be invited to be peer tutors in the next year's summer bridge program.

Campus Location and Population: Penn State Altoona
Bridge Program: Engineering Enhancement through Early Engagement *(e^4)*

The Engineering Enhancement through Early Engagement *(e^4)* program is a four-week residential bridge program for incoming underrepresented Engineering students. The goal is to enroll 15 students per summer. After being accepted for admission, students who are racially underrepresented will be sent invitation letters. Morning sessions will consist of math, physics, chemistry, and English review. Students will engage in a minimum of 30 hours of math review. Students will be divided into two groups focused on Calculus I or pre-Calculus, depending on math placement scores. Math instruction will be enhanced by our *Math Through the Real World,* which utilizes everyday applications to deepen student understanding. Afternoon sessions will include hands-on activities for the students to apply math and physics to Engineering concepts, assisted by peer mentors. Other activities will include tours of the campus library, computer labs, and Learning Center and a visit to a local company that employs Engineers. Peer mentors will engage the students during the weekends in fun activities. During the first year, students will participate in a bi-weekly seminar on college survival skills and professional development.

Campus Location and Population: Penn State Berks
Bridge Program: *Engineering Summer Enhancement through Science Education (ESESE)*

The goal of the ESESE program at Penn State Berks is to create a support system and provide academic enhancement for incoming underrepresented Engineering students from diverse socio-economic and cultural backgrounds to ensure success in college. The ESESE program is a four-week summer bridge program designed specifically for first-year students from populations who are underrepresented in Engineering, including women, first-generation students, and racially underrepresented student. ESESE is a fully residential four-week summer program for 20 incoming Engineering students. Intense exposure to mathematics as well as basic skill building hands-on activities typical of the Engineering disciplines form the curricular backbone of the program. A math faculty member exclusively trained to teach first-year

Engineering and Science students will teach math at the pre-Calculus level, with the learning outcome of preparing the students for the college-level first-year Calculus courses. The course will also prepare those students placed in pre-Calculus Algebra/Trigonometry courses. The course will immerse the students in activities to enhance their problem-solving skills in Math and Engineering through academic activities.

In addition to close daily interaction with the faculty, participants will be exposed to cooperative learning under the supervision of upper-class Engineering and Science peer mentors. Guest lectures and hands-on activities in Physics, Chemistry, Biology, and Engineering will demonstrate the application of Calculus in the STEM fields. To support academic success and cohort building, the following will round out the bridge curriculum: study skills, time management, career planning, an introduction to campus resources (e.g., faculty and support staff, the Learning Center, Library, Career Services, Office of Advising, ITS), site visits to local Engineering firms, weekend recreational activities. Living together in the dormitories during the summer will facilitate developing bonds of support and friendship for an effective transition to the first year. For continuity during the academic year, these students will be placed in the same Engineering Freshmen Year Seminar sections in the first semester. Following the completion of the grant, it is expected that preparing and exposing the students to multiple bridge programs during their first two years of the degree program will lead to improved retention and graduation of the Engineering students. The college will have resources available to sustain the approach following completion of the grant. The broad goal is the potential enrichment of diversity in the nation's engineering workforce.

Campus Location: University Park
Campus Population: The 16 regional Penn State campuses without local Engineering bridge programs
Bridge Program: Academic Summer Enhancement (ASE)

The Academic Summer Enhancement (ASE) Program is a math-intensive, residential, four-week orientation and math review of pre-calculus concepts located at University Park. It targets African American, Native and Hispanic students from Penn State regional campuses who wish to major in Engineering but who are not prepared for first-year college calculus. ASE participants review pre-Calculus, entry level Chemistry, and English to ensure success in first-year courses they will take in the fall. Students also receive professional development training, several university technical tours, and a field trip to a corporate location.

ASE was originally implemented in 2003 because the retention rate of underrepresented students in Engineering was 13% in the junior year. When asked, those who did arrive indicated that they had never been to University Park until they became juniors and changed campuses in the fall. The adjustment was daunting. ASE created an environment where students could experience the University Park academic culture, and have a sense of destination and purpose when returning to the regional campus. The 5-year graduation rate for ASE participants in 2010 was 64%, with 42% graduating in Engineering at University Park. Students who will start Engineering at any of the 16 regional campuses other than Abington, Altoona, and Berks will be encouraged to attend ASE at University Park.

