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Offering multiple STEM outreach touchpoints to middle school girls is associated with engineering and university recruitment outcomes

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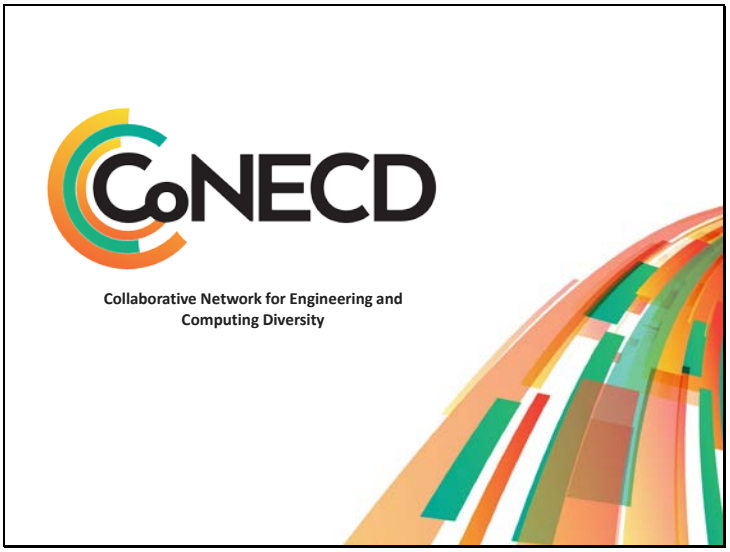
CoNECD
Collaborative Network for Engineering and Computing Diversity

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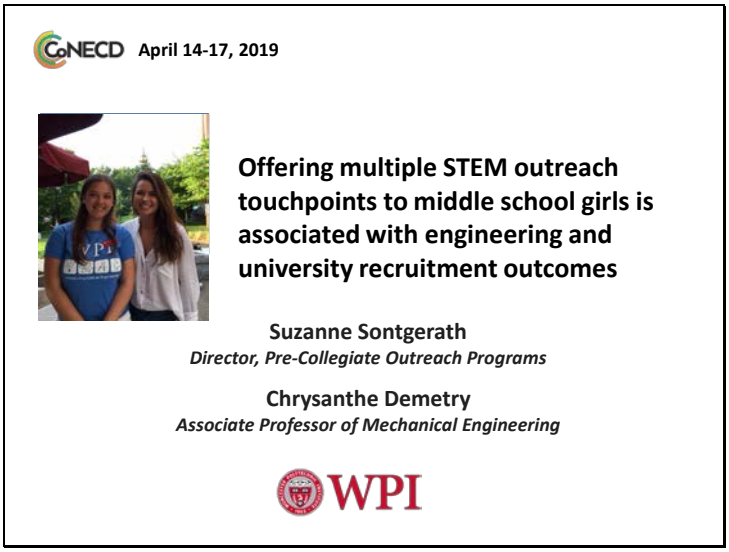

Please note: Full details of this study have been submitted for publication to the *Journal of Women & Minorities in Science and Engineering*.

We expect that most in this audience are well aware that the middle school years are a critically important time for identity development and career planning for girls, particularly with regard to supporting interests in engineering.

Some would argue that offering engineering programming for middle school girls is important and valuable regardless of long-term outcomes. But program funders and host universities typically want to see more than that, such as entry into STEM majors or recruitment to the university. This study captures our effort to track long term outcomes of a program that's been running at WPI for the last 25 years.

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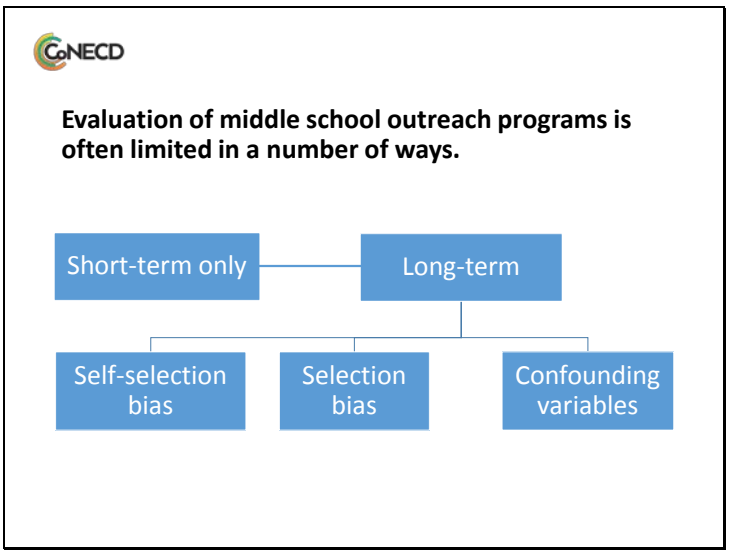

Of course the main problem is underrepresentation of women and URM in STEM. Many institutions are doing things to address the problem, but evaluation of middle school programs longitudinally is particularly challenging.

