Engineering Pathways Fellows: Four Years of Successful Retention Initiatives, Including International Collaboration

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Abstract

The graduation rate in engineering can be correlated to several factors, including race and gender. Nationally, the populations with the highest engineering graduation rates are majority males, with Asian males at 66.5% and Caucasian males at 59.7%. The goal of diversity and inclusion program practitioners is to establish parity in graduation rates for all populations. There are several interventions that are proven to increase the retention and graduation of underrepresented students in engineering. Some of these include math intensive summer bridging, tutoring, cohort building where students establish a learning community. Singly these are somewhat effective, but when multiple interventions are applied over multiple years, the effect is additive and there is a significant increase in the likelihood of graduation. Outside of traditional applications, there other interventions that are shown to be effective on student retention, but they are not typically applied to underrepresented students. One of these is international scholarship, or study abroad experiences.

The research question addressed by this project is the following: *While long term applications of traditional retention programming for underrepresented students yield graduation rates at parity or exceeding that of majority males, could the graduation rate be even higher with the addition of a scholarly international experience, an intervention not typically applied to underrepresented populations?*

In this study, traditional interventions were applied to 10 students at Pennsylvania State University (all underrepresented in engineering by race or gender) over a four year period. In addition, an international or study abroad experience was added. Interventions were applied addressing four known variables that increase retention: financial support, math and academic preparation, the learning community/cohort building, and international education. Three objectives or expected outcomes of this project were:

1. Increased retention and graduation rates of participating students in STEM fields.
2. Improved programs and strategies for sustaining diversity in STEM fields.
3. Improved access to engineering educational opportunities.

The quantitative measure of success for the NSF Pathways project is determined by the retention and graduation rate of the students in STEM fields at the end of five years. The current four-year retention rate for these students in 2017 was at 100%. The graduation rate of these ten students who completed all interventions is also expected to be at 100% in a STEM field, with 90% in engineering. Qualitative data through focus groups and essays indicated the importance of building a strong learning community, and the added impact of international scholarly collaboration.

Introduction

There are many initiatives that focus on the retention and graduation of underrepresented populations in engineering and other STEM fields. Research literature is often written about a given set of interventions applied in a single year, perhaps two, or about a single program [1, 2, 3, 4]. When this is done, the group of students who completed the intervention are readily identified, and if they remain at the university they can be counted again at other points in time to check for retention and graduation years later. It is more difficult to ensure that all students participate together in the same multiple interventions each year as they become upperclassmen. It is understandable that the focus of most programs is on the first year since this is the time of highest attrition when students are most likely to leave the engineering major or the university. If students compete the first year, they increase the likelihood of graduation [2, 5].

Beyond the first year, at Pennsylvania State University, and other institutions, courses become more challenging and many students must apply to the engineering major in the third year to continue towards a degree. Entrance is based on grade point average (GPA), and completion of core courses such as calculus, physics, chemistry, and differential equations. In addition to this, nationally there is a correlation of graduation rate in engineering with race and gender. The national graduation rate of Asian males in engineering is at 66% and at 59% for Caucasian males. The same figure for majority women is at 61%. For Hispanics, Native Americans and African American engineering students, these figures are 44.4%, 38.6% and 38.3% respectively [2]. While the obstacles are many, there is successful programing that has demonstrated capability of raising the graduation rates of underrepresented students and women to a level that is higher than the national average for these populations, or even at parity with majority males [1, 3, 5, 6].

While it is difficult to ensure that all students participate together in the same set of interventions over multiple years, an exception in the world of retention programs would be the Meyerhof Program at the University of Maryland, Baltimore County [6]. This initiative offers selected students in STEM majors substantial scholarships, and participation in mandatory long term programming (a condition of acceptance of the scholarship). This programming includes a six-week math intensive summer bridge, housing in an on-campus a living and learning community for the first two years, summer research each summer of the undergraduate academic tenure, mandatory study sessions and extensive coaching on preparation for the graduate school application process. The end goal is that students spend 4 years preparing for graduate school and go on to achieve a PhD. While Meyerhof has contributed to a high percentage of African American PhDs in the nation, the reality is that most students who enter engineering are not seeking a PhD, but a Bachelor's degree. This author could find no similar programming model designed for the goals of this larger underrepresented population. The Pathways initiative was designed, with consideration of all of the above models, with a goal of graduation of the participants at parity or at a higher rate than majority males in engineering.

The Pathways Fellows Program incorporates a few of the most effective intervention tools over a four-year period for a cohort of ten students who began in engineering in 2013. Several of the most effective and traditional of the interventions identified most in the literature can be categorized into three areas: financial support, academic enhancement and strong learning

communities [2, 3, 5, 7, 8, 9, 10]. Examples include full or partial scholarship support and stipends, summer bridging programs, tutoring, mentoring, cohort building, special living housing options. The strongest programs were long term, with retention programming throughout, varying with maturity level of the students over the academic career. In addition to traditional interventions applied to underrepresented students, other interventions were examined that were not typically applied to these populations even though they have a data proven ability to increase retention and gradation in engineering. One of these is the international educational experience [11,12,13]. The merits of each these four variables applied to the Pathways Fellows Program are described further.

Financial Support

Scholarships are one of the most basic of retention tools for those in college. Without financial support, many students cannot attend. For those who cannot afford the cost of tuition, room and board, scholarships are a must. Family income is a primary indicator of a student's likelihood to graduate from college, regardless of major. It is an equal determinant of graduate success along with excellent retention programming and academic enhancements [9, 10,14]. Scholarships can also determine the level of engagement a student has in the educational experience. It can determine if a student partakes of additional educational opportunities, such as studying abroad or attending national conferences.

