An Effective Industry-Based Mentoring Approach for the Recruitment of Women and Minorities in Engineering

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Abstract

This article reflects upon an investigative study of the powerful impact that mentoring partnerships have on pre-college students and young engineering professionals in Hartford, CT. It was found that these partnerships can provide very strong foundations for a diverse pre-college student engineering pipeline that includes significant numbers of women and under-represented minorities. The approach used is based on the principle of cross-age peer mentoring and combines industry-based mentoring with diversity-aware mentor recruitment strategies to 1) cultivate and train a corps of diverse mentors; 2) develop a suite of informal mentoring activities; and 3) apply and generate knowledge about the impact of effective mentoring strategies in overcoming barriers to women and under-represented minorities in engineering. The mentoring program was established at three Greater Hartford area public schools serving different population segments: suburban, multicultural suburban, and urban tuition-free charter school. Diverse engineering professionals were recruited from local tech companies and trained to hone their mentoring skills. Additionally, mentoring assistants, including female and minority undergraduate engineering students, were recruited to help during mentoring sessions. The mentoring activities, evidence of program success, and future plans are presented and discussed. Results show that students who participate in industry-based mentoring are 55% more likely to demonstrate more interest and confidence in STEM subjects as well as 25% more likely to show greater interest in pursuing STEM careers.

1. Introduction & Background

1.1 Statistics

Statistics show that colleges and universities in the United States currently award approximately 300,000 STEM degrees annually. Projections, however, indicate that one million more will be needed in the next decade, than the US will produce at the current rate if the country is to retain its preeminence in science and technology (President's Council of Advisors on Science and Technology [PCAST], 2012). This situation calls for roughly a 34% annual increase in undergraduate STEM degrees through a combination of increased recruitment of students into STEM fields and increased retention of STEM majors. A closer inspection of the statistics reveals that the bulk of the burden lies with recruitment in engineering, primarily mechanical, electrical, civil, and chemical engineering, which account for nearly two-thirds of all engineering degrees at the bachelor's level (Fig. 1). According to the National Science Board (NSB, 2014) US colleges and universities conferred only 83,263 bachelor's degrees in engineering in 2012, approximately 38% below the numbers required to fill the needs of the US engineering workforce. Jobs requiring engineering training are growing five times faster than other occupations (National Science Foundation [NSF], 2014), but pre-college student interest in science and mathematics, which is an essential preparation for an engineering college degree, has been eroding nationally among women and minorities, as well as in communities where a college education has not been the norm.

1.2 Gender & Racial Disparities in STEM

The low rates of participation of under-represented minorities (URM)—women and ethnic minorities—in the engineering workforce has been a concern of policymakers who are interested in developing diverse human capital to maintain the United States' global competitiveness and pre-eminence in STEM. With regard to gender disparities in STEM employment, historically, men have outnumbered women by wide margins and although billions of dollars have been devoted to leveling the field, the disparities are still staggering (NSF, 2014) with women representing only 28% on average of those individuals in STEM occupations. Female numbers are lowest for engineering at 13% followed by computer science 23% and the physical sciences 30% (Fig. 2). The participation of URM in the STEM workforce (Fig. 3) also exhibits similar

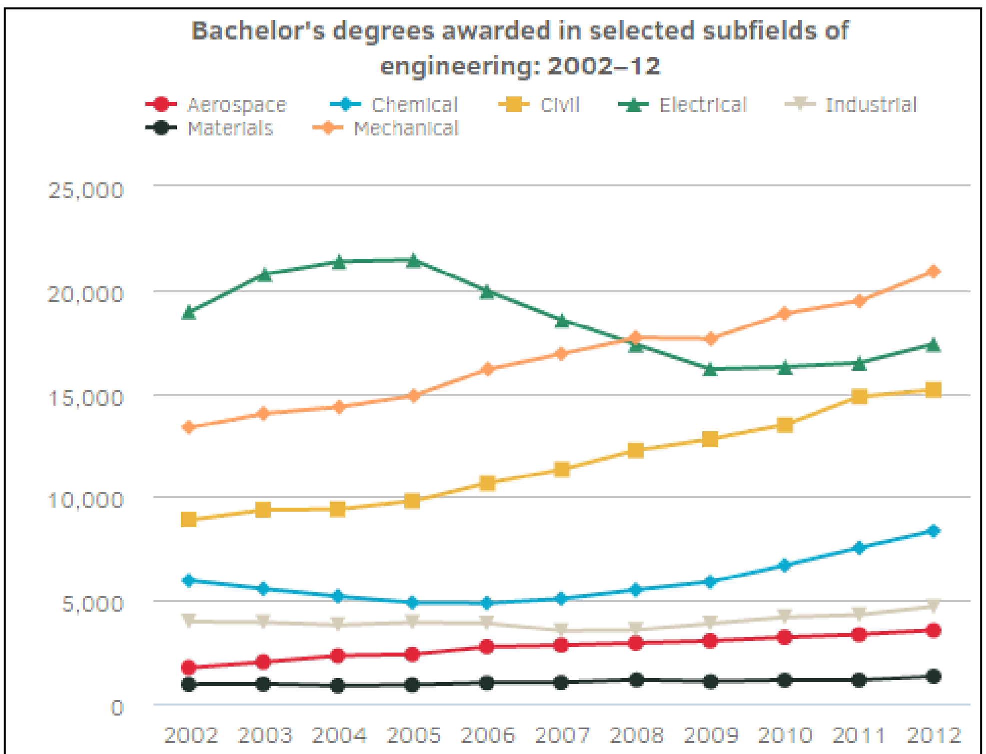

Figure 1. Bachelor Degrees in Engineering (Source: NSF, Science & Engineering Indicators 2014, Ch. 2, Undergrad Education, Enrollment & Degrees in the US). Retrieved from: https://www.nsf.gov/nsb/sei/edTool/data/engineering-01.html