Because of resource and time constraints, many programs only conduct short term evaluation to assess the effects of the program on participants and to identify strengths of the program as well as areas for improvement. Many programs are able to show positive short-term outcomes.

The work that we're presenting today is driven by the question: Do we know if a middle school intervention can have a long-term impact for entry into engineering majors? Under what conditions? This type of evaluation is challenging too. Most programs cannot control for **self-selection bias**. In other words, if long-term outcomes are strong, is that because those who participated in the program were pre-disposed to STEM pathways? Some programs at the middle school level also do not control for **selection bias**. Participants may be selected based on achievement or interest measures that again may make the participant group pre-disposed to STEM pathways. In addition, many studies cannot account for the possible influence of **other variables** such as quality of high school education and presence of engineers in the family and socioeconomic status.

The main contribution of this study is that it overcomes many if not all of these limitations.

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In today's presentation, we will share the details of a longitudinal study on a middle school outreach program for girls. We will begin by sharing some background on Camp Reach and the original elements of its design which have remained relatively constant over the last 20+ years. In addition, we will share some brief information on other outreach programs at WPI, since participation in these outreach programs is one of the main sources of the touchpoints we discuss in our research.

Next, we will discuss the study design of this particular research. Camp Reach was originally developed with the intent of conducting longitudinal research. Therefore, the program is structured such that there is a control cohort each year which can be used as a comparison to the experimental group. In this section, we will discuss the methods we used which led to our findings.

Finally, we will share the findings, which have been very encouraging for us as an institution. WPI has made a significant commitment to offering extensive youth outreach programs, including Camp Reach. Our results suggest that support not only of Camp Reach but of additional opportunities for STEM touchpoints can impact a girl's decision to enter a STEM field in college.

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In today's presentation, we will share the details of a longitudinal study on a middle school outreach program for girls.

Background on Camp Reach

Discussion of Study Design

Evidence of Impact

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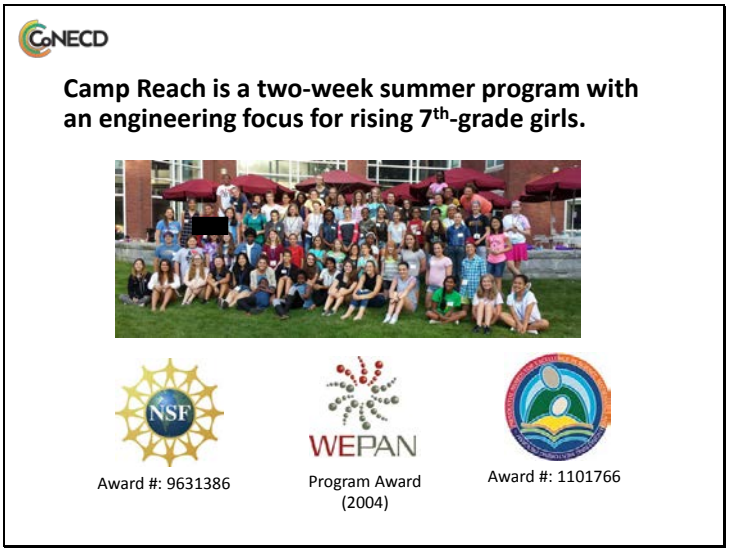

Camp Reach is a two week residential summer experience for rising 7th grade girls. **It focuses on engineering** since they see less of that in school and since stereotypes about engineers are especially prevalent. We are fortunate that this program, which was originally funded by the NSF, has been sustained for over 20 years through corporate or foundation funding and tuition. We are proud that Camp Reach has received national awards, from WEPAN and the White House.

Each summer 30 young women participate in the program. They reside in WPI residence halls for two weeks and are supervised and mentored by a combination of high school Teaching Assistants (TAs) who were once campers themselves, residential program assistants who are WPI undergraduates, WPI staff and faculty, and three middle school teachers from local middle schools. The campers spend approximately ½ their day working on a service learning design project with a non-profit client in the Worcester community. The other half of the day is spent in hands-on engineering workshops. Evenings and weekends are dedicated to fun and building community. In addition to the opportunity to come back to campus as TAs, all program participants are invited to semi annual reunions as well as follow-up celebrations for their service learning projects. The program maintains a Facebook group and regularly emails the camp participants about outreach opportunities at WPI.

