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The Business Case for Engineering Skills-based Volunteerism in K-12 Education

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Michael Richey is an Associate Technical Fellow currently assigned to support workforce development and engineering education research. Michael is responsible for leading learning science research, which focuses on learning ecologies, complex adaptive social systems and learning curves. Michael pursues this research agenda with the goal of understanding the interplay between innovation, knowledge transfer and economies of scale as they are manifested in questions of growth, evolvability, adaptability and sustainability.

Additional responsibilities include providing business leadership for engineering technical and professional educational programs. This includes topics in advanced aircraft construction, composites structures and product lifecycle management. Michael is responsible for leading cross-organizational teams from academic, government focusing on how engineering education must acknowledge and incorporate this new information and knowledge to build new methodologies and paradigms that engage these developments in practice. The objective of this research is focused on achieving continuous improvement and sustainable excellence in engineering education.

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Deepa is responsible for developing Boeing's strategies to support early learning, primary and secondary education, and ensure alignment with post-secondary workforce initiatives across the company. Throughout her career, she has worked on a range of issues including U.S. public health, global health and economic development, the arts, and nonprofit capacity development. Prior to Boeing, she was a senior program officer for the MacArthur Foundation and a consultant with McKinsey. In 2012, President Obama appointed her to the National Council on the Arts. Deepa has an MBA from Northwestern University, an MPA from Harvard University, and an AB from the University of Chicago.

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Current research interests involve socio-cultural perspectives on cognition, learning, graphical representation, and use of technology in formal and informal learning environments. I explore diffusion of innovations systemically across multiple learning environments and stakeholder communities. In particular, I am interested in teacher/learner interaction across various settings, including multi-dimensional design-based implementation research (DBIR) in various workplaces and academic institutions. In addition, my work looks at the impact of co-constructed methodologies in settings that are a mix of informal sites as well as traditional (but evolved) classrooms. I am engaged in a longitudinal research project for teacher professional development in informal learning environments and blended arenas (MOOCs and SPOCs) that impact student performance and engagement. I look at questions involving fluency in geo-literacy around consequential everyday issues and 'sense of place.' For this research I examine prevailing western worldviews of science that are constructed and derivative of Cartesian principles and philosophic underpinnings and compare them with other worldviews that take native and aboriginal account of the ways we view our relationship with the planet and with each other.

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Danielle L. Vermeer is a strategist focused on corporate citizenship, employee community engagement, and social innovation. In her current role as a Strategy Analyst on the Global Corporate Citizenship team at Boeing, she provides strategic support and coordination for GCC's K-12 education investments, and contributes to the company's integrated corporate citizenship and skills-based volunteerism initiatives. Prior to Boeing, Danielle worked as a program manager at a philanthropy and social impact consulting firm, advising philanthropists, foundations, and impact investors on how to be more strategic in their investments in education, environmental sustainability, global health, and other areas. She is also a Fellow at the StartingBloc Institute for Social Innovation, a network for over 2,200 emerging leaders in corporate responsibility, social enterprise, and nonprofits. Danielle has a B.S. with honors from Georgetown University's School of Foreign Service.

The Business Case for Engineering Skills-based Volunteerism in K-12 Education

Abstract

Skills-based volunteerism programs can provide technical employees effective and meaningful opportunities to utilize, develop, and transfer their skills while contributing to their companies' community engagement objectives in K-12 education. While many companies encourage their employees to engage in education-related volunteerism, these efforts are often one-off events related to student outreach or recruiting, rather than opportunities for employees to utilize their skills to not only give back to community, but also develop professionally and personally. This study focuses on assessing the impact of a pilot skills-based volunteerism program on the skills and mindsets of professional engineers, who translate their science, technology, engineering, and math (STEM) skills in open-ended engineering design challenges that they subsequently teach to elementary students and their families in underserved, community-based out-of-school programs. This study suggests that community partners, engineers, and the sponsoring company each benefit from this skills-based volunteerism program: community partners directly gain access to working engineers and high-quality, real-world STEM content; engineers develop their communication, creativity, and leadership and mentoring skills, while also broadening their cultural awareness of and engagement with underserved communities; and sponsoring companies indirectly benefit from their engineers' increased skills, networks, and engagement.

Introduction

Education is fundamental to developing and sustaining healthy, productive, and innovative societies and economies. In a rapidly changing, globalized economy, the skills that every student needs to be successful in the 21st century include problem solving, creativity, critical thinking, and analytical reasoning—skills that are increasingly important for jobs that require academic degrees in science, technology, engineering, and math (STEM), as well as those that do not necessarily require STEM degrees.[1] Furthermore, the rate of job and industry growth in STEM subjects is outpacing other sectors.[2,3] In the United States, however, there are an inadequate number of students graduating in STEM fields, a situation which results in increasing competition among companies for a limited pool of local talent.[4] U.S. high school graduation rates are low compared to other developed countries, and of U.S. students who do graduate, many are unprepared to succeed academically.[5] These challenges are felt acutely by manufacturing[6] and high-tech employers, especially those with largely U.S.-based workforces and an increasingly global footprint.

While education is a main focus for many companies' corporate citizenship or community engagement programs, companies with expertise in engineering, science, advanced manufacturing, and other high-tech areas are particularly interested in engaging in educational programs and reaching students who are traditionally underrepresented in STEM fields. These companies are interested in not only building students' STEM-related skills, but also their awareness of potential careers and opportunities in these sectors. Skills-based volunteerism programs enable employees to contribute to their company's corporate citizenship objectives in

K-12 education by inspiring and preparing students and by helping to develop a more diverse pipeline.