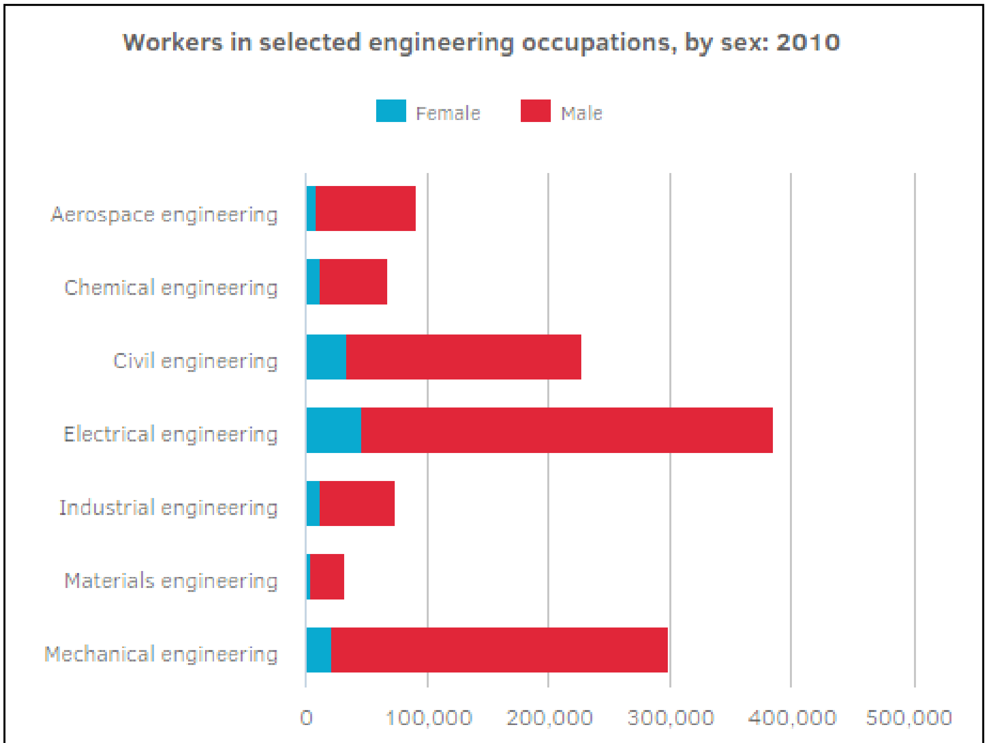

Figure 2. Gender Disparities in Engineering Jobs (Source: NSF, Science & Engineering Indicators 2014, Ch. 3, Women and Minorities in the S&E Workforce). Retrieved from: https://www.nsf.gov/nsb/sei/edTool/data/engineering-03.html

disparities: in 2010, among the 5.4 million workers employed in STEM occupations, 70% were white, similar to the proportion (68%) in the US population. Asians, with nearly a million workers in STEM occupations, accounted for 19% of STEM employment, far above their proportion in the general population (5%), while Blacks at 6% and Hispanics at 5% reflected proportions well below their numbers in the general population. Although the majority of interventions designed to address gender and racial disparities in engineering exclusively target the **undergraduate college population**, it is widely acknowledged that the lack of interventions in **K-12** is why so few URMs entertain the idea of a career in engineering. By waiting until students are in college before applying interventions, we are directing recruitment and retention resources at a mere 9% of potential female and 4% of potential minority engineers. Here we propose a more effective strategy that introduces simple engineering concepts and applications informally early in K-12 so that the role of the engineer in society, as well as the requirements for obtaining an engineering degree, are clearly understood well before the students begin to think about applying to college. In this case, negative stereotypes about engineers are dispelled early and students are trained to focus on long-term benefits of engineering as a career rather than short-term challenges (such as difficulty with topics in math and physics) that are notorious for derailing students. Although the Next Generation Science Standards (NGSS) seek to address the problem of lack of early exposure to engineering, so far, very few states have adopted these standards. Overall, there is a critical need for interventions that (i) target the pre-college female and minority population, (ii) can be quickly and easily implemented and (iii) do not require significant changes to K-12 science curricula. The work that is reported in this paper presents an intervention that simultaneously aligns with these requirements.