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Details about the program design can be found in earlier publications, so we'll just summarize briefly here. First, the program aims to **build self-efficacy** by challenging and supporting participants to succeed with multiple, hands-on engineering design experiences. We also provide a wide spectrum of female **role models and peer support.** We surround the girls with female staff who are engaged in STEM fields, including HS students, undergrad & grad students, and faculty. The program shows how engineering provides a range of opportunities to fulfill **humanistic and people-oriented values and goals**. This is done through selection of workshop topics but especially through a real-world service learning project where teams of 10 girls use the engineering design process to develop a solution to a problem or opportunity presented by a non-profit organization in our city. An important decision was to **facilitate multiple touchpoints** after the two-week summer experience, to provide ongoing peer support, role models, and to reinforce messages about nature of and opportunities in engineering. We do this through twice-annual reunions, the opportunity to return as a counselor/TA, and by encouraging them to attend additional programs at our university both during the academic year and the summer. Research shows that parents are an important source of support and encouragement. Since not all girls have adults in their lives who know about engineering, we provide **programming for parents** as well.

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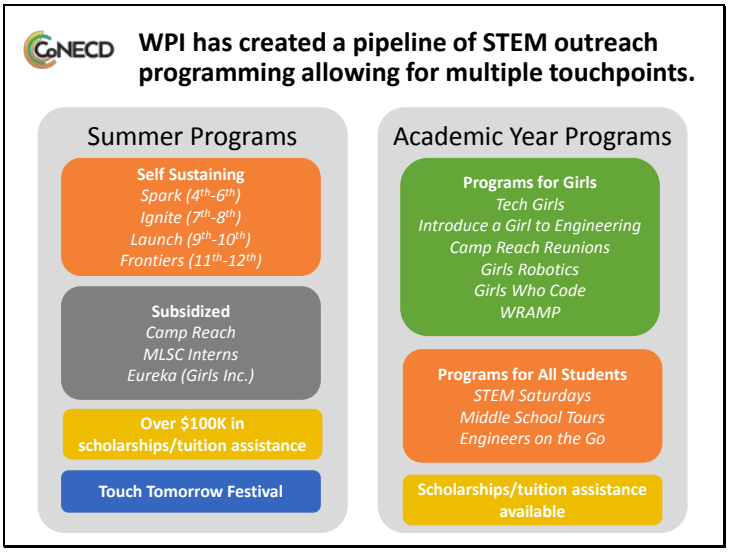

Summer program opportunities at WPI range from Robotics camps to Women in Science to two week immersion programs with faculty for high school students. Summer programming is typically 1 or two weeks long. Students in grades 4-12 are welcome to attend. With the exception of Camp Reach, most of the programming is commuter until the students reach high school and then there is a residential component as well. The programming has become extremely popular and some programs sell out in the first few minutes they are offered (robotics in particular). Part of the charge of my office is to strategically add programming that ensures we maintain quality and reach the underserved populations.

During the academic year, we focus on reaching out to underserved populations in STEM through Geek is Glam, Tech Girls, Introduce a Girl to Engineering Day and middle school tours. A couple of examples include: Each October we partner with the GSCWM to bring Geek is Glam to campus where over 400 girl scouts spend the day learning about STEM. Through out middle school tours program, we have about 800 middle schoolers on campus each year to do engineering activities with our undergraduates.

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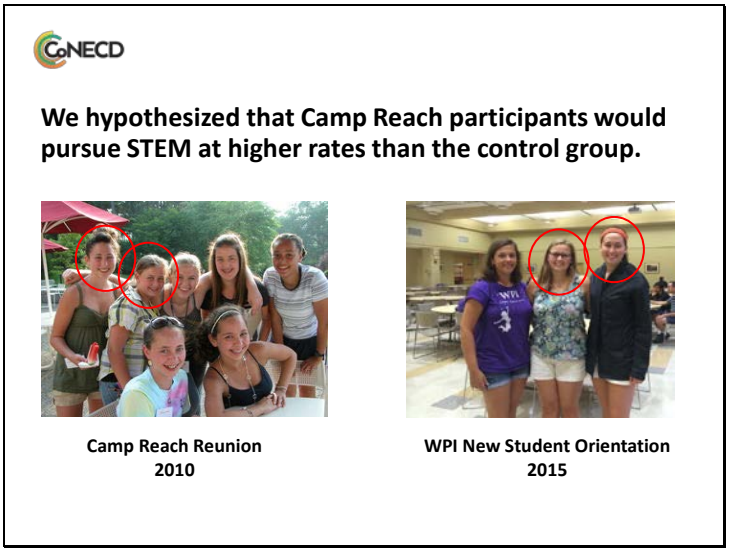

In a previous study, we determined that program participants matriculated to WPI at a higher rate than the control group. In this study, we sought to extend that research using National Student Clearinghouse data to analyze the rate at which participants pursue engineering and STEM degrees **at any institution** as compared to the control group.