It is common to describe community benefits of volunteer activities; however, the effects of volunteerism on the individual and the underserved communities comprise a two-way street. There is a reciprocal impact on the volunteer that feeds back into the corporate entity. This study focuses on the latter contribution and tests whether tangible benefits to the individual engineers and/or the corporate entity can be identified from the program. We establish the volunteer engineer as a unit of study – either in solo or in dyadic/triadic teams–and ask if the volunteer can develop professional skills, including simplifying the communication of complicated science and technical concepts; amplify an ability to work in teams; transfer knowledge to their colleagues and non-technical audiences; and develop adaptability in a highly-variable learning environment such as a community-based out-of-school program. This research, therefore, is focused on assessing the impact of a volunteerism engagement on the skills and mindsets of working engineers, who translate their knowledge of science and engineering in the creation of open-ended engineering design challenges that they subsequently teach to students and their families in community-based out-of-school programs called Family Science Nights.

This skills-based volunteerism program is the result of a partnership between the Global Corporate Citizenship team – the community engagement arm of the company – and a nonprofit educational organization to develop open-ended engineering design challenges that are intended to bring aerospace engineering, technical, and scientific content to life for K-12 students and their families. Through this partnership, the company plans to engage 80-100 engineers and scientists over the next 18 months, who will create 25 design challenges based on their work and expertise. These challenges will be integrated into community-based programs that the Global Corporate Citizenship arm of the company supports with philanthropic dollars across several major geographic sites. This study reports on the first two iterations of this program where two cohorts of volunteer teams (N=26) delivered STEM design challenges in different geographic regions in Family science events described here. To support the kick-off of the creation of these design challenges, the engineering and technical function of the company co-invested in the program, providing labor budget to defray the cost of engineers' time (around 8 hours) in online and in-person trainings, where they learned how to create the design challenges and teach effectively to elementary and middle school students and their families. Engineers volunteered the remaining time – up to 15-20 hours of work – to develop the design challenge and engage with families at a Family Science Night.

Program Goals

The Family Science Nights are intended to benefit both participants and engineers. The goal for students and their families is to generate exposure to the field of engineering and the engineering design process by engaging with working engineers, as well as to nurture and cultivate students' curiosity, persistence, and creativity through the development, test, and retest of engineering design challenges. These tangible, positive, and experiential learning opportunities and direct engagements with engineers attempt to make the engineering field more accessible to underserved communities, thereby opening up a pipeline to low-income and/or minority students who are traditionally underrepresented in STEM fields. Prior research has shown that volunteerism models similar to the one used in this project are effective in engaging underserved students and parents in informal STEM-related learning, and that these programs lead to positive changes in attitudes and behavior regarding science exploration and engineering design challenges.[7]

Meanwhile, the goal for engineer volunteers includes a plan to inspire and prepare students through engineering design challenges and, at the same time, to develop their own professional and personal skills. Engineer volunteers self-assigned in small teams (pairs or trios) that aligned with company prescribed strategic imperatives. These consisted of coupling more senior, technical experts (mentors) with more junior, technical colleagues (mentees) to facilitate knowledge transfer within the company, and further, to facilitate boundary crossing and relationship-building across business units and generations.[8] Engineers are particularly challenged to develop existing and new skills; communications skills by translating their work effectively and simply to non-technical audiences; leadership skills by presenting the engineering design challenge in partnership with their co-facilitator(s); and creative problem-solving skills by assisting students and their families in iterating and persevering in the design challenge process.

Employee Community Engagement and Corporate Citizenship

Employee community engagement or corporate citizenship initiatives such as skills-based volunteerism programs can contribute to overall employee engagement and drive value for the business. Companies are increasingly investing in employee engagement efforts in order to recruit, retain, and develop their workforce amidst high levels of disengagement, shifting workforce demographics, and a competitive marketplace for talent. Research by Gallup indicates that less than one-third of workers in the United States are engaged in their jobs, resulting in higher turnover rates, lower productivity and profitability, and higher costs to companies and the overall economy.[9] In fact, Gallup estimates that actively disengaged employees cost the U.S. economy between $450 billion and $550 billion annually.[9] In addition, for many companies, the demographics of their workforce are shifting rapidly as they onboard millennial employees, 90% of whom want to work for companies with strong corporate citizenship reputations and programs.[10] Companies are also promoting employee engagement efforts in order to attract and retain talent in a strengthening and therefore more competitive market.[11]

One key component of a company’s engagement efforts is volunteerism, including both traditional and skills-based volunteer opportunities. According to Deloitte, 88% of human resources executives report that employee volunteerism has a positive impact on an organization’s reputation, 65% believe that employees develop skills through skills-based volunteerism, and 52% consider volunteerism an extremely or very important part of the corporate culture.[12] Companies that strategically align their volunteer programs with skills and leadership development, among other efforts, may improve recruitment and retention of talent, especially among millennial and skilled workers who view volunteerism as one of many ways to grow professionally.[13]

Methodology

Research Questions

This study focuses on measuring the collateral value of skills-based volunteerism programs to a company and its employees. Key questions relate to these issues: How does an aerospace company translate the work of professional engineers into meaningful engineering design challenges for underserved communities? Is it possible to itemize a business case for philanthropic commitments (time and effort) to underserved communities? In other words, is it possible to document the impact of volunteerism at a corporate level through studying the trajectory of individual engineers as they engage, create, and deliver engineering design challenges in local communities?