Regional campus students who attend the ASE program at University Park build good relationships. However, typically only one to two students from a particular regional campus attend the ASE program at the University Park campus. Thus, when the ASE bridge students disperse across the state to start the fall semester at their regional campuses, their academic social network decreases. Compared to a bridge program at their local campus, a limitation of the ASE program at University Park is that when the regional campus participants arrive at their local campus in the fall they have not developed a familiarity with the campus or social bonds with as many students, faculty, or staff.

In the past, there has not been follow-up of the ASE students during the academic year. The Sustaining Bridges program seeks to bolster the social bonds formed during ASE with students across many regional campuses by the implementation of an interactive communication program during the freshmen year. ***Engineering Night Live*** and ***on the Go*** is a virtual and/or mobile program. The intended objective is to conduct early academic and social intervention for potential incoming transfer students at any of Penn State's 19 regional undergraduate campuses. The goal of this outreach is to provide the targeted students with a venue for workshops and discussion forums that will give them an early and successful predisposition for transfer to the University Park campus. The virtual forum will also provide early introduction of academic expectations and resources, social engagement, and mentoring from peers already enrolled at the University Park campus. Specific forums, panels and workshops on academic planning, Entrance to Major, time management, housing, and academic support will be offered using virtual media such as Adobe Connect, Google Chat and Skype.

Campus Location and Population: University Park
Bridge Program: PreFirst Year in Engineering and Science Scholars program (PreF)

To improve retention among incoming underrepresented Engineering students starting at the University Park campus, the PreFirst Year in Engineering and Science Scholars program has been offered for over 20 years. It is a 6-week residential bridge which reviews Calculus, Physics and Chemistry for approximately 30 incoming freshmen. Students also receive information on professional development, academic advising and campus resources. Students exit that program to continue the year living in a STEM residence hall and working with mentors. In 2010, the 5-year graduation rate for those students was at 83%, with 65% graduating in Engineering. That rate is higher than the overall graduation rate of majority engineering students (55%) students at Penn State University Park. Among the African American, Hispanic and Native American students who start at University Park, a high proportion are first-generation college students and enter college with inadequate math preparation. Math-intensive intervention makes a difference.

Method

Participants

Participants were 81 incoming undergraduate students in Engineering or Science at Penn State. Table 3 shows the demographic characteristics of the students for the whole sample and broken down by each of the five summer bridge programs. Seventy percent of the sample was male (n = 57). Participants described themselves as Native American or Pacific Islander (n = 3), Black (n = 32), Asian (n = 9), Hispanic (n = 21), and White (n = 16). For the purposes of this study, 56% were underrepresented students in Engineering (defined as Native American or Pacific Islander, Black, or Hispanic). Thirty percent of the sample indicated they were first-generation college students.

Summer bridge participants were recruited with letters mailed to their homes describing the programs sent to students admitted to Penn State. Recruitment focused on students who were racially underrepresented in Engineering, female, and first-generation college students. Four of the programs were free to participants. The Penn State Abington program charged a $125 administrative fee.

Materials

Participants were asked to complete the Academic Social Network survey using the Kahn and Antonucci (1980) social ties diagram that asks participants to list all the academic social ties (e.g., students, faculty, staff) who provided Frequent, Quite a Bit, or Occasional academic support (e.g., Fingerman, Hay, & Birditt, 2004). Two numbers were computed: the Total number of people identified as providing academic support and the number of people identified as providing Frequent academic support.

Procedure

The five summer bridge programs commenced at the end of June 2016 and ran for either four weeks or six weeks. Students provided informed consent to allow examination of their background characteristics and academic performance using information in the Penn State Data Warehouse.