We further studied whether outcomes would vary based on factors such as race/ethnicity or number of STEM touchpoints.

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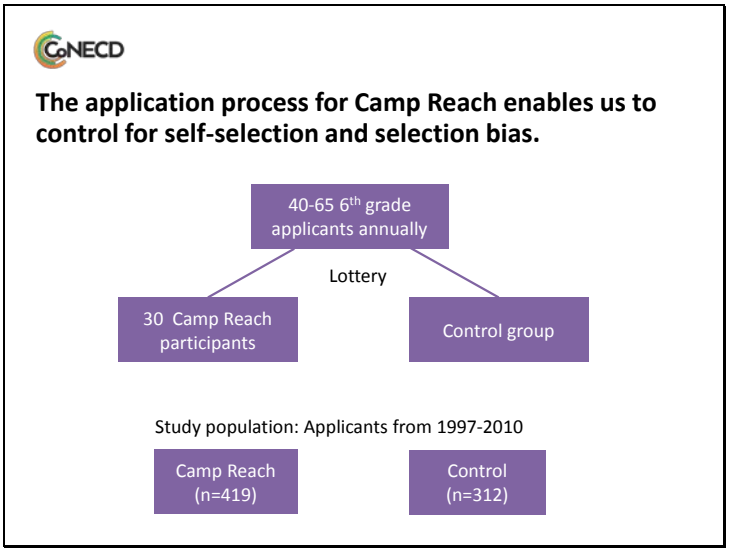

Our application and selection process is what enables us to identify an appropriate control group for longitudinal studies. The application involves a brief essay about working hard at something. We do not consider or collect references or grades. There is a surplus of applicants each year for a limited number of spots. Rather than choosing the best essays we simply use a lottery which results in a natural control group– girls who applied to the program, showing openness to a 2-week STEM experience as a 6th grader, but were not randomly selected to participate.

This study focuses on applicants in the first 14 years of the program (1997-2010), which includes 419 in the intervention group and 312 in the control group.

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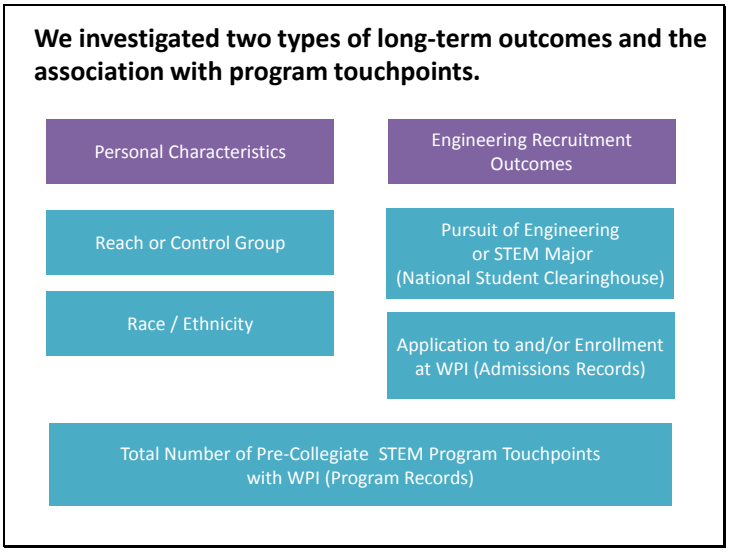

We investigated two types of recruitment outcomes. First was the major they pursued in college. Data about applicants' college major and/or degree attainment were obtained from the National Student Clearinghouse (NSC) StudentTracker for Colleges & Universities, a nationwide source of enrollment and degree data. The NSC reports that more than 3,600 institutions regularly provide enrollment and graduation data. This set of institutions enrolls over 98% of students in public and private institutions of higher education in the U.S. **We obtained data about major or degree field for 576 of the 731 subjects (79%) in the study.** (Many others were found but their universities did not include degree field in the data they reported.) We used categories from the National Center for Education Statistics (NCES, 2011) to classify majors as Engineering, STEM or non-STEM fields. This classification does NOT categorize the social or behavioral sciences or health fields as STEM. We chose this classification because it was most consistent with the goals of our program.