Research Methods

This study utilizes a mixed method research design. This involves collection and analyses of quantitative and qualitative data from surveys, interviews, and observation protocols.

1. Quantitative data is primarily collected through a pre- and post-survey instrument that is used to measure changes in behaviors, attitudes, or experiences. The data are intended to analyze and document attitudinal and emotional changes. The objective is to better understand individual volunteer experiences and describe how these translate to tangible changes in the workplace and for the company overall. There are currently two sites of data collection and analysis in this study. The first site of data collection was gathered in Southern California at two locations (Huntington Beach and El Segundo) where engineers developed, presented, and facilitated design challenges to students and their families in local communities. The second site of data collection took place in the Puget Sound region of Washington State.

2. Qualitative, ethnographic data is also gathered from structured phone interviews with volunteer engineers after they present their design challenges at the Family Science event; video recordings in situ at the location; and in-person observations by trained observers during the presentation and design challenge build. This analysis relies on grounded theory [15,16] to specify the conditions that give rise to specific actions and interactions associated with the skills-based volunteerism program in similarly underserved urban locations. We employ system-wide theoretical assumptions (in relation to the settings), and analyze the symptoms that emerge. We look at questions that bring meaning to volunteerism from a corporate standpoint, and which investigate the social, political, economic, and civic implications for industry partnerships with the educational system.

Research Instruments

This mixed method study uses three research instruments to collect data: (1) pre- and post-survey, (2) a structured observation protocol, and (3) an exit interview protocol.

1. Pre- and Post-Surveys

The pre- and post-surveys were designed to better understand the impact of skills-based volunteerism on incumbent engineers and by extrapolation, on the company. The pre- and post-surveys each contained identical questions and solicited information about volunteers' beliefs pertaining to their communication skills and attributes, teaching and mentoring skills and attributes, community engagement, and attitudes about how this particular volunteer experience relates to their professional skills. The pre-survey contained an additional section with demographic questions to elicit further information about the volunteers in the program, including gender, previous volunteer and teaching experience, engineering specialty, current employment position, and number of years working at the company. The objective of this type of data collection was two-fold: (i) to establish a baseline snapshot of participant populations in terms of demographics, experience within their field, and relevant experience pertaining to presenting and/or teaching in K-12 environments; (ii) to ascertain if engineer volunteerism has an impact at the corporate level inside the company, and, in particular, to describe and understand any impact on morale and growth of personal skills/attributes that play out in the workplace as a result of this engagement.

Quantitative data from the pre- and post-surveys were analyzed using Statistical Package for the Social Sciences (SPSS, analytics software) with various frequency and central tendency analyses to establish significant findings with regard to identifying employees' attitudes, beliefs, and self-evaluation of various employment, mentoring, and communication skills. Data from subsequent phases of this study will be added to the database as it becomes available, and additional statistical analyses will be performed. Data was collected electronically via a proprietary internal company survey tool and all identifying representations were scrubbed to ensure anonymity for participants during analysis. Participants were also protected by Internal Review Board structures, which were adhered to in the implementation of this study.

2. Observation Protocols

The observation protocol enabled detailed collection of volunteer engagement and interaction during the two-hour Family Science Nights in local communities. Trained volunteer observers gathered data as the Family Science event progressed. The protocol contained tables and comment sections for monitoring and capturing engineers' interactions and engagement levels with their mentor or mentee, students, and families who were engaged in the Design Challenge.