While scholarships are awarded at the college level, family income also dictates several pre-college factors which determine the level of math preparation students receive that would enable them to be successful in a STEM field [15,16,17,18]. These factors include tutoring, SAT preparation, and computer access. U.S. public schools are funded through the local tax base; therefore, poorer communities have fewer resources available for school infrastructure, while wealthier communities have more to invest in the local education system. This would allow wealthier schools to hire qualified teachers, purchase current textbooks, and offer a broad selection of advanced courses for study with modern science labs [17]. School budget reductions directly affect the number of math and science offerings available, rendering students in those schools less prepared to enter STEM professions. Underrepresented populations compose a large percentage of the poorest families in the nation. These students are eliminated from competition very early on based on low family income. There is a positive correlation between the income of a community where a high school is located and the math preparation of its students. To follow, there is a significant correlation between math preparation and graduation in engineering [1, 19]. For this reason, scholarships are often combined with retention programming to bridge the gap to successful academic performance and persistence to graduation.

Academic Enhancement

There is much in the literature regarding the importance of math preparation and its relation to success in STEM fields [1,6]. Typical academic enhancements include tutoring, applications of math to engineering projects and team building, and the summer bridges. All of these are shown to increase the graduation rate of participants. The summer bridge is especially effective when all best practices are implemented including: the learning community, math preparation, scholarships, team building, summer credit, professional development, and both peer and faculty

mentoring [3, 6, 10, 14, 20, 21]. A typical summer bridge is four to six weeks long and takes place in the summer after high school and preceding the students first fall semester. Students are selected at a certain math SAT range, enter the program as a cohort, and live in a residential community on campus. Days are filled with math-intensive course work and team oriented projects. Bridge programs are typically offered at a deeply discounted cost (or none at all) to the student's family. A pseudo college environment is created to prepare the student for the skills needed to be successful as a first-year student in engineering or other STEM fields. Upon completion of this program, students continue their friendships and collegiality throughout the first year, often choosing to be housed in a designated learning community in the fall. Graduation rates for these students are typically higher than for the general population.

Learning Communities

There is substantial information on how learning communities are formed and the effect on the persistence of students. Tinto completed several studies on the success of learning communities from 1975 through 2008 with several audiences of students including community colleges and four-year institutions [4, 7, 8, 10, 22, 23, 24]. The learning community includes a student cohort, faculty mentoring, collaborative course offerings and shared living or work areas. The findings were that students developed trust with faculty they saw frequently in different venues both in and out of the classroom. Students also supported each other during study and tended to return to the community when confronted with academic problems. Students in living and learning communities were retained significantly longer than those that were without a learning community. In 2007 and 2008, Tinto and Engstrom applied these theories to underrepresented populations and found similar outcomes, pointing out that living communities were most effective when other retention tools, such as scholarships, were also applied [7, 10].

International Educational Experience

In the U.S., racially underrepresented students are among the least likely to travel abroad, typically due to lack of funding [11, 12, 13]. International travel abroad enhances retention such that graduation rates are increased when this is added to the academic experience. Xu showed that students who traveled abroad had a 1.8 higher likelihood of graduating in 5 years than those who did not [25]. Students who complete a study abroad tour show a significantly higher level of confidence after completing the trip, especially those who are first-time passport holders [13].

Cost is a primary factor preventing underrepresented populations from engaging in international learning opportunities [11, 12]. For the Pathways Fellows, funding became available and this opportunity was added to ensure that these ten students had the richest college experience available. When choosing to add this option, the faculty managing the Pathways project were unsure of the effect it would have on retention, but rather thought of adding a global context because it would make the students better engineers, and add new perspectives to their view of the world and problem solving skills. The international experience was added in the same way that a summer bridge or tutoring would be added, at no expense to the students (with exception of procuring a passport and required vaccinations, if needed). Like all other Pathways programming, the international program element was mandatory for the Pathways Fellows to attend. Students spent a semester studying the country and the project. In May, 2015, all ten

students went to Lima, Peru, and collaborated with Peruvian students at the Universidad Nacional de Ingenieria (National University of Engineering) in Peru. The trip culminated in a four-week venture that is described later in this document. The outcomes are reviewed in the qualitative data collected in focus groups and a summary of essays written by the students. Throughout the program after that event, all agreed that this trip contributed significantly to their persistence and graduation.

Programmatic Objectives

The objectives for the Engineering Pathways Fellows project were to achieve the following:

- Increased retention and graduation rates of participating students in Engineering fields
- Improved programs and strategies for sustaining diversity in engineering fields.
- Improved access to engineering educational opportunities

The target retention and graduation rates were to achieve a level of parity with (or higher than) the national graduation rates for the most successful populations, being Asian males at 66.5% or majority males at 59.7% [2]. As opportunities were discovered to enhance the program's success, these strategies were added to this program as it progressed and were considered for future iterations of this program or others like it where graduation in engineering is the goal. The expectation was that improved access to engineering educational opportunities would render an increased appreciation for the profession, and an intensified desire to persist to graduation.

Program Description

Ten undergraduate students (Engineering Pathways Fellows) were selected as recipients of a renewable scholarship award at Pennsylvania State University (Penn State) through funding from the National Science Foundation. The Engineering Pathways Fellows initiative is designed to recruit and retain racially underrepresented students, women students and first-generation students in STEM fields through renewed scholarships, academic retention programming, a long-term learning community, and an international experience. The Engineering Pathways Fellows included 5 women and 5 men. Of these 10 students, 8 are African American or Latino. This cohort of ten engineering students was followed for four years, starting in 2013.