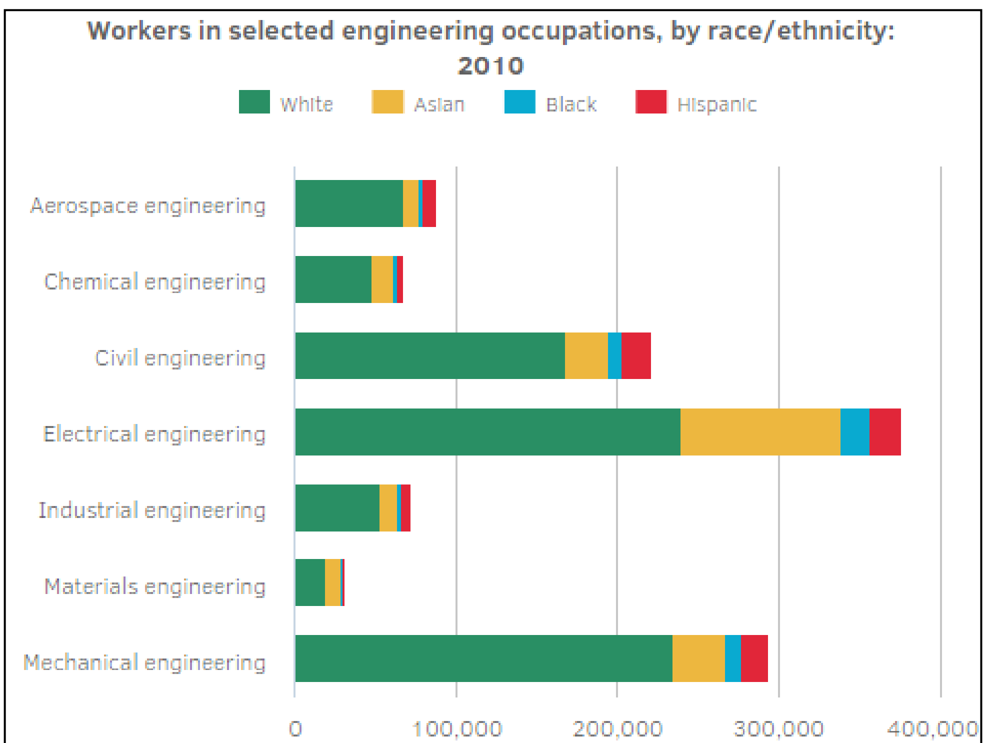

Figure 3. Racial and Ethnic Disparities in Engineering (Source: NSF, Science & Engineering Indicators 2014, Ch. 3, Women and Minorities in the S&E Workforce). Retrieved from: https://www.nsf.gov/nsb/sei/edTool/data/engineering-03.html

1.3 The University of Hartford STEM Program—*STEM UP!*

As female engineers, the authors have a wealth of first-hand national and international experience in academia and the engineering industry. The lead author, Abby Ilumoka had a successful career as a minority female professor of electrical and computer engineering at the University of Hartford (UHA) for over twenty years prior to taking up her current position as program director for engineering education at the National Science Foundation. One of the co-authors, Ivana Milanovic is an accomplished female professor of mechanical engineering with research interests in vortical flows and computational fluid dynamics at the University of Hartford. The other co-author, Natalie Grant is a dynamic female minority mechanical engineer with expertise in measurement systems and instrumentation for aircraft engine design at Pratt & Whitney Aircraft Inc.

During her tenure as a minority female engineering professor at UHA, the lead author recognized that in the engineering classroom women and minorities are simultaneously cast into two opposing roles. On the one hand, they are active agents in the classroom because they bring to it uniquely rich perspectives and creative thinking styles, but on the other hand they are "victims" in the sense that they are thrust into a learning environment specifically designed for and dominated by males for the last 250 years. In 2008, at the University of Hartford ***STEM UP!*** was established. *STEM UP!* is a comprehensive pre-college STEM immersion program designed to identify strategies that overcome barriers to women and under-represented minorities in STEM, particularly in engineering. With enthusiastic support from school administration and faculty, ***STEM UP!*** was conducted at three middle and high schools in Greater Hartford (Ilumoka, 2012a). The program was composed of four components: 1) industry-based mentoring program featuring practicing female and minority STEM professionals as mentors; 2) after-school, classroom-based, hands-on STEM workshops involving construction and testing of real-life engineering subsystems; 3) five-week summer day camp involving exposure to hands-on STEM projects; 4) parent/guardian workshops designed to inform and empower parents in their efforts to support their children's success in STEM.

The lead author in partnership with the coauthors sought answers to a barrage of important questions regarding pedagogical practices and student experiences in the STEM classroom. Examples include: How do boys and girls experience STEM classroom culture differently? How do minorities experience STEM classroom culture? What are the key factors driving recruitment and retention of women and minorities in STEM classrooms? How do gender and racial differences in communication styles affect the dynamics of STEM classroom learning? Does the fact that women find equal fulfillment in relationships and achievements affect learning in the STEM classroom? Results are reported in the literature (Ilumoka, 2012a; Ilumoka, 2012b; Ilumoka & Srivastava, 2012).