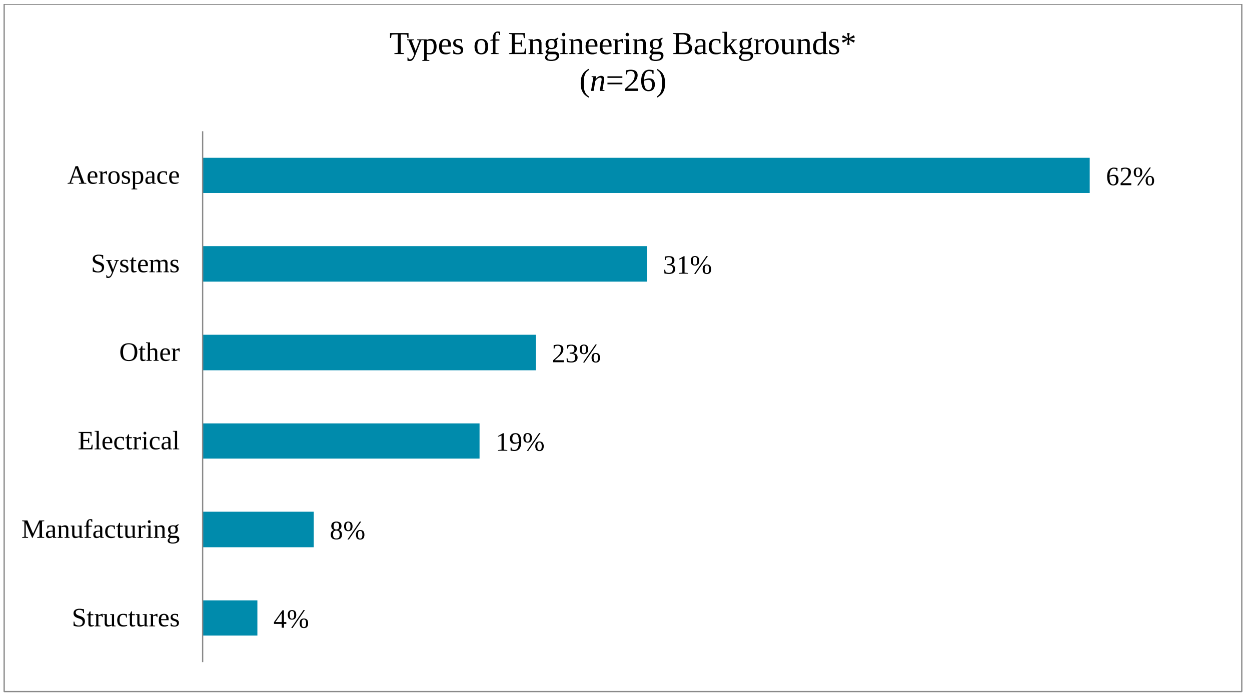
3. Exit Interviews

Each engineer also participated in a standardized, 25-30-minute exit interview via phone that discussed facets of the skills-based volunteerism program, such as their motivation for participating, perceived impact on their professional and personal skills, impact on their relationship with their mentor or mentee, and assessment on how the program represented the company in local communities.

Subjects

Participants in this study derive from highly qualified engineers and scientists who self-selected from the company's Technical Fellowship program, which comprises approximately 1.5% of the company's workforce and represents some of the best engineering and scientific minds in the industry. These Tech Fellows were invited to participate (collaborate with their technical mentees) to inspire K-12 students with STEM skills and knowledge, based on real-world examples related to their work. Twenty-six participants self selected for the first phase of this study. An additional 39 engineers are currently participating in this skills-based volunteerism program in other locations, and their data will be incorporated into the overall analyses as it becomes available. Most of the participant engineers were Technical Fellows who have been at the company for over 20 years and have aerospace engineering backgrounds (see Figure 1. Engineering Type in the Design Challenge Volunteering Project). Of the 26 volunteers in the first phase of this study, half (50%) are Tech Fellows, 31% are technical mentees, and 81% are male. In addition, 62% of the participants were aerospace engineers, an expected outcome of working at an aerospace company.

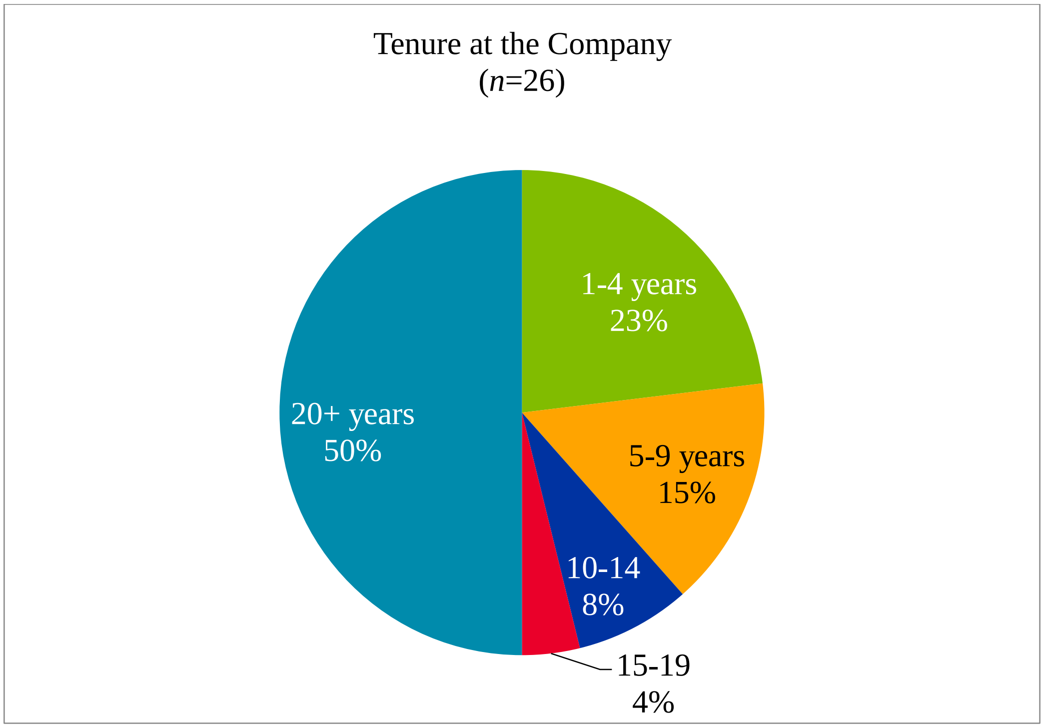
Figure 1. Engineering Type in the Design Challenge Volunteering Project



*Note: Percentages do not sum to 100% because respondents selected all choices that applied to their backgrounds.