The following section includes a review of the selection process and a description of the programing that students were required to participate in. These include first year programs, mentoring, and a summary of other activities with a timeline showing when programs were carried out in Table 1.

Selection of Engineering Pathways Fellows

The Engineering Pathways renewable scholarships were awarded to a qualified incoming first-year cohort of 10 students. This same cohort was expected to continue for four years with a goal of graduating in engineering, or in a STEM field if the major was changed. Academic qualification was based on the university's academic predictor index which is based on a number of factors including student high school grades and SAT scores. Students had to have an

evaluation index with a predicted college GPA of ≥2.7 to be eligible for an Engineering Pathways Fellowship.

To retain the Fellowship from year to year, students had to have high academic standards, actively participate in program, and make clear progress towards a degree in engineering. Students were required to maintain a college average GPA of ≥2.7, and complete courses for their major consistent with the standard curriculum. Students who failed to meet these criteria would be given an additional semester of aid on a provisional basis. In these cases, intensive counseling would be provided. Active participation in program events was critical to general success of the program. In cases where students did not actively participate in at least 75% of scheduled activities, they were counseled that they were jeopardizing their continuation in the scholarship program. Activities were designed to maximize coordination with student schedules.

Traditional Retention Programming

Engineering Pathways Fellows were required to participate in the following programs designed to enhance the first year experience. These programs included a summer bridge, a housing option and continuing mentoring from faculty and peers to encourage community building and establishment of long term relationships early on. Three of these activities are detailed below:

- *Pre First-Year Engineering & Science Program (PreF)* - This introductory, 6-week, residential summer session was designed for first-year students who were accepted to the College of Engineering. The program typically accommodated 25-30 students and had been successful for 20 years. Many of the students were engineering scholarship recipients. The introductory courses, Calculus, Physics, and Chemistry were reviewed to ensure the success of academically promising students. Students also received professional development including a visit to a corporate technical site. The addition of the Pathways Fellows raised the number to 40 students in the summer of 2013.

- *First Year in Science and Engineering (FISE) House* is a housing option targeting women and underrepresented engineering and science students. It is a supportive living and studying environment that enhances the retention of technical students. It includes in-house tutoring and retention workshops that address college survival. FISE House is a diverse residence hall that also houses a variety of other scholars. All of these elements increased the global competence of Engineering Pathways Fellows, and encouraged students to build community among technical peers.

- *Faculty-Student Networking Sessions* – Faculty members further interacted with students in weekly or monthly sessions held during the academic year. The workshops focused on leadership topics, research exposure and other information which encouraged students to think early about graduate school and academic success. All faculty members involved had a history of developing strong relationships with students, also serving as mentors, and positive role models.

Table 1. Timeline of Intervention Activities

Activities	*Years*			
	1	2	3	4
Enter engineering as a first-year student	x			
Participation in a first-year summer bridge (PreF)	x			
Participation in a first-year living option (FISE)	x			
An international scholarly experience (Peru)		x		
Opportunity for community ervice (Habitat for Humanity)			x	
Renewable scholarship of $7500/year	x	x	x	x
Participation in ongoing meetings with faculty mentors	x	x	x	x
Establishment of a learning community	x	x	x	x

Application of Variables

Each of the traditional intervention variables, financial support, academic preparation, the learning community, and international education were applied throughout the program in the following ways. Financial support was provided in the form of annual renewable scholarships, and funding for the Peru trip which is explained in detail in the following section. Academic preparation was applied through the summer bridge and the in-house tutoring through the FISE House living and learning community in first year. The learning community, by definition was extensive and was reflected in the summer bridge, FISE House, faculty mentoring over four years, the week spent with Habitat for Humanity, and the month-long Peru trip. The details of this initiative is explained below.

International Educational Experience: Peru

The research to determine if the study abroad parameter is a significant factor in achieving high-percentage rates (> 90%) in graduation is limited [12, 25]. Surprisingly, this parameter is rarely applied to underrepresented students who are less likely to travel abroad [11, 12]. Most of the Pathways Fellows who participated in this project had not traveled abroad before, and 8 out of 10 indicated that funding was a critical determinant of whether they would have traveled or not. The trip to Peru was designed to provide the students with a global scholarly and humanitarian experience. Other impacts of the trip were the acquisition of cultural and social capital that cannot be accomplished through non-experiential activities [13]. The trip included a project in Lima, daily tours to museums in this city, national research labs, and a final trip to Machu Picchu, the Lost City of the Incas in Cuzco.

Project: A Sustainable Approach for Informal Settlements or Asentamientos Humanos *in Peru*

Educational research has demonstrated that a rich learning environment plays an important role in improving learning achievements and also attitudes toward studies and research [26]. This type of environment can be implemented through project-based learning that also helps to develop lateral and vertical thinking [27, 28, 29]. In addition, pedagogical research has shown that this thinking should be integrated into a specific context [21]. Exploring different solutions to project design creates lateral thinking, while choosing a solution develops vertical thinking. The project in Lima, which consisted of finding solutions for *Asentamientos Humanos*, was designed with this learning technique. This engineering project also showed students from Penn State the importance of being globally articulate and engaged. The students worked for about two weeks on this project with 5 students from Universidad Nacional de Ingenieria in Peru in a fabrication laboratory (*FabLab*) of another institution, Universidad ESAN, also in Lima, Peru.