Table 3. Demographic Characteristics of the 2016 Summer Bridge Students

	Summer Bridge Program											
	PSU Abington		**PSU Altoona**		**PSU Berks**		**Academic Summer Experience**		**Pre-First Year in Engineering and Science**		**Grand Total**	
	N	**%**	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**
Sex												
Male	10	77	8	67	9	69	9	69	21	70	57	70
Female	3	23	4	33	4	31	4	31	9	30	24	30
Ethnicity												
Native Am. & Pacific Islander	0	0	1	8	0	0	1	8	1	3	3	4
Black	2	15	5	42	2	15	7	54	16	53	32	40
Asian	4	31	0	0	3	23	0	0	2	7	9	11
Hispanic	3	23	1	8	2	15	5	39	10	33	21	26
White	4	31	5	42	6	46	0	0	1	3	16	20
First Generation College Student												
Yes	5	39	3	25	6	46	5	39	5	17	24	30
No	8	62	9	75	7	54	8	62	25	83	57	70

Note: N = 81.

Results

Participants' academic performance data for high school and for the first semester of college are shown in Tables 4 and 5. On average, the first cohort of students who participated in the summer bridge programs scored 556 on the SAT math exam and earned a 3.47 high school grade point average. Incoming students are required to take a math-placement exam based on ALEKS, which is web-based educational software for assessment and learning originally developed using NSF funding. Scores on the math-placement exam can range from 0 to 100 and are used to assign the math course that students enroll in for the first semester of college. It is optional to take the ALEKS math-placement exam more than once. Fifty-two participants (64%) took the math-placement exam a second time. Ten students (12%) took the exam a third time. The average ALEKS math-placement score for all 81 participants was 60, which corresponds to placement in Algebra II and Trigonometry. Participants who took the math-placement exam a second time scored 76, which corresponds to placement in Calculus I. The average score was 77 for students who took the exam a third time. For students who took the exam a second time, they gained an average of 23 points. Students who took the exam a third time gained an average of 11 points.

Cohort 1 is in their second semester of college as of this writing. Thus, there is limited college academic performance and retention data for them. However, we examined three objective indicators that were available: fall semester math course grades, fall semester grade point average, and spring semester enrollment at the University. The data are shown in Table 4 for the bridges combined and in Table 5 for the programs separately. Math course letter grades were converted to a numeric grade point equivalent using a standard scale (e.g., A = 4.0, F = 0.0). On average, participants earned a C (2.1) in their first college math course. On average, participants earned a 2.5 grade point average in the first semester of college. Three out of the 81 bridge students (4%) did not enroll for the spring semester.

Table 4. Academic Performance Data for the 2016 Summer Bridge Students

Variable	*N*	Mean	Standard Deviation
SAT Math	81	556	81.64
High School GPA	81	3.47	0.45
1st ALEKS Math Score	81	60.30	18.74
2nd ALEKS Math Score	52	76.06	15.34
3rd ALEKS Math Score	10	76.60	14.21
Change in 1st to 2nd ALEKS Score	52	22.77	13.92
Change in 2nd to 3rd ALEKS Score	10	11.10	12.76
Fall 2016 Math Course Grade	70	2.14	1.35
Fall 2016 Grade Point Average	81	2.53	0.92

Table 5. Freshman Year Academic Performance for Cohort 1 by Program

	Summer Bridge Program											
	PSU Abington		PSU Altoona		PSU Berks		Academic Summer Experience		Pre-First Year in Eng & Science		Grand Total	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
FA2016 Math Course Grade	2.42	1.42	1.96	1.31	3.10	.84	1.70	1.45	1.92	1.36	2.14	1.35
FA2016 GPA	2.72	.80	2.52	.90	2.88	1.01	2.55	1.05	2.54	.91	2.62	.92
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
SP2017 Enrolled												
Yes	12	92	12	92	12	92	13	100	30	100	78	96
No	1	8	1	8	1	8	0	0	0	0	3	4

Note: *N* = 81. *M* = Mean. *SD* = Standard Deviation. FA2016 = Fall semester 2016. SP2017 = Spring semester 2017.