For the second outcome variable, we used our university's admissions records to record whether each subject in the study applied to, was accepted to, or enrolled as an undergraduate at our institution.

We also created another variable called "touchpoints." Attending a WPI STEM program is referred to as a "touchpoint." Returning during high school as a volunteer Teaching Assistant is also considered a touchpoint. An important limitation is that we could not find records for numerous programs across several years, including some programs for rising 9th and 10th grade girls. However, this limitation applies equally to both study groups. The touchpoints also do not include returning for Camp Reach reunions (typically 30-40 alumnae attend each reunion), since

we did not keep reliable records of attendance. For both of these reasons, the touchpoints reported in this study must be considered a lower bound. We show this variable straddling both columns because it could be considered either an independent or dependent variable.

Analysis methods: Cross tabulations were created to compare the number of subjects in the Camp Reach and Control groups who demonstrated particular outcomes. Pearson's chi-square test of independence was used to determine whether differences between the two groups were statistically significant. If differences were significant, Cramer's V was used to characterize the strength of association between the variables. The effects of race and touchpoints on STEM and recruitment outcomes for subjects in both groups were examined using two-level chi-square tests.

Limitations: The analysis methods used in this study are quite basic and must be considered exploratory in nature. We considered conducting a logistic regression analysis (i.e., a logit model) with study group, race/ethnicity, and touchpoints as independent variables and entry into STEM majors and recruitment outcomes as the dependent variables, which would enable us to discern the relative influence of each independent variable. However, we decided that such a model would be potentially misleading for a number of reasons. Other studies have shown the influence of additional demographic factors including parents' education, occupation and socioeconomic status, in particular, on young women's pursuit of STEM education pathways. Those data are not requested in our program application, and we cannot account for the possible influence of those variables on differential education and recruitment outcomes of the Camp Reach and Control groups. We also have no information about subjects' school experiences and participation in non-WPI STEM enrichment programs, both of which could influence the dependent variables in this study.

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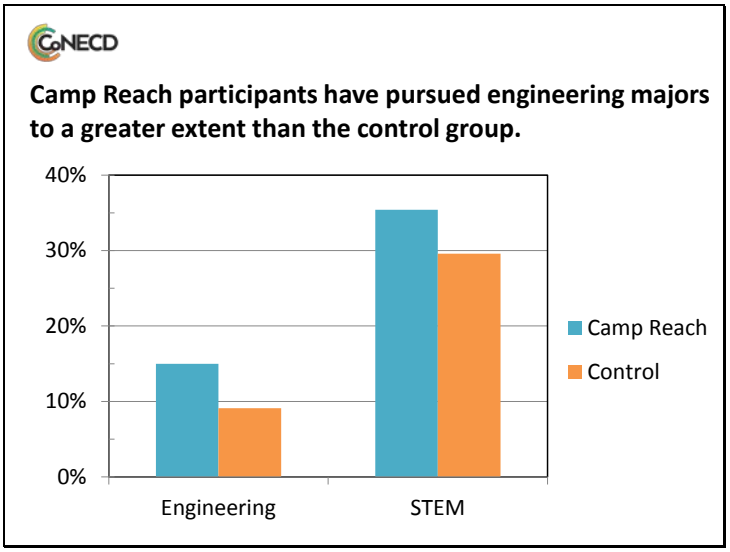

Compared to the control group, more women who had completed Camp Reach in middle school pursued **engineering pathways at any university** (15% vs 9%). A chi square test revealed a significant relationship between group membership and engineering degree/major. The value of Cramer's V statistic indicates that the strength of association between group membership and pursuit of an engineering degree is small, however. There was no significant relationship between group membership and pursuit of STEM degrees/majors (35% for Camp Reach, 30% for Control).

This result suggests that the engineering focus of the program is effective in helping young women understand what engineering is and to see themselves as engineers. Being introduced to engineering and women engineers during the formative middle school years in an out-of-school context may be helpful given that, compared to the sciences, there is less attention to engineering in formal schooling and fewer role models who are engineers.