The United Nations Habitat report [30], placed Lima as one of the eight mega-cities in Latin America, with a population close to 10 million. Lima, the capital of Peru, is considered Peru's economic, social, cultural, and political center. Lima is the source of about 52% of gross domestic product. It is the third high-density city in Latin America, containing 30% of Peru's national population [31]. Lima has about two million houses, of which around 60% have been built by self-management construction processes [32, 33]. These houses are usually built in unsafe public and private lands that are illegally occupied by very low-income habitants. The construction of these houses follow a very chaotic development, lack basic public and human services such as pavement, street lighting, water, sanitation, etc., and do not have legal property titles [34]. These informal settlements are known in Peru as *barriadas* or *asentamientos humanos*.

Students were divided in teams of three, each team included one local Peruvian student. First, the students had to study the culture of informal settlements, or *asentamientos humanos,* where communities build living spaces wherever there is available land. Each team had to identify ways to improve housing elements at a very low cost (all solutions less than about 1,000 soles or about 300 USD) for these populations. In order to do so, the students visited one *Asentamiento Humano* called Pamplona, near Lima. A picture of some of the houses there can be seen in Figure 1. The students spoke with residents, and worked with the 5 Peruvian students to produce a list of housing elements that they could potentially improve. Figure 2 (left), shows a diagram that summarizes the main problems they identified, while the (right) depicts individual elements that they created and decided to tackle. Overall, the students considered environmentally friendly low cost solutions. They could only apply their knowledge acquired in their respective fields of engineering so far, and then had to find solutions with whatever local materials and stores that were available in Peru. These findings were presented by the collaborative student groups to the President and Faculty of the two host universities in Peru. A full description of the thinking and working aspects of multidisciplinary and teaming aspects of cross-cultural background is beyond the scope of this paper, however, presented in Appendix 1 are the students' interpretations of the meaning of this trip with regards to their personal and professional growth. Every single response was extremely positive and appears to have had a unique impact in their lives.

Figure 1: An informal settlement on the south periphery of Lima (Pamploa), Peru

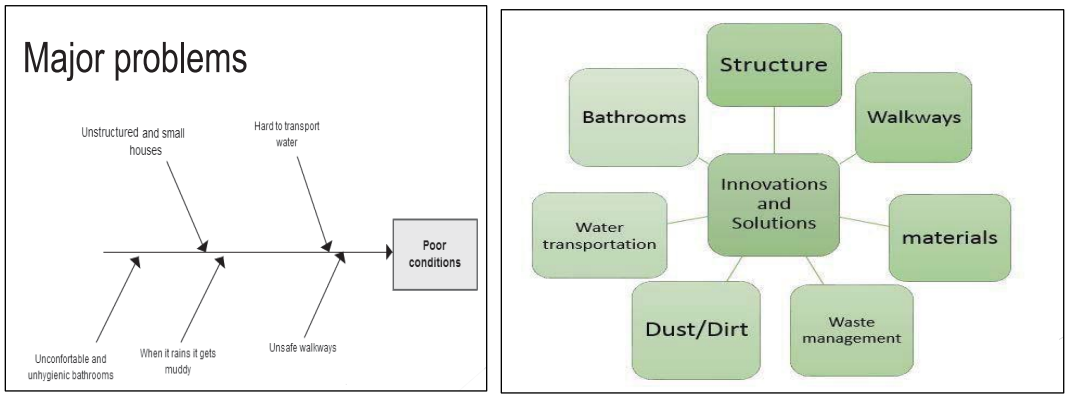

Figure 2: (left), A list of the main housing problems (right), A graphical view of the elements that the students focus on solving.

Quantitative Outcomes

From a quantitative perspective, the measure of success for the NSF Pathways project is determined by the retention and graduation rate of the students in STEM fields at the end of five years (or from year to year). The four-year retention rate for these students as of 2017 was at 100%. The graduation rate of these ten students who completed all interventions is also expected to be at 100% in a STEM field, with 90% in engineering. In 2016-17, they began their final year as seniors, and gave insights regarding the past four years spent together. Qualitative data through focus groups and essays indicated the importance of building a strong learning community, and the added impact of international scholarly collaboration. This well exceeds the national level of parity with majority males. The international experience, in combination with other interventions, proved to be a transformational factor for the participants.

Qualitative Evaluation Methodology

In order to evaluate the outcomes of the program, multiple sources of data were collected. These sources included quantitative data on student retention, annual student surveys, focus groups at the end of the program, and student reflective essays. For this paper, summaries of the focus groups and reflective essays are discussed. In addition, quantitative data on student retention and other outcomes are provided. The guiding questions for the evaluation of the program, as summarized in this paper include:

1. *What impact did the program have on student outcomes such as retention and GPA?*
2. *What benefits did the students perceive that the program provided for them regarding academic, social, and professional outcomes?*

Impact on Student Outcomes

Quantitative data taken in Year 4 (2017) of this project shows that all ten students who completed all of the program interventions are retained at 100% in STEM, with nine in engineering and one in biology. Eight are scheduled to graduate in 2017 and two in 2018. Regarding professional development, the average number of internships, undergraduate research, or summer leadership opportunities taken per student over the four years was 4.3, with some completing research experiences during the academic year. The average cumulative GPA of the group was at 3.14. The group well exceeded all expectations regarding retention rate and expected graduation rate in engineering and STEM.

Perceived Benefits of Pathways Program: Results of Student Focus Groups

During the last year of the Pathways program, three separate focus groups were held. All ten funded students participated in the focus groups. The assessment team, led by individuals from the College's teaching and learning center, was interested in understanding the academic, social, and professional impacts that the program had on the student fellows. The focus groups were recorded and summarized by a graduate student working on the project. Appendix 1 gives additional detail for the focus group questions and sample responses.