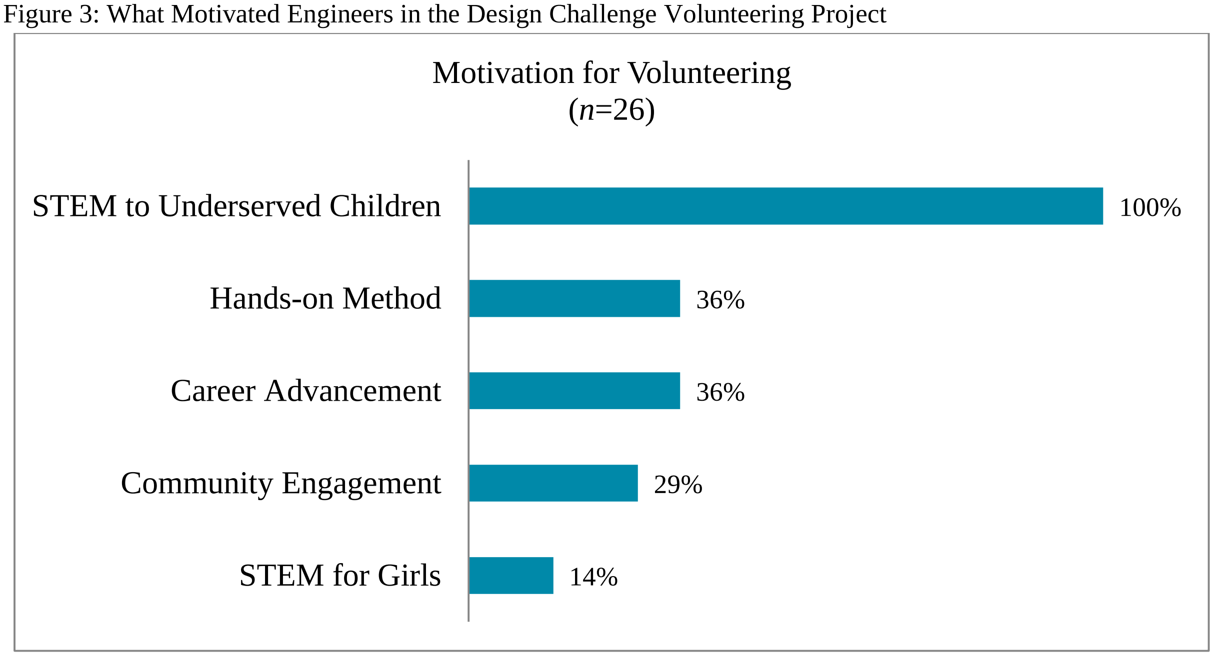
Most participants also skewed toward either just beginning their career at the company (e.g., 1-4 years) or being more advanced in their careers (e.g., 20 years or more at the company), which is likely the result of recruiting from the Technical Fellowship program (see Figure 2. Length of Time at the Aerospace Company in the Design Challenge Volunteering Project).

Figure 2. Length of Time at the Aerospace Company in the Design Challenge Volunteering Project



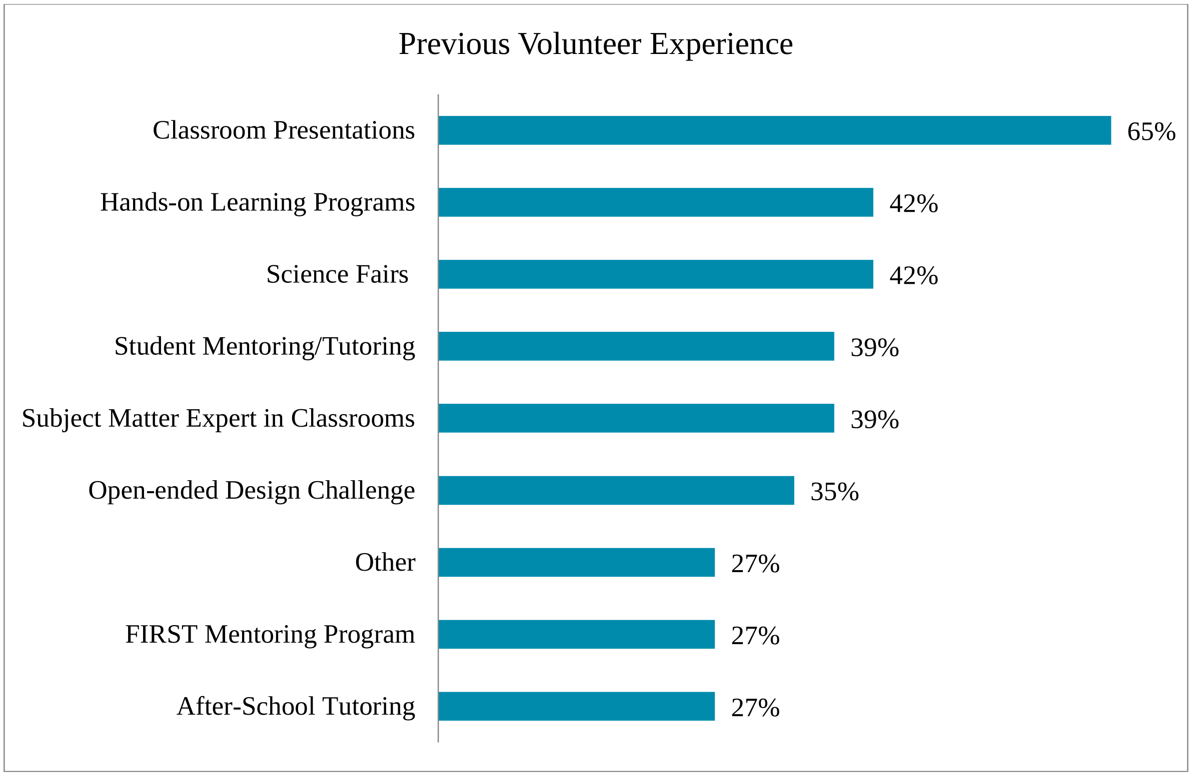
The volunteers' main motivation for participating was to encourage students, especially those from underserved backgrounds, to build their STEM knowledge and skills (see Figure 3). To a lesser degree yet still notable, engineers were also interested in the program because it incorporates hands-on, problem-based learning and can contribute to their own career development or personal advancement.