2. Industry-Based Mentoring

A large number of powerful interventions aimed at increasing the number of URM in STEM have been implemented nationwide over the last thirty years. These interventions are generously funded, grounded in educational theory and often based on compelling evidence. This raises the question: Why so little impact? Given the experience with ***STEM UP!*** and based on diligent examination of pertinent literature in STEM diversification over the last three decades, the authors concluded that one very likely reason why the level of representation of URMs in STEM has failed to increase is the fact that a vital "catalytic agent" is missing from many of the interventions devised. This missing ingredient is **mentoring,** specifically, mentoring by industry-based professionals. For the purposes of this paper, the following relatively broad definition of industry-based mentoring is assumed: a program or intervention that is intended to promote youth interest in engineering via relationships between young persons (less than eighteen years old) and specific non-parental adults who are professional engineers acting in a non-professional helping capacity. Mentoring is a flexible intervention strategy that can be applied in diverse contexts for a wide range of purposes. When it comes to promoting URM interest in engineering fields, no amount of technological gadgetry, pedagogical innovation, or financial intervention can replace the person-to-person bond of encouragement forged in a structured and intentional mentoring relationship. At its best, this type of mentoring relationship is similar to one between a parent and a child or between a committed faculty member and a student. A recent meta-analysis of more than seventy-three independent mentoring programs (DuBois, Portillo, Rhodes, Silverthorn, & Valentine, 2011) found positive outcomes across social, emotional, behavioral, and academic areas of youth development. Because of the perception that math and science are abstract and challenging fields of study, the authors posit that when industry-based mentoring is included as a key component, interventions that seek to broaden participation in engineering are much more likely to be successful. There are a host of different types of mentoring relationships depending on the individuals, goals envisioned and the environment; however, to be truly effective, mentoring needs to be long-term, continuing throughout the mentee's educational and professional careers. This is especially true at critical career points such as the transition from high school to college, from college to the workplace, and during various promotion and advancement experiences.

This paper describes a powerful and effective strategy that was observed to increase interest in engineering of female and minority middle and high school students. The approach taken is to establish strong mentoring partnerships between pre-college students on the one hand and young engineering professionals on the other. The latter includes recent engineering graduates practicing in a variety of high tech industries in the Greater Hartford area. The professionals were individuals motivated to mentor middle and high school students to become knowledgeable and confident about engineering through participation in the industry-driven mentoring program, a key component of ***STEM UP!*** The mentoring component is based on the principle of cross-age peer mentoring (Kammeyer-Mueller & Judge, 2008; Bruce & Bridgeland, 2014; Karcher, Kuperminc, Portwood, Sipe, & Taylor, 2006; Allen, Eby, O'Brien, & Lentz, 2007) in which a person who has lived through a specific experience (peer mentor) provides support and encouragement to a person relatively close in age who is new to that experience (the peer mentee). The industry-based mentoring concept combined with diversity-aware mentor recruitment strategies was used to achieve the following three goals

(i) cultivate and train a corps of diverse industry-based engineering mentors
(ii) develop a suite of informal mentoring activities that can be made available to schools in the Greater Hartford area
(iii) study impact of and generate knowledge about mentoring strategies that are effective in overcoming barriers to URMs in STEM

STEM UP! activities provided the basis for answering the following two research questions:

1. To what extent and in what ways does participation in industry-driven mentoring improve students' interest and confidence in STEM subjects?
2. To what extent does participation in industry-driven mentoring improve students' interest in pursuing engineering as a career?

As described in section 1.3, the ***STEM UP!*** program featured a variety of informal learning activities including hands-on projects, summer programs, parent workshops, and shadowing experiences in industry (Ilumoka, 2012b). The program laid the foundation for the construction of a diverse pre-college engineering pipeline in Greater Hartford.

2.1 Industry-Based Mentor Concept & Mentor Recruitment

The idea of industry-based mentoring was conceived at the University of Hartford in Connecticut in 2008. Why industry mentors as opposed to any other type of mentor? Industry-based engineering mentors are engaged in solving real life engineering problems on a daily basis. They have both the theoretical grounding and the practical perspective needed to solve these complex problems. Industry mentors routinely engage in the iterative engineering design process, making critical trade-offs between multiple conflicting objectives, often having to take into account the business and financial aspects of the problem. Frequently, they also have to deal with ethical and moral constraints in relation to engineering design. For these industry mentors, the theoretical foundations of math and science that once appeared tedious and unnecessary now form the bedrock of engineering system design. The trigonometry and physics are no longer abstract, but instead provide the contextual and theoretical backdrop to problems. These facts combined with today's computer simulation and 3D-visualization capabilities give mentors a much fuller understanding of the engineering system at multiple levels of operation. As a result, industry mentors are able to bring into the classroom an engineering perspective that is socially relevant, exciting, and understandable for pre-college students. This is particularly helpful to students hesitant about pursuing an engineering career due to math and science-related anxiety.