When considering their decision to participate in the Pathways program and to attend Penn State University, the financial assistance provided by Pathways played a very important role. Several students, particularly those who came to the university from out of state, reported that the offer of financial assistance swayed their decision to come to the university, and stated that they would probably not be here otherwise. All of the students involved but one, who is now a Biology major, stayed within the College of Engineering (or in an engineering major housed in another college) for the duration of their undergraduate careers. Students stated that by attending PreF (the first-year summer bridge), they became members of a strong-knit cohort consisting of the Pathways fellows and other students. They felt that PreF and this community were major factors in their retention in STEM majors and at the university. The Pathways program offered a community of diverse, like-minded peers and faculty mentors for the students. The students mentioned that their peer group was almost entirely based on knowing others from PreF or Pathways Fellows. They felt they had experienced much together socially and that they felt they would always have someone to go to talk about academic struggles. The trip taken by the group to Peru, discussed more below, also played an important factor in the retention of some of the students as engineers, because it shed light on the way engineers can positively affect a community in need.

Academically, the PreF program hosted at Penn State the summer before the students' freshman year had the most significant impact on them. They reported that this program not only prepared them for the rigor of entry-level STEM and English college courses, but also provided a safe

space in which they could acclimate to the culture of college student life, including learning more about the campus, building relationships with peers outside of the Pathways fellows, and picking up general skills like time management. This transition period was also made easier by the heavy involvement of the engineering faculty involved in the program. Coming out of this program, the students reported that they had formed a strong network with students in similar positions as themselves (both in and out of the program) and a strong connection with the faculty. Some of them carried their ties with peers into the future through study groups, and all of them continued to rely on support from the faculty. One student recalled that after she had received her first bad grade in a difficult engineering course, she was reached out to by a faculty member to make sure she was okay and to discuss what had happened. Another student made the comment, "Best decision I ever made [was] to attend PreF."

In addition to feeling like they had received a "leg-up" academically, the encouragement of the Pathways Fellowship to participate with several professional and volunteer organizations helped the students to build impressive networks and resumes. Several of the students spoke of the opportunities that had become available to them through networking at conferences and within other university organizations. Again, in this context, students spoke about how their bonds with faculty in the program had helped them to become aware of opportunities that they could pursue. Many of them stated that they approach their faculty mentors when they were actively looking for internships or needed to figure out what to do over the summer, and others mentioned that the faculty keep them in mind and reach out to them when these opportunities become available. Most students mentioned during their interviews that they had taken on leadership positions in different student organizations, and that the weekly meetings for the Pathways program had also helped them to develop great social skills they could use to present themselves in interviews.

As important as networking opportunities have been for the students, the résumé building experiences they have been afforded have been just as impactful. Students spoke of two trips in particular: Peru and a Habitat for Humanity experience in New Jersey. Perhaps the most important sentiment students shared is that both of the travel experiences had shown the students how their engineering education will translate to real world applications. They mentioned that they had to learn not to assume that their clients would prefer certain amenities, but instead needed to listen to what problems existed for the individuals they were working with in different contexts. For example, they had assumed that the Peruvians they were designing for would be interested in high tech things like solar panels, but in reality, their clients were interested in affordable solutions for problems like sanitation rather than energy efficiency. Both the Peru trip and working with Habitat for Humanity also inspired many of the students to recognize the worth of giving back through engineering, and they indicated that they want to carry this "pay it forward" mentality with them into their careers. As résumé builders, both of these unique experiences have been great gateways for students to speak with potential employers about their development as young engineers. Students said that during interviews, the employers were extremely interested in their travel experience to Peru.

The students in each focus group spoke extremely positively about the Peru trip they all participated in, without even any question prompts. This trip was clearly the most significant aspect of the Pathways program for many of the students. The students felt that they grew as individuals simply from being immersed in a new and unique culture for three weeks. The

students had a varying level of familiarity with the Spanish language. Despite the fluency of some of these students, they all experienced an inability to communicate consistently with the people who lived there. This pushed each of these students to learn how to work around communication barriers by using body language and patience. A great description of the process of dealing with cultural barriers was, "It was a good lesson in being able to adapt." Because the Pathways fellows are a multicultural group, none of whom come from Peru, some of the students felt that they experienced some biases while they were traveling there. Some individuals in Peru made comments about the group or stared. As stated by one student, "We took it [these experiences] with a grain of salt." Learning to thrive in a new culture raised the perceived global awareness of these students and left many of them with the desire to incorporate international travel and experiences into their career trajectories.

Overall, the students involved in the Pathways program felt that their time at Penn State University has been a great success. They've been given financial, social, and professional opportunities above those of many of their peers, and as a result they were now at the point of graduating from the university as marketable engineers. All of the students spoke of going into industry after they graduate; many are already working with the companies they will be joining full time. A few are considering graduate school in the future. While satisfied with their experiences, students did provide some suggestions for improving the program for a future cohort. These included a project or travel experience between the freshman and sophomore years (decided upon through a democratic process by the next cohort and faculty) and the incorporation of additional mentors for the students. Specifically, some of the students felt that alumni of the Pathways program (in all of the relevant areas of engineering) could provide an industrial perspective and answer a wider variety of questions. Appendix 1 provides several detailed student responses from the focus groups.

Perceived Benefits of Pathways Program: Results of Student Reflective Essays

In addition to focus groups, students were asked to complete several open-ended questions asking about the impact of the program.