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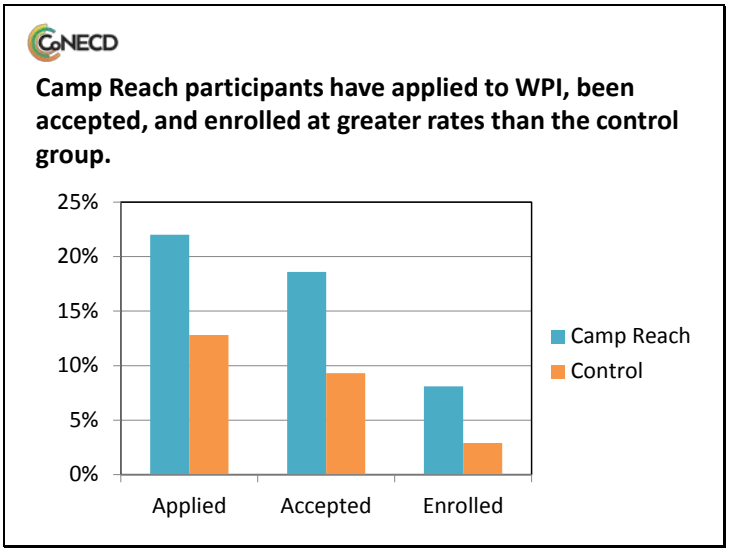

This graph shows that alumnae of Camp Reach were more likely than those in the Control group to apply, be admitted, and to enroll at WPI. Our university is STEM intensive (more than 90% are STEM majors), so this also suggests significant interest in pursuing STEM). All of these differences are statistically significant with small strengths of association. The acceptance rate was somewhat higher for the Camp Reach group (85%) than for the Control group (73%). The admissions yield, defined as the percentage of accepted applicants who enrolled, was 44% for the Camp Reach group compared to 31% for the Control group.

We considered and ultimately rejected the possibility that differential admissions practices or special consideration for Camp Reach alumnae might explain the differences in recruitment outcomes between the two groups. (Can provide details after talk if anyone is interested.)

One limitation of this study is that it does not provide insight into the reasons behind the more positive WPI recruitment and enrollment outcomes for the Camp Reach study group. Without qualitative data, we can only speculate about possible factors. One possibility is that coming to the university for multiple programs creates a sense of connection and "fit" with the campus community that affects the college choice. There's some support for that in the literature. It is also possible that Camp Reach alumnae are attracted to WPI's project-based curriculum, which includes significant elements of collaboration and teamwork, a project in the humanities and arts, and an intensive interdisciplinary project embedded in a social-humanistic context. (In fact, the project experience in Camp Reach was modeled after that particular undergraduate degree requirement.)

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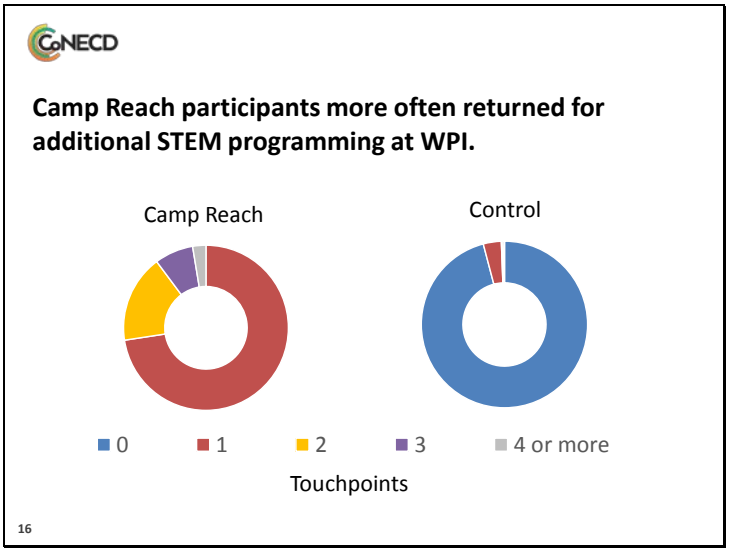

These graphs show that girls in the Camp Reach group were much more likely than those in the Control group to have multiple touchpoints with WPI pre-collegiate programming. Within the control group, only 4% (red and gray portion of right donut) had one or more touchpoints; that is, after applying to Camp Reach and not being offered a spot, they applied for and attended a different pre-collegiate STEM program at our university. In contrast, 27% of the girls in the Camp Reach group (yellow, purple, gray) had two or more program touchpoints; after completing Camp Reach they attended at least one additional STEM program.