Mentor recruitment was relatively easy in the Greater Hartford area. Hartford is fortunate to have many high-tech engineering industries located within a twenty-five mile radius of the city, including the headquarters of Pratt & Whitney Aircraft, one of the largest manufacturers of aircraft engines in the world. Other industry giants include Hamilton-Sundstrand (now UTC Aerospace Systems, UTAS), Otis Elevators, ASEA Brown Boveri, and Kaman Aircraft. The College of Engineering Technology and Architecture at the University of Hartford is home to a thriving research and development hub known as the Engineering Applications Center (EAC, 2016) a vehicle for collaboration with industry in conducting applied research involving students, faculty and staff. Partner companies in the EAC work side-by-side with faculty and students to develop cross-disciplinary solutions to industry challenges. Engineering students are exposed to real-life engineering challenges through capstone projects and research. Through the EAC's industry-based projects and professional connections, the authors were able to recruit diverse mentors to participate on a voluntary basis in the industry-based mentoring program.

3. Description of the Industry-Based Mentoring Program (*STEM UP!*)

3.1 Mentees

Hartford, Connecticut, is the second most segregated metro area in the United States (Florida, 2014) with regard to economic dissimilarity between its population and others in surrounding towns. Given Hartford demographics (43% Hispanic, 39% African American, 16% Caucasian) and an urban school system with many challenges, the huge potential benefits of the diversity-aware, industry-based mentoring program are clear. The mentoring program was established at three public middle/high schools in the greater Hartford area: 1) Jumoke Honors Academy Middle School; 2) Bloomfield High School; and 3) Simsbury High School. Bloomfield High is a multicultural suburban high school serving 700 students in grades 9 through 12 with 92% minority students. Simsbury High School is a suburban public school serving 1500 students in grades 9 through 12, 90% of whom are Caucasian. Jumoke Honors Academy Middle School is a tuition-free public charter school that allows taxpayer dollars to empower parents and students through educational choice. Jumoke Academy serves 450 students (98% minority) in grades 6 through 8 and is located in an urban setting. At each of the two high schools, cohorts of 15 young women in grades 9 and 10 were encouraged to voluntarily participate in the industry-based mentoring program one afternoon per week after school during the academic year. Additionally, at Jumoke, cohorts of twelve girls in grades 6 through 8 were encouraged to enroll for the all-girls mentoring program conducted separately from an all-boys' program (cohorts of twelve boys) on a different day of the week.

3.2 Industry Mentors

Twenty-five ethnically diverse male and female engineers with an average age of about 27 years were recruited from local tech companies as ***STEM UP!*** industry mentors. They were encouraged to train online to hone their skills in a variety of areas of mentoring areas (National Mentoring Resource Center, 2015) including clear communication, promotion of self-directed learning, invi-

Figure 4. Pratt & Whitney Mechanical Engineer Explains Principle of Aerodynamic Thrust

Figure 5. Otis Elevator Computer Engineer (right) Explains Electrical Conductivity to Middle School Student

Figure 6. High School Student (left) Displays Soda-Bottle Solar Flashlight to UT Aerospace Industry Mentor

tation of conversation about different points of view, and provision of constructive feedback. Industry mentors were very busy individuals, practicing engineers (Figs. 4-6) who were genuinely invested in the success of URMs in engineering and who generously volunteered their time to visit schools as role models. Each mentor made a commitment to be available for 40-75 minutes no more than one afternoon per month after the school day (between the hours of 2:00 and 4:30 p.m.). Additionally, to assist the mentors in the classroom during the ***STEM UP!*** mentoring sessions, a diverse group of mentoring assistants were recruited. They consisted of college students from the University of Hartford, – primarily female and minority engineering sophomores and juniors.

3.3 Mentoring Activities

A typical mentoring session lasted 45 to 75 minutes and was conducted by the industry mentor with a school teacher present in the classroom. The mentoring session began with an interactive presentation by the mentor on topics ranging from her daily activities on the job to personal career experiences and pathways to engineering. Many mentors realized the importance of connecting with the students in a way that showed a desire to help and often invited the students to sit with them in a circle on the floor while they shared workplace experiences. They talked frankly about challenges they faced as minority and/or female engineers in a male-dominated field and dispelled the myth that to major in engineering a student had to be a math wiz. Some mentors provided healthy snacks and used this as a launch-pad for discussions about the role of the engineer in the food industry. Mentors brought in artifacts from work (Fig. 4) to illustrate concepts for students and to serve as a souvenir of the visit. Mentor presentations were interactive and followed by questions from and discussions with students. After the presentation, mentoring assistants helped to coordinate synergistic activities inspired by the industry mentors' presentation. For example, after interaction with an industry mentor from the biomedical engineering field on the biomechanical design of a prosthetic arm, the college mentor organized students into teams to design prosthetic arms using simple everyday materials such as empty paper towel rolls, elastic bands, string, glue, and balloons. Students then competed in teams to see which arm was able to grip and lift the greatest weight. On another occasion, following a presentation by a civil engineering industry mentor who worked in bridge safety monitoring, the mentoring assistants organized students into teams to construct bridges using balsam wood and glue. A competition then followed to see which bridge could withstand the greatest load. Other popular topics were robotics illustrated by construction and programming of sumo wrestling robots and renewable energy demonstrated by construction of soda bottle solar flashlights (Fig. 6). For interested students, over the summer, ***STEM UP!*** industry mentors, in collaboration with parents, arranged shadowing visits to their workplaces.