The summaries of both the focus groups and reflections are somewhat similar, mentioning the collective effect of several elements of the program. Summarized results from four of the questions follow.

1. *What were your expectations before entering College, how accurate did you find them to be after being in college for a year.*

Six out of ten said that they expected that academic work in college would be similar to that of high school and had clearly miscalculated. Three expected that they would be isolated, but found community instead.

> "I never minded hard work and I liked the sound of good money. These were the things I was expecting. Little did I know what awaited me here at the university. 'Hard' was an understatement. I thought calculus in high school was hard. Now, I reminisce about the days of calculus."

> "Coming into college I was so afraid that I wouldn't have friends, that classes would be much more difficult than high school (at least that's what all my teachers kept saying), and that I would have no idea what I was doing with no one to help me out. However after the first year, I had discovered that none of these things were true. Through the scholarship I was required to participate in a summer bridge program that summer before starting college, and there I met 20+ people that I could hang out with, ask questions, and work on homework with."

2. *Name three things that affected you most with regard to the Pathways program.*

100% mentioned some aspect of the learning community: faculty mentoring, bridging, and the group of friends formed over four years. 7 out of 10 mentioned the international trip to Peru.

> "The friendships that I gained from being in such a close-knit learning community affected me the most. Even when we are not at group meetings some of us still get together to hangout. I feel like this connection with other people in the same situation helps you get through some of the harder times because you have these people to rely on."

3. *Pathways Fellows will have an exceptionally high retention and graduation rate in engineering and the STEM fields. What aspects of the Pathways initiative contributed to your retention and graduation that you did not expect?*

Six out of ten listed the warm community of scholars and friends. An example is:

> "An unexpected benefit of being a Pathways fellow has been the constant support system and accountability that has come with being in the group. Having a group of students that are going through the same thing you are is helpful because an area that I might be deficient in, someone else can help me with and vice versa. Also, having weekly meetings and just having conversations about what we are going through on a daily basis acts as a de-stressor for me, which makes everything better."

> "Some aspects of the Pathways program helped me in ways I did not expect. The trip to Peru, was an incredible opportunity that I never would have gotten without this program. And, while it helped me understand what it means to be a global engineer like I expected, it helped me in an even bigger way... I was strongly considering dropping out of engineering in favor of English or education. However, the Peru trip convinced me to stay in engineering. Something about the experience reminded me why I wanted to be an engineer in the first place, to help people and solve the world's problems."

4. *Over the past four years, how has your participation as an Engineering Pathways fellow changed your perception of how you can impact your profession or community in the future (local, national or global).*

All mentioned that this program brought them some aspect of enlightened understanding that engineering is more than just a technological profession, but also a humanitarian contribution to the world. Several mentioned learning that it was possible to contribute now without waiting for completion of the the degree or years in the profession to contribute to the global community.

Some of these were not the answers expected, full of allusions to enhancing technical expertise, but rather, the depth of humanitarian awareness was an unexpected outcome, and is helpful in informing future programs of this sort. Following are quotes from two students:

> "I have found through the Pathways Fellowship, my impact as an engineer does not have to be limited to technical projects. The ability to leave a positive impact on someone is mostly dependent on one's character. The fact that we will be engineers is more like a toolbox for us to utilize when we help people. The motivation to leave a positive impact on someone, on the other hand, is purely driven by character which cannot be taught in calculus, or thermodynamics, or heat transfer classes. It is something that must be developed through personal interaction and small acts of kindness."

> "By being part of the Habitat for Humanity in Manasquan, NJ, it was really cool to see how, while many strive to help others internationally, it's also important to help those in our local community, and we did just that. My most rewarding experience for both projects, I have to say in getting to meet the families in the impoverished communities in Lima, Peru and working with volunteers and meeting the family that will be living in the home we helped build in New Jersey. Our work was very well appreciated and I could not have felt more lucky to have met the people I did, and to have learned so many new things."

Conclusion and Limitations

The application of multiple traditional interventions over a long-term period of four years significantly contributed to increasing the retention and graduation rate of this group, higher than many typical single intervention or short term application of less than one year. The inclusion of international exposure was an effective element to add to existing efforts to increase retention of this underrepresented population.

The limitation of this project, if applied on a large scale, is funding. These ten students each received scholarships of $7500 per year over four years. The cost of the Peru Trip (travel, housing, subsistence, several educational tours including Macchu Picchu, Cuzco, and a number of venues in Lima) for ten students and three chaperones was approximately $50,000 (provided through NSF, the College of Engineering, and scholarships through Penn State University Global Programs). The costs of the first-year PreF summer bridge program was at about $5000 per student for room, board, course credit, and program administration. To positively affect a larger group of underrepresented students through all of these retention tools, a significant grant or long-term commitment from the university or other donors would be required. The final limitation to be aware of is that with a larger group, it is possible to lose the effect of the small group relationships which were critical to this project.

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Appendix 1

Pathways Focus Groups

Everything written here was paraphrased directly from the students' comments or is a direct quote. It was difficult to pull many specific individual quotes, because in most cases the students were talking together to construct a single response to a question.