Figure 3: What Motivated Engineers in the Design Challenge Volunteering Project



In addition, many engineers were eager to build relationships and rapport with their colleagues outside of formal work environments and to share their technical knowledge with their mentees through the engineering design development process. Most of the engineers' previous volunteer experience involved classroom presentations, science fairs, and hands-on learning (see Figure 4. Previous Experience for Engineers in the Design Challenge Volunteering Project). However, this was the first time for most of the engineers to be involved in elementary education programs of this nature.

Figure 4. Previous Experience for Engineers in the Design Challenge Volunteering Project



Limitations

As with many studies that focus on interactions between elementary school children, their parents and high-skilled contributors, access, time commitments, and scheduling presented limitations. This volunteerism study involved engineers with their industry demands limiting the number of engineers who could devote time and space to this engineering design challenge. A small *n* limits the generalizability and transferability of claims associated with the findings. Furthermore, although 26 participants were involved in this study from start to end, only 15 post-surveys were collected, further limiting conclusions that can be drawn. For this reason, we have specifically chosen to explicate our findings using a mixed method analytic frame[i] that triangulates data sets and variables. As this study moves further into the second phase, additional data collection and improved survey tracking will increase participant numbers and survey responses. This study is currently limited to basic distribution (frequency), central tendency analyses (median, mode), and other statistical procedures as a result of the Likert scale (1 to 5) individual question items, but as more survey data are collected, construction of scaled composite variables may allow for more nuanced statistical analyses.

Findings

We begin with quantitative results that emerge from pre- and post-survey tools that sought to ascertain the impact of this project on skills and attributes of the volunteering engineers. Results will be displayed under several headings that serve to summarize the skills and attributes in succinct areas on meaning to the company and culture: (i) communication; (ii) teaching and mentoring; (iii) community engagement, and (iv) volunteerism.

Quantitative Results

Overall findings suggest that community partners benefit directly from skills-based volunteerism programs, while volunteers and, by association, companies indirectly derive value from these engagements. In almost all survey questions, for instance, volunteer engineers reported stronger communication skills after their volunteer experience than before.

1. Communication skills and attributes

The pre-survey prompted volunteers to report whether they expected the skills-based volunteerism program to help them develop professional skills such as effective communication, critical thinking, and working with elementary aged children (see Tables 1a and b). Overall, the engineers indicated in the pre-survey that they expected the volunteer experience would help them develop some types of skills, but would not improve other types of skills. Most engineers expected the program to improve their communications skills through focus on listening, (52%), presenting (60%) and effectively explaining difficult/technical concepts to non-technical people (64%). Table 1a displays pre survey responses for 25 participants (central tendency—Mode—is highlighted in green), and Table 1b compares post survey responses for 15 participants (some of the participants were not able to complete the post survey due to work engagements).

Table 1a. Agreement with statements related to communicating technical concepts

Pre-Survey Communication Skills & Attributes	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	n
Listening is one of the most important aspects of effective communication	0%	0%	0%	52%	48%	25
I have strong presentation skills	4%	0%	16%	60%	20%	25
I can effectively explain difficult/technical concepts to non-technical people	0%	0%	16%	64%	20%	25
I believe that my body language all support the information I am conveying	0%	0%	40%	56%	4%	25
I believe difficult technical concepts can be explained or modeled for children.	0%	0%	16%	44%	40%	25

*Central tendency (Mode) is highlighted

The post-survey assessed the engineers' perspective on skills development after they had completed the skills-based volunteerism program. In comparison to the pre-survey, engineers in the post-survey reported agreeing more that the program improved some key professional skills. Most of the engineers (75%) indicated that their communications skills were improved as a result of participating in this volunteer program, which included an intensive training on how engineers and scientists can effectively translate their technical knowledge and experiences to non-technical audiences. In particular, volunteer engineers report that their presentation skills were enhanced by this program (73%), and that their ability to effectively explain difficult/technical concepts to non-technical people had improved (67%). In that same vein, participants strongly agreed that difficult/technical concepts could in fact be explained or modeled for children (47%).

Table 1b: Agreement with statements related to communicating technical concepts

Post-Survey Communication Skills & Attributes	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	n
Listening is one of the most important aspects of effective communication	0%	0%	0%	50%	50%	14
I have strong presentation skills	0%	0%	13%	73%	13%	15
I am able to effectively explain difficult/technical concepts to non-technical people	0%	0%	7%	67%	27%	15
I believe that my body language all support the information I am conveying	0%	0%	20%	53%	27%	15
I believe difficult technical concepts can be explained or modeled for children.	0%	0%	13%	40%	47%	15

2. Leadership, Teaching, and Mentoring Skills

A number of questions in the study related to engineers' leadership, teaching, and mentoring skills before starting their engagement in this program and again directly after their involvement in the family science event (see Tables 2a and b). Data from the pre- and post-survey comparisons are described here. While, in general engineers had pretty optimistic and positive impressions about how their skills would relate to design challenges with elementary school children and their families, a number of items stand out as being enhanced by the participation in the program. For instance, most engineers agreed that at the outset they were fairly effective at teaching difficult concepts to non-technical people (58%). However after their experience in the family Science program, more participants agreed that they could effectively teach difficult topics to non-technical people (67%). Similarly, awareness and sharpening of teaching ability was evident by the increase from Pre- (50%) to Post- (60%) survey results of capacity in defining learning objectives in the Family Science program. Learning objectives are an essential ingredient of successful teacher preparation enabling knowledge transmission to others in a standard learning environment. Many engineers don't have opportunities to think about assessment in their typical work schedule let alone formative assessment techniques for improving learning in the classroom. Yet in this interactive engagement with elementary school children, these volunteer engineers had to implement formative assessments in their design challenges so that learning would be observable and families and students would be successful in their design and build endeavors. As a result, engineers report that their belief in the use of formative assessment in classroom instruction improved from 58% pre-survey to 71% post-survey.