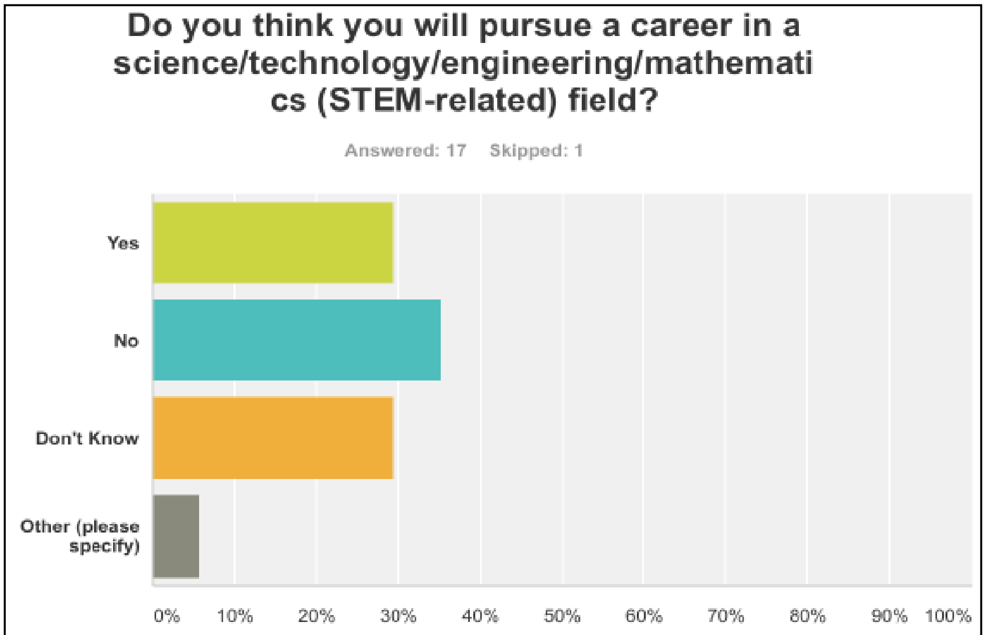

Figure 7. Interest in Pursuing a Career in STEM: Pre-Mentoring Response

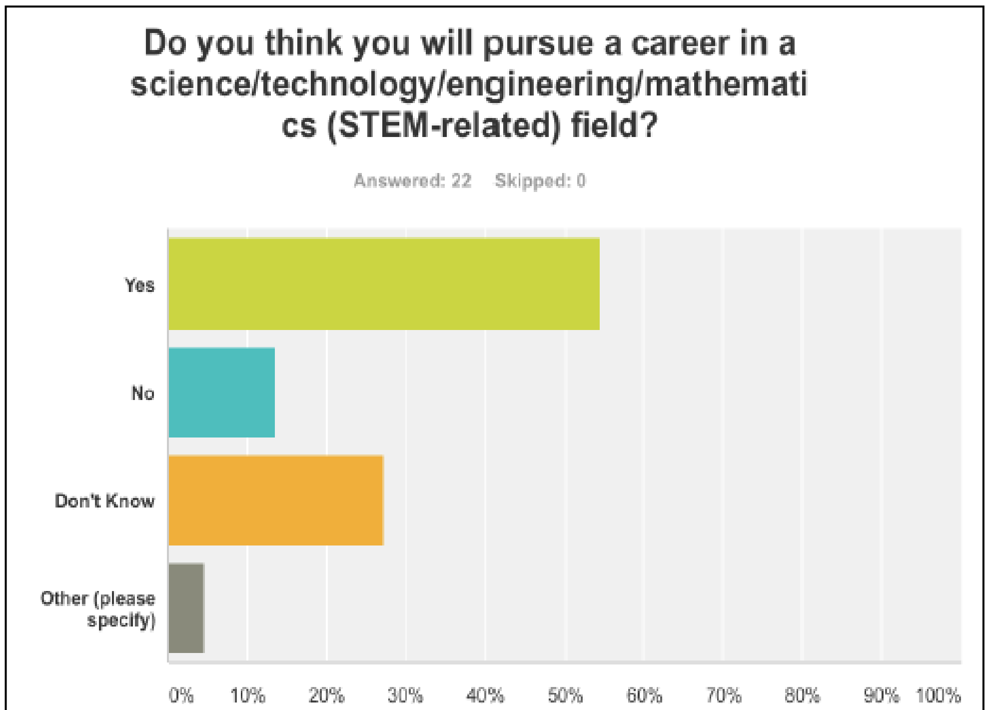

Figure 8. Interest in Pursuing a Career in STEM: Post-Mentoring Response

3.4 Surveys

Web-based surveys created in Survey Monkey were administered anonymously to students. Survey questions varied widely and were designed to elicit responses that helped to answer research questions and identify best practices for industry-based mentoring. Survey results gave valuable insight in many areas including (i) changes in mentee interest and confidence in engineering; (ii) changes in mentee interest in pursuing engineering as a career; (iii) changes in mentees' critical thinking skills; and (iv) changes in mentors' career satisfaction. Mentored and non-mentored students were surveyed and the results compared (see section 4 below). Mentors were also periodically surveyed to ascertain their opinions on certain aspects of the program.