Introductions:

- 10 total participants
    - One of these is in Biology now and will go on to participate in AmeriCorps next year
    - Of the others, 3 explicitly mentioned that they are considering graduate school after working in industry for a few years
    - All of the engineers (9 participants) are intending to go into industry immediately following completion of their graduate degrees

Academic Impact:

- Weekly meetings of the entire group reinforce mutual progress for each student
- The program gives a good perspective on the "real world" application of engineering
- Financial help makes it easier to focus on academics
- Faculty mentors from the program have been extremely helpful
- PreF program prepared the students to transition into life as college students
    - "Best decision I ever made [was] to attend PreF"
    - Some students formed study groups with students (outside of the program) that they met through PreF
    - Learned about things like "time management" in addition to brushing up on basic STEM courses and English

Social Impact:

- Program provided a culturally diverse group of peer with similar academic interests
    - "We wouldn't have come together otherwise"
    - "The Peru trip 10-fold strengthened our bond"
- Performing all of the extracurricular service trips through this program has led to lasting bonds between these students, and they feel that they are a very strong community
- The students expressed a lot of gratitude for the mentors they have gotten from this program
    - They said that they feel very comfortable discussing things like switching majors and discussing internships and other life experiences with the Pathways faculty members
    - "I'm not sure who my advisor actually is" (Referring to their assigned academic advisor. This student was saying that they always go to their Pathways advisors in lieu of their actual advisor. The idea behind this comment was agreed with by the other 3 students in the focus group.)
- The students conveyed that the social bonds they've formed through the pathways program have led to their increased retention in the Engineering program at Penn State. Particularly because these social interactions with faculty and other students have gotten them more involved in the profession of engineering (by participating in professional

organizations in the field alongside their peers) and by using their peers as models encouraging them to get involved early on in their academics.

- The program has lead the students to develop their networking sills by encouraging (or in some cases requiring?) them to get involved in "sooo" many professional organizations and conferences
    - The biology student has not had these experiences, and said, "If I had those experiences I would be better at it [networking]."

Professional Success:

- This was another area where the students spoke about how helpful the faculty in the program have been to them
    - "They help me with writing emails and setting up visits with employers."
- They have developed their networking skills to help them get internships and jobs
    - "A lot of introductory opportunities (ex. Internships) have led to even more opportunities and resume building experiences."
    - Interacting in their weekly meetings also made some of the students feel like they can interact more "normally" (less as an introverted engineer) during their interviews
- Peru has come up in every single one of the participants interviews since the trip
    - "Employers always want to know what that was about"
    - "I can use that experience to explain the skills I developed to an employer"
        - The Peru trip in particular showed the students the value of service and giving back through engineering, they will take this value into their future careers
        - The Peru trip helped the students with international communication and awareness
        - On the Peru trip students learned how to "take and react to criticism."
- The students also said that their Habitat for Humanity trip was "Eye-opening and humbling"

Conclusion:

- Two groups of students said that they wouldn't suggest changing anything to improve the pathways program, and that the program's "general roadmap was very successful."
- The third group suggested some changes
    - Include more groups/projects (particularly earlier in the college experience, between freshman and sophomore years)
    - Have a larger variety of mentors (some engineering specialties felt slightly left out, because there was no one from their specific program)
        - They said these mentors could include alumni of the program or corporate mentors

Quotes specifically about the Peru trip

- **Biggest impacts of the Peru trip:**
  - "I think the best thing about the trip was. We were given a problem, and everyone came up with really, really great ideas for it. And one of the teachers was like, oh, well, we wanted this, this, and that. All we had to do was ask us what we wanted, and we would have designed the perfect vehicle or whatever. Which was what we were designing. That was one of the best things that I learned from the project, was that you're never going to design anything to the best of your ability if you don't ask the people who live there … I use that a lot now."
  - "We went to the community, we talked to the family, and we based our design off of what they needed, and not what we thought they needed."
  - "I also got to really immerse myself. Go up the mountain, see their home, be invited. Where as, if I were to do that by myself, I don't think I would be able to get away with it … To actually be able to go to the informal settlements and talk with the families was really rewarding as well."
  - "The Peru trip was huge. Getting to go to like a foreign country, and kind of work with other students in that country to do projects that could possibly help the people there. It was a great life experience for any major really."
  - "It embodied everything that we've been working on here."
  - "To work with a University that's renowned for engineering, I thought was really inspirational."
  - "For example, once we went to Peru we were able to implement everything we learned into designing a solution for the people there. It really opened my eyes to see how what I'm learning can make an impact on the world and help me to stick with it."
  - "I would say that, socially, even though that we were pretty great friends already before the trip, I feel like afterwards that bond got even stronger. I say ten-fold based on events that happened there."
  - "That's all we still talk about. The Peru trip, and that was summer of 2015."
  - "It was just something that I'm personally thankful for, because that was a once in a lifetime experience."
  - "Understanding how things are the same in a different country but they might be manifested differently."
  - "It was interesting to see that there were people all around the world learning the same stuff we were."
  - "You can get cultural experiences everywhere if you look hard enough, but there you didn't have to look for culture."
  - "Working with them intellectually was pretty cool. They were also just as smart as us, because they've been studying the same stuff that we have." (More detail that's difficult to transcribe around 16:30 on audio 3).
  - "The projects they gave us in general were really interesting, and really out of my frame of reference."
  - "I think it could have been more valuable if we went a year later, because we weren't really deep into our major classes.