Table 2a. Agreement with statements related to leadership, teaching, and mentoring

Pre-Survey Teaching and Mentoring Skills & Attributes	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**n**
I effectively teach difficult concepts to non-technical people	0%	0%	35%	58%	8%	26
I can clearly define learning objectives for elementary school children	0%	8%	42%	50%	0%	24
Engineers often have blind spots making it hard to teach basic ideas to novices	4%	4%	12%	62%	19%	26
Student mindset can be influenced	0%	0%	39%	46%	15%	26
Formative assessment should dynamically support classroom instruction	0%	0%	35%	58%	8%	26
Student questions are an integral part of the learning process	0%	0%	4%	12%	84%	25
Design spaces that include impact on society inc. conceptual understanding	4%	8%	4%	58%	27%	26
Hands on design challenges are fundamental to learning	0%	0%	4%	31%	65%	26
Exposure to graphical lang. is critical to understanding the design processes	0%	4%	19%	42%	35%	26

*Central tendency (Mode) is highlighted

Change in percentages of volunteer responses are included in this post-survey table (2b) below where central tendency is highlighted in green.

Table 2b. Agreement with statements related to leadership, teaching, and mentoring

Post-Survey Teaching and Mentoring Skills & Attributes	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	n
I effectively teach difficult concepts to non-technical people	0%	0%	27%	67%	7%	15
I can clearly define learning objectives for elementary school children	0%	0%	40%	60%	0%	15
Engineers often have blind spots making it hard to teach basic ideas to novices	0%	0%	13%	60%	27%	15
Student mindset can be influenced	0%	0%	33%	47%	20%	15
Formative assessment should dynamically support classroom instruction	0%	0%	21%	71%	7%	14
Student questions are an integral part of the learning process	0%	0%	0%	40%	60%	15
Design spaces that include impact on society inc. conceptual understanding	0%	0%	33%	40%	27%	15
Hands on design challenges are fundamental to learning	0%	0%	0%	47%	53%	15
Exposure to graphical lang. is critical to understanding the design processes	0%	0%	14%	57%	29%	15

*Central tendency (Mode) is highlighted

3. Community Engagement

The volunteer participants were also asked to evaluate their agreement or disagreement with a series of questions related to their community engagement. As indicated by pre- and post-survey responses (see Tables 3a and b), all of the participants agreed or strongly agreed that they volunteer because they want to positively contribute to society, help underserved communities, and inspire students through science and engineering.

Table 3a. Agreement with statements related to community engagement

Pre-Survey Community Engagement	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**n**
I volunteer because I want to positively contribute to society	0%	4%	12%	24%	60%	25
I volunteer because I want to help underserved communities	0%	8%	27%	39%	27%	26
I volunteer because I want to inspire students through science & engineering	0%	0%	4%	42%	54%	26
I am culturally aware when I volunteer or engage with diverse communities	0%	8%	31%	46%	15%	26
Volunteerism can contribute to career advancement	8%	8%	35%	27%	23%	26

*Central tendency (Mode) is highlighted

The participants' beliefs about whether volunteerism can contribute to career advancement were more mixed with most participants reporting neutral responses. While it is possible that the volunteer engineers may be coming from a place of genuine altruism rather than self-interest as they concentrated time and effort to volunteering with underserved students, it might also be the case that corporate culture does not actively promote or demonstrate the value of volunteerism to the workforce. These beliefs may be reflected in the results.

Table 3b. Agreement with statements related to community engagement

Post-Survey Community Engagement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	n
I volunteer because I want to positively contribute to society	0%	7%	0%	40%	53%	15
I volunteer because I want to help underserved communities	0%	7%	20%	47%	27%	15
I volunteer because I want to inspire students through science & engineering	0%	0%	0%	53%	47%	15
I am culturally aware when I volunteer or engage with diverse communities	0%	7%	27%	47%	20%	15
Volunteerism can contribute to career advancement	0%	13%	33%	27%	27%	15

*Central tendency (Mode) is highlighted

4. Impact on professional skills through volunteering

The volunteer participants were also asked to evaluate their agreement or disagreement with a series of questions related to their professional skills with a view to understanding if any of these skills were somehow enhanced through their volunteering experience. Table 4a shows the participants' anticipated skills outcomes as a result of the volunteer experience and Table 4b show the participants' agreement about the relationship between the volunteer experience and skills development. As indicated by pre- and post-survey responses (see Tables 4a and b), the majority of the participants believed that the program did not improve their ability to identify, formulate, and/or solve engineering problems, neither did it affect or improve their skills in entrepreneurship and intrapreneurship.