4. Outcomes & Lessons Learned

The activities of the industry-based mentoring program led to two significant outcomes linked to the two research questions in section 2. First, increased interest and confidence in STEM subjects was observed in students who participated in the program. Second, increased interest in pursuing engineering as a career was also observed. These results were derived primarily from survey responses and student interviews. Due to space limitations, only the most important findings (see Figs. 7-8 and Table I) are presented here.

With regard to careers in STEM, prior to exposure to industry-based mentoring, only 29% of students (Fig. 7) indicated that they might pursue a career in STEM. After fourteen weeks of participation in ***STEM UP!*** including exposure to ten industry mentors, the percentage of students interested in pursuing STEM careers almost doubled, increasing to 55% (Fig. 8). Along with this, prior to mentoring (Fig. 7), the proportion of students who did not want to pursue careers in STEM was 35%. Post-mentoring (Fig. 8), this percentage dropped significantly to 12%.

With regard to the impact of industry-based mentoring on students' interest and confidence in STEM subjects, the results are also clearly very positive (Table I). Fifty-five percent of students reported that the experience moderately increased their confidence and ability to participate in school in science and engineering projects, while 9% reported great increases and 27% slight increases in confidence (Table I, row h). It is worth noting that 80% of students reported slight to moderate impact on their decision to work harder in school (Table I, row e). Ninety percent of students felt more confident in their ability to successfully pursue STEM subjects in school and college (Table I, row g). Finally, seventy-three percent decided to reassess their future course selections in light of what they learned from exposure to ***STEM UP!*** industry-based mentoring (Table I, row f).

On the whole, the authors observed that students formed positive relationships with industry mentors as well as the mentoring assistants, seeking advice on projects and career choices. Industry-based mentors helped to set realistic and quantifiable goals when it came to students' psychological and academic preparation. It was found that students' relationships with school teachers were strengthened; furthermore, mentors reported many positive effects on their lives. Although ***STEM UP!*** began with 56 students and 25 mentors at just three schools, the program very quickly expanded into a highly sought-after enrichment experience in the Greater Hartford area. The summer sessions in particular had an acceptance rate of about 10%, while the after-school program was fully subscribed months ahead of time.

5. Sustaining the Mentoring Pipe-line

For URMs, it is important that the mentorship experience be sustained throughout their careers. There are documented concerns from organizations such as the Society of Women Engineers that track the attrition rate of women who work within the STEM fields. An anonymous survey of 3,200 engineers across four major companies (3M, Booz Allen Hamilton, Honeywell Aerospace, and United Technologies Corp.), focused on values and perceptions of corporate culture in an attempt to find out why so many women leave jobs in the science, technology, engineering, and math fields within a decade of entering the STEM workforce while their male counterparts do not (Zazulia, 2016). The study revealed that although men and women may have the same values, they react differently to challenges and frustrations within corporations. Women tend to have less tolerance for the bureaucracy and politics that often impede them from achieving their career goals and therefore end up leaving the STEM workplace around the decade mark (Zazulia, 2016). For URM, the mentoring relationship, once successfully established in the K-12 phase, is a good but not sufficient foundation for ensuring persistence in STEM. Often, the mentoring experiences inspire URMs to actively seek out worthwhile mentors throughout their STEM careers thus helping to mitigate the risk of departure from the profession. Mentors can provide valuable information about how to navigate failures in workplace relationships, challenges and frustrations with respect to industry expectations, as well as facilitate extended periods of successful growth in industry. Career-long mentoring is a topic of further research for the authors.

6. Conclusions and Future Work

Research described in this paper confirms that quality industry-based mentoring relationships can have powerful and positive effects on the life trajectory of mentees. Experiences with the ***STEM UP!*** mentoring program at the University of Hartford have demonstrated that young people who are exposed to industry-based mentors have more positive visions of themselves and their futures. With regard to careers in STEM, they achieve more positive outcomes in math and science in school and are more likely to continue on to college to study engineering. Overall the results show that students who participate in industry-based mentoring are 55% more likely to demonstrate more interest and confidence in STEM subjects as well as 25% more likely to show greater interest in pursuing STEM careers. The indication is that industry-based mentors help to set realistic and quantifiable goals when it comes to psychological and academic preparation of middle and high school students for engineering. They also help maintain focus and lay the groundwork for connecting students to useful engineering career resources.

Row	Effect of Mentoring	Not Sure (%)	Not At All (%)	Slightly (%)	Moderately (%)	A Great Deal (%)
a	(a) Helped me understand science/engineering better	0	0	27.3	63.6	9.1
b	(b) Led me to a better understanding of my own career goals	0	9.1	18.2	54.5	18.2
c	(c) Increased my interest in studying science/engineering in college	0	0	54.5	36.4	9.1
d	(d) Made me think more about what I would do after graduating high school	0	27.3	18.2	18.2	36.4
e	(e) Made me decide to work harder in school	20	0	40	40	0
f	(f) Made me decide to take different classes in school than I had planned	18.2	9.1	45.4	18.2	9.1
g	(g) Made me more confident in my ability to succeed in science/engineering	0	9.1	36.4	45.4	9.1
h	(h) Increased my confidence in my ability to participate in science/engineering activities	0	9.1	27.3	54.5	9.1

Table I. Effect of Industry-Based Mentoring: Interest and Confidence in STEM Subjects

7. References

President's Council of Advisors on Science and Technology (PCAST). (2012). *Engage to Excel: Producing One Million Additional College Graduates with Degrees in STEM.* Washington, DC.