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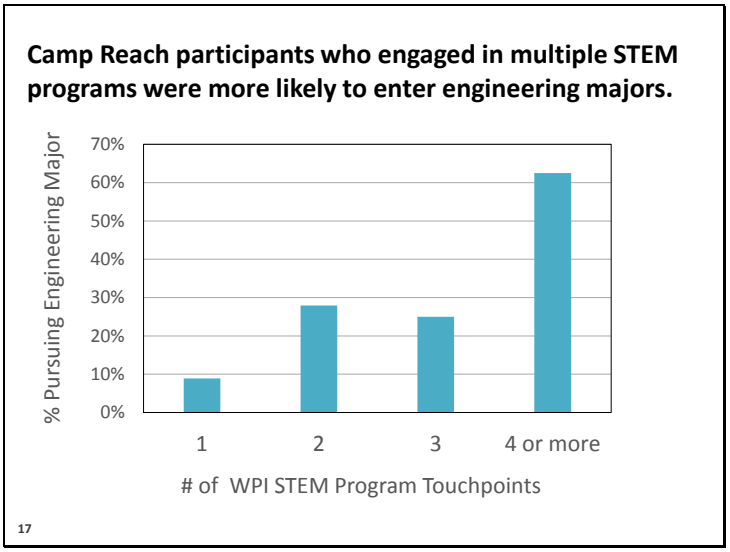

The number of program touchpoints was strongly associated with both engineering education outcomes and WPI recruitment outcomes for all girls in the study population, regardless of study group. In this graph, for simplicity, we show just girls in the Camp Reach group. The association between engineering education outcomes and program touchpoints was stronger than that between engineering education outcomes and study group. The same held true for applications to WPI.

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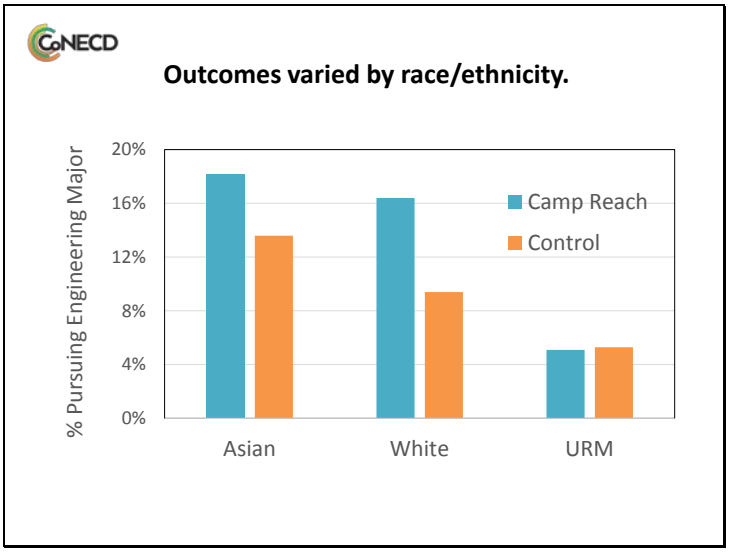

A disappointing, if not surprising, finding of this study is that the positive education and recruitment outcomes of Camp Reach differ by race/ethnicity. The positive association between those outcomes and participation in Camp Reach is dominated by the benefits for young white women. Outcomes for Asian women were strong, and outcomes for URM women were weak, whether or not they participated in Camp Reach. Thus, this program has not yet disrupted those same patterns of inequity seen in U.S. society. Once again, we can only speculate as to the reasons why. This study cannot account for the confounding influence of other variables such as quality of schooling, socioeconomic status, and parental education or support. An analysis of the touchpoints data for Camp Reach participants does show a significant association between racial group and number of WPI program touchpoints: Only 10% of URM participants in Camp Reach returned in subsequent years to another program, compared to 30% of White participants and 43% of Asian. It is possible that the program experience is not as positive for URM participants, or that they experience stereotype threat which may lessen the likelihood of their returning for another program. It may also be that the families of URM participants disproportionally do not have the financial, time, or transportation resources to take advantage of additional STEM programming at WPI.

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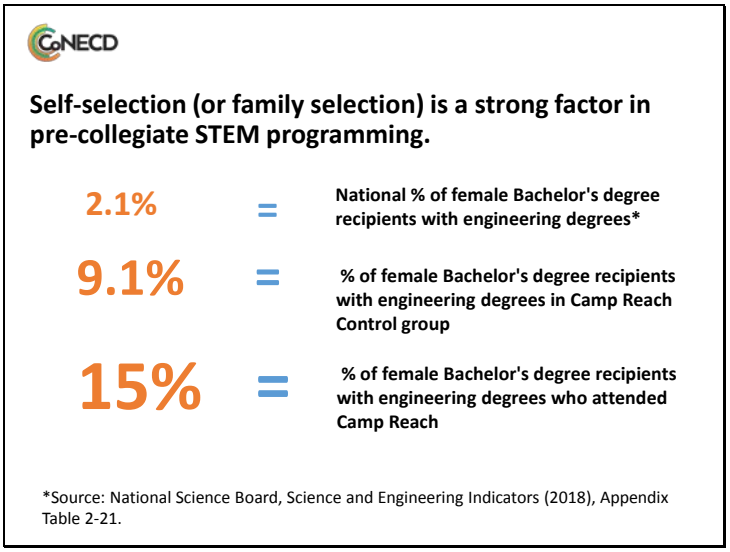