Table 6 shows the bivariate correlations between the study variables. Higher SAT Math scores were associated with higher high school grade point averages ($r = .35$, $p < .01$). Those variables shared 12% of their variance. As might be expected, high school academic performance data were significantly associated with academic performance in the first semester of college. Higher SAT Math scores and high school grade point averages were significantly associated with higher ALEKS math-placement exam scores and math grades in the first semester of college. The association between SAT Math scores and math-placement test scores (first time taken) were particularly strong ($r = .59$, $p < .001$). Those variables shared 35% of their variance. Higher SAT Math scores were also associated with higher first-semester college grade point averages. To put the results in context, high school academic performance data were statistically related to academic performance during the first semester of college, generally accounting for 10 to 12% of their variance. Other variables not measured here account for the remaining variation between the variables.

Table 6. Correlations Among the Study Variables

		SAT Math	HS GPA	1st ALEKS Math Score	2nd ALEKS Math Score	3rd ALEKS Math Score	Change from 1st to 2nd ALEKS Score	Change from 2nd to 3rd ALEKS Score	Fall 2016 Math Course Grade	Fall 2016 GPA
SAT Math	*r*	--								
	n									
HS GPA	*r*	.35**	--							
	n	81								
1st ALEKS Math Score	*r*	.59***	.45***	--						
	n	81	81							
2nd ALEKS Math Score	*r*	.38**	.33*	.64***	--					
	n	52	52	52						
3rd ALEKS Math Score	*r*	.44	.63*	.62	.68*	--				
	n	10	10	10	10					
Change from 1st to 2nd ALEKS Test	*r*	-.27	-.26	-.53***	.31*	.16	--			
	n	52	52	52	52	10				
Change from 2nd to 3rd ALEKS Test	*r*	-.29	-.02	-.44	-.58	.20	-.29	--		
	n	10	10	10	10	10	10			
Fall 2016 Math Course Grade	*r*	.34**	.34**	.20	.08	-.42	-.37*	-.04	--	
	n	70	70	70	44	8	44	8		
Fall 2016 GPA	*r*	.32**	.21	.19	.23	-.20	-.14	-.07	.86***	--
	n	81	81	81	52	10	52	10	70	

Notes: *r* = Correlation. *n* = Sample size. *$p < .05$. **$p < .01$. ***$p < .001$.

Discussion

This paper presents an overview of the Sustainable Bridges study (NSF IUSE #1525367) and data for the first cohort of students to enroll in the freshmen summer bridge programs in their first semester of college. The goal of the study is to increase retention and graduation among underrepresented students in Engineering. After we have gathered longitudinal data on 3 cohorts of students we will examine retention in Engineering, STEM, and the University as a function of (a) students' transfer status within the University (completed degree at one campus vs started at regional campus and transferred to flagship campus) and (b) bridge location (at campus where matriculate in the first semester of college vs at a different campus than matriculation in the first semester).

We recently completed the first year of this five-year project. The first cohort of students in five bridge programs for incoming freshmen also recently completed their first semester of college. Based on math course grades and grade point averages from the first semester of college, the bridge participants did not perform as well as expected. We are examining our procedures to see whether additional academic assistance should be added this semester. We are also currently preparing for the second cohort for bridge programs for incoming freshmen and the first cohort for a bridge program focused on Calculus II and Physics for rising sophomores. We expect that a good proportion of students who participated in the freshmen bridge programs will enroll in the bridge for rising sophomores.

Conclusions

At this point, it is too early in the study to draw any conclusions about the success of the interventions toward increasing the number of underrepresented students who successfully enroll in an Engineering major in their junior year. One challenge we are trying to tackle is the balance between the most financially efficient and most academically effective way of offering summer bridge programs at small regional campuses. On the one hand, it may be more cost effective to bring incoming Engineering students from various regional campuses to the flagship campus for summer academic enhancement. In this case, students primarily benefit from academic enrichment but do not garner some of the other advantages of bridge programs. On the other hand, students may have better long-term academic success if they participate in a bridge program at their regional campus where they also benefit from acclimating to the campus they will be attending in the fall, establishing relationships with faculty, and building a supportive learning cohort among their peers in addition to the academic enrichment.

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