National Science Board (NSB). (2014) *STEM Education Data and Trends 2014.* Retrieved from: http://www.nsf.gov/nsb/sei/edTool/data/engineering-03.html

National Science Foundation. (2014). *Science and Engineering Indicators 2014*. Retrieved from: http://www.nsf.gov/statistics/seind14/index.cfm/chapter-3/c3s5.htm

Ilumoka, A. (2012a), Strategies to Overcome Barriers to Women and Minorities in STEM, *Integrated STEM Education Conference (ISEC)*, March 2012, Ewing, NJ.

Ilumoka, A. (2012b), Strategies to Overcome Barriers to Women and Minorities in STEM, *ASQ STEM Agenda Conf*, July 2012, Univ. of Wisconsin, Menomonie, WI.

Ilumoka, A. & Srivastava, P. (2012) , Strategy for Encouragement of Women and Minorities in STEM Using Peer-led Micro-Nano Technology Instruction, *Micro-Nano Technology Conference*, May 2012, Penn State University, PA.

DuBois, D. L., Portillo, N., Rhodes, J. E., Silverthorn, N., & Valentine, J. C. (2011). How Effective Are Mentoring Programs For Youth? A Systematic Assessment of the Evidence. *APS Association for Psychological Science, 12*(2) 57-91. doi: 10.1177/1529100611414806.

Kammeyer-Mueller, J. D., & Judge, T. A. (2008). A quantitative review of mentoring research: Test of a model, *J. Vocat. Behav.*, 72, 269–283. doi: 10.1016/j.jvb.2007.09.006

Bruce M., & Bridgeland, J. (2014). The Mentoring Effect: Young People's Perspectives on the Outcomes and Availability of Mentoring. Washington, DC: Civic Enterprises with Hart Research Associates for MENTOR: The National Mentoring Partnership.

Karcher, M. J., Kuperminc, G., Portwood, S., Sipe, C., & Taylor, A. (2006). Mentoring programs: A framework to inform program development, research, and evaluation. J. *Community Psychol, 34*(6), 709-725. doi: 10.1002/jcop.20125.

Allen, T. D., Eby, L. T., O'Brien, K. E., & Lentz, E. (2008). The state of mentoring research: A qualitative review of current research methods and future research implications, *J. Vocat. Behav., 73*, 343–357. doi: 10.1016/j.jvb.2007.08.004.

Engineering Applications Center (EAC), University of Hartford. Retrieved from: http://www.hartford.edu/ceta/about/activities/eac/

Florida, R. (2014). The US Cities Where the Poor Are Most Segregated from Everyone Else. The Atlantic City Lab. Retrieved from:
http://www.citylab.com/housing/2014/03/us-cities-where-poor-are-most-segregated/8655/

National Mentoring Resource Center, Resources for Mentors. Retrieved from: http://www.nationalmentoringresourcecenter.org/index.php/what-works-in-mentoring/resources-for-mentoring-programs.html

Zazulia, N. (2016). Women Leave STEM Jobs for the Reasons Men Only Want To. US News & World Report. Retrieved from:
http://www.usnews.com/news/articles/2016-04-08/study-women-leave-stem-jobs-for-the-reasons-men-only-want-to

National Mentoring Resource Center, Resources for Mentoring Programs
http://www.nationalmentoringresourcecenter.org/index.php/what-works-in-mentoring/resources-for-mentoring-programs.html

Abby Ilumoka currently serves as program director for engineering education in the Division of Undergraduate Education at the National Science Foundation. Prior to joining NSF in September 2015, Abby was a Professor of Electrical and Computer Engineering at the University of Hartford in Connecticut, a position she held for 22 years. Abby's research focus within DUE is to use her experience and background in engineering research to broaden participation in STEM nationally by harnessing extensive information about diverse students' backgrounds, interests and perceived barriers in STEM as well as data on NSF funding decisions to optimize the STEM education enterprise.

Ivana Milanovic is a full-time faculty member in the Mechanical Engineering Department at the University of Hartford. Her area of expertise is thermo-fluids with research interests in vortical flows, computational fluid dynamics, multiphysics modeling, and collaborative learning strategies. Dr. Milanovic is a contributing author for more than 80 journal articles, NASA reports, conference papers, and software releases, and she is a member of the Connecticut Academy of Science and Engineering.

Natalie Grant is a dynamic female minority mechanical engineer with expertise in measurement systems, instrumentation, and egress for aircraft engine design. She has fourteen years of experience and currently works for Pratt & Whitney Aircraft, a United Technologies Company. In her spare time Natalie enjoys spending time with family, practicing the piano, meditating, and Tai Chi. She attributes her success as a mother and an engineer to the infinite support from her family. Natalie is also a proponent of encouraging young children to pursue a career within the STEM fields and volunteers in activates promoting the progress of our communities.