Table 4a. Agreement with statements related to professional skills

Pre-Survey Volunteer Experience	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	n
The Family Science experience will improve my professional skills in…						
Physical sciences and engineering science fundamentals	0%	15%	46%	35%	4%	25
Ability to identify, formulate, and solve engineering problems	7%	21%	36%	29%	7%	14
Systems integration	4%	15%	62%	19%	0%	26
Curiosity and persistent desire for continuous learning	0%	15%	19%	46%	19%	26
Self-drive and motivation	0%	19%	23%	50%	8%	26
Broad cultural awareness	0%	0%	39%	42%	19%	26
Economics and business acumen	4%	23%	46%	27%	0%	26
High ethical standards, integrity, and responsibility	0%	15%	27%	46%	12%	26
Critical thinking	0%	12%	27%	58%	4%	26
Willingness to take calculated risks	4%	19%	46%	23%	8%	26
Ability to prioritize efficiently	12%	15%	19%	50%	4%	26
Project Management: supervising, planning, scheduling, budgeting, etc.	4%	15%	27%	50%	4%	26
Teamwork skills and ability to function on multidisciplinary teams	4%	8%	31%	54%	4%	26
Entrepreneurship and intrapreneurship	4%	15%	50%	27%	4%	26

*Central tendency (Mode) is highlighted

Based on questions focused on professional skills that might have been activated by involvement in the Family Science night in underserved communities, participants were neutral as to whether the volunteer experience improved their professional skills in systems integration, economics and business acumen, high ethical standards, and willingness to take calculated risks. Engineers did report strong improvements in self-drive and motivation and an increased awareness of cultural situations.

Table 4b. Agreement with statements related to professional skills

Post-Survey Volunteer Experience	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	n
The Family Science experience will improve my professional skills in…						
Physical sciences and engineering science fundamentals	7%	13%	33%	47%	0%	15
Ability to identify, formulate, and solve engineering problems	0%	20%	40%	33%	7%	15
Systems integration	0%	33%	40%	27%	0%	15
Curiosity and persistent desire for continuous learning	0%	7%	13%	47%	33%	15
Self-drive and motivation	0%	13%	27%	60%	0%	15
Broad cultural awareness	0%	0%	13%	67%	20%	15
Economics and business acumen	13%	27%	53%	7%	0%	15
High ethical standards, integrity, and responsibility	0%	0%	57%	36%	7%	14
Critical thinking	7%	13%	27%	33%	20%	15
Willingness to take calculated risks	7%	13%	40%	40%	0%	15
Ability to prioritize efficiently	0%	7%	20%	60%	13%	15
Project Management: supervising, planning, scheduling, budgeting, etc.	0%	7%	33%	53%	7%	15

Teamwork skills and ability to function on multidisciplinary teams	0%	0%	20%	60%	20%	15
Entrepreneurship and intrapreneurship	7%	7%	40%	47%	0%	15

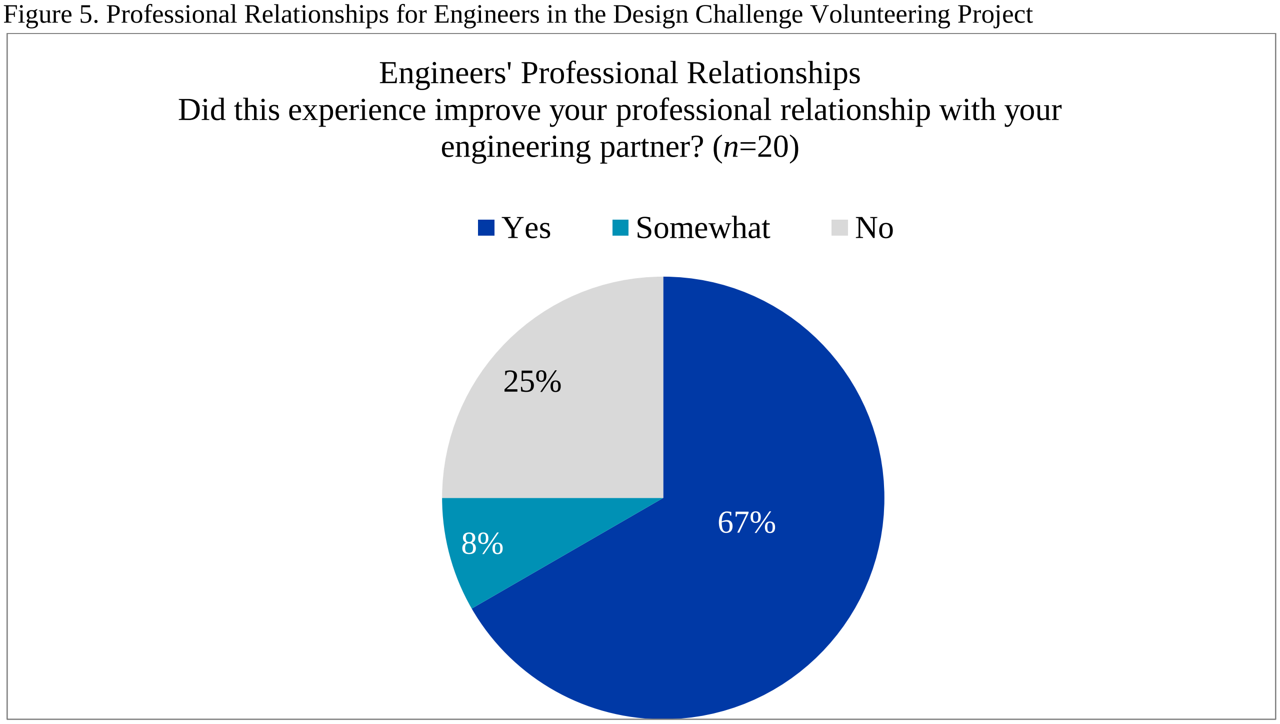
*Central tendency (Mode) is highlighted

A rather noticeable improvement was reported in areas that were associated with teamwork skills, and ability to function in ambiguous circumstances like after school events with audiences that are totally outside their comfort zones. In this next section we explore engineer reports and take-away in observational reviews and exit interview transcripts.

Qualitative Results