This study also illustrates the importance of acknowledging, and controlling for, self-selection bias when assessing the outcomes of pre-collegiate STEM programming. A comparison of this study's data with national statistics shows that girls who applied to this engineering-intensive outreach program as sixth graders were much more inclined than the overall population of females seeking higher education to pursue engineering or STEM degrees as an undergraduate. In 2007, the year when most in the first cohort of Camp Reach applicants graduated from college, 1.6% of female bachelor's degree recipients were in the fields of engineering or engineering technology. By 2015, that figure increased to 2.1%. In comparison, 15.0% of the Camp Reach group and 9.1% of the Control group, with approximate graduation years of 2007-2020, either earned or are still pursuing bachelor's degrees in engineering or engineering technology. Clearly, many girls' interests in STEM have already been formed by the sixth grade, and many others have already rejected those pathways, which supports arguments for interventions in even earlier grades.

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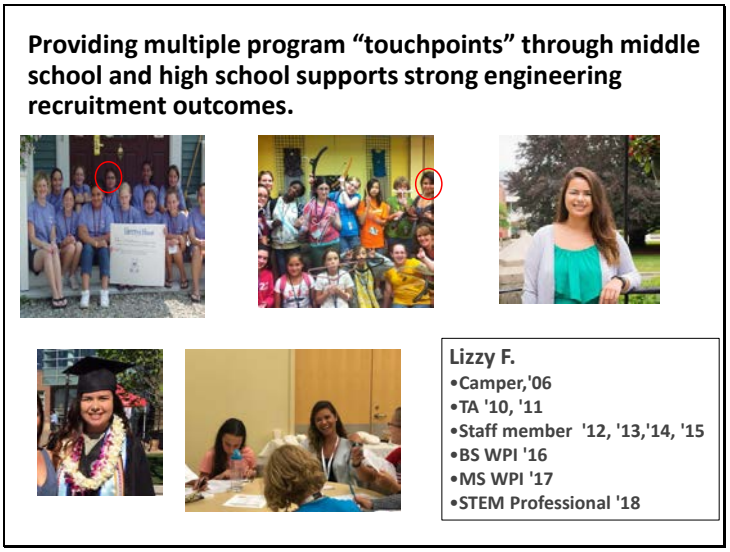

Perhaps the biggest contribution of this study is that it shows the **benefit of universities offering multiple STEM outreach programs** for young women, from early middle school through high school. The number of WPI STEM-program touchpoints was strongly associated with engineering education outcomes, regardless of study group. Outcomes were not nearly as strong for those who had a "one and done" experience with WPI as a rising 7th grader. We should be especially careful not to infer causality, however. We cannot differentiate between the possibility that participating in multiple outreach programs enhances persistence, or that pre-disposition and high levels of interest in engineering leads to participation in multiple programs, or a combination of both. Still, studies of STEM identity formation would seem to suggest the benefits of returning to, refining, and deepening one's self-concept as an engineer or scientist through multiple authentic experiences in the practice of engineering or science, reconnecting with or expanding a set of role models, and socializing with a supportive peer group.

Our study also suggests that coming to a host university for multiple programs may create a sense of connection to the campus community that affects the **college choice**. The young woman portrayed above is one of our campers, Lizzy. Lizzy joined the program after being encouraged by a teacher who had participated in the program previously. Lizzy frequently attended reunions and stayed in touch with the program until she was old enough to be a teaching assistant. She participated as a teaching assistant for two years. After she applied and was accepted to WPI, she continued to work with Camp Reach as a staff member for 4 years while she was an undergraduate. She is currently working as a professional and returned to the program this summer in the capacity of professional mentor.

While not every program participant will have a story like Lizzy's, there is a significant amount of similar qualitative data for other program participants. This anecdotal information in combination with the results of this study, make a very strong case for institutions to consider creating a pipeline of programming that allows for program participants to return to campus on a regular basis.

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CoNECD

Please take this opportunity to make comments or ask questions.