- **Ability to speak the language:**
    - "I speak not a lick of Spanish … Learning to get around that language barrier was awesome. Learning to use your resources to translate … Learning how to get around. Learning words, I definitely started to learn the language, but not a lot. I learned how to say chicken and bottle of water real quick. Um, and just that was the biggest thing for me. Really learning what it feels like to be in a new country and knowing what it feels like not being able to speak the language or know the culture."
    - "Taught me how to get around it. How to kind of use words that I knew and use words that they knew. And try to draw pictures and stuff like that. Use forms of language that didn't involve talking.
    - "I don't know like technical words in Spanish … I had a lot of trouble explaining technical things … So we had to use a lot of hand signals, get up, point at things."
    - "We bonded so much more [with the woman they stayed with] because we speak Spanish."
    - "They were willing to work with you. Either teach you Spanish, or you teach them English … they were very patient with us. They wanted to learn English as much as we wanted to learn Spanish … It was the effort that really meant a lot."
    - "If you want to communicate with people internationally, it gave us a better sense of what might be culturally or politically correct from their standards. So that a formal or informal conversation doesn't turn into something that it shouldn't."
    - "Pretty much, as the trip went on, the woman whose house we were staying in, I was trying to have a full-on conversation with her."
    - "I said one phrase that I didn't think about in English, and it just came out. I was like oh my gosh! … I made it. That was one kind of aha moment I had over there."
    - "I think that … being proficient, but not fluent, made my experience so much more valuable … I could learn about where they came from, from their own mouths instead of somebody translating it."
    - "There was one time where he kept saying we should use madera, madera! And we were like, what is madera? And we found out that madera meant wood. In that one moment it was so difficult, because it was almost like we were trying to read each others' minds at that point. But you can't, so you have to communicate in different ways. But as we learned from each other, we were able to communicate better and come up with a better product."
    - "It made me appreciate the effort they put in in trying to speak English … I knew this is your country, you don't have to talk to me in English if you don't want to. That's not an obligation you have."
    - "I had to trust them. Sometimes they would say things and I didn't know what was happening."

- **Cultural Biases:**
    - "One thing I didn't know about Peru, is that they have a huge Asian influence … That's something I didn't know about Peru, and I wasn't really expecting it."
    - "One of the things that caught my attention … Over there, with engineering itself, it's very obviously male dominated … they have less bathrooms for women than

men. One time we went to their university to take a tour … there was only one [female] bathroom that had been built on the outside of the building… you had to get a key to it … there was only one female student. She must have been ecstatic, because there were five of us."
    - "We had no female instructors."
    - "We did a radio show, a couple of us, and at the end—which also mind boggled me—was the main guy, he's a huge scientist over there, but at the end he wanted a picture with all the girls. That would never happen here."
    - "Hold your head up high. I think it was the first day that we were there … We went to this one place and we were just walking around. This one guy was in the corner, and he was just like, "Hey! Africa!"
    - "Our group together was some of the whitest and some of the blackest people they've ever seen in their life, as one group … It wasn't really tough to deal with. Just like ah well, people are gonna be looking your way a little more."
    - "A similar thing happened when we went to Machu Pichu, and you could tell by the body language that the person was not as happy as the other one … We just walked by, and he was like "Okay, Hakuna Matata (sp)." I thought he was the same as the guy from Lima, but looking at the body language you could tell he meant something different."
    - "For the most part, you kind of had to [ignore the situation]."
    - "We did a project and presented at the university … One gentleman was very upset and was like, this is very poor, and I think he had the conception that American's think they can come in and do XYZ. And he really let us have it." (paraphrased)
    - Response to previous experience: "That kind of let me learn how to take criticism well. That you can't make everybody happy."
    - "With a grain of salt. Same way you would anywhere else. For example, the stereotype in Peru of black people is that they like to eat cats. One day we were walking down the street, and this one guy was on the corner advertising for a restaurant. And he was saying to us, "Hey, hey! Come to my restaurant, we have cats for you guys!"
    - "I got a lot of stares. Partially because I'm hella pale. Like, I'm super pale … in the sunlight my hair can be bright red. It was never an offensive thing, sometimes you get stared at … It was interesting standing out like that, because I normally don't stand out."

- **Global Readiness:**
    - "For me, it's helped me to be able to talk to anyone from any different background… before that, I would have found it outputting or hard to make the first contact."
    - "Inspired me to study abroad in Rome, and just me seeing how easy it was for us to fit it with them speaking Spanish, and how kind of more difficult it was for people who didn't speak Spanish got me really interested in language. Now it's my goal to learn at least six languages. I'm already almost fluent in Italian."
    - "I was ecstatic about this trip, and if anything, it confirmed that this is what I really wanted to do later on … They have a department here in the College of

Engineering called Humanitarian Engineering and Social Entrepreneurship, and I just got involved in this research for solar installations in Africa. And it's really cool having been in Peru and seeing the informal settlements kind of has prepared me … they're more focused on, oh there's so much dust here, than me coming in like we're going to put all this lighting … and they're just like, no, I just want sanitation and no dust."

- "I like to understand how people think, and that helps me do group projects and stuff … A bunch of Peruvians … they could probably get taught at different angles … and I haven't worked with these guys (the other fellows) either … So, I get to experience a lot of different ways of thinking, so that when I take that into future capstones or other projects it will help me understand more types of people."

- **Interviewing with Peru on the resume:**
  - "Every time I interview they love the Peru experience. It embodies so many different things, because you are working on a project but you're also working in a group and you're also meeting people of different cultures so there's a language barrier. Companies love that."
  - "One of the main things I try to talk about is my Peru trip … It's easy to talk about and it's easy to make it sound amazing, because it was amazing."
  - "It gave me a leg up between all my other peers who had never had any structural design experience."
  - "Anybody who's ever touched my resume has asked me about the Peru trip. That gives me an experience that not many people have had … I use the general experience and I use that to talk about the skills that I picked up … Getting past the communication barrier and dealing with setting."
  - "It's very unique, what is this? What did you do there?"
  - "Oh, tell me about this trip. And the rest is kind of history."
  - "People are like, oh I see you went to Peru, and I'm like, oh, let me tell you about my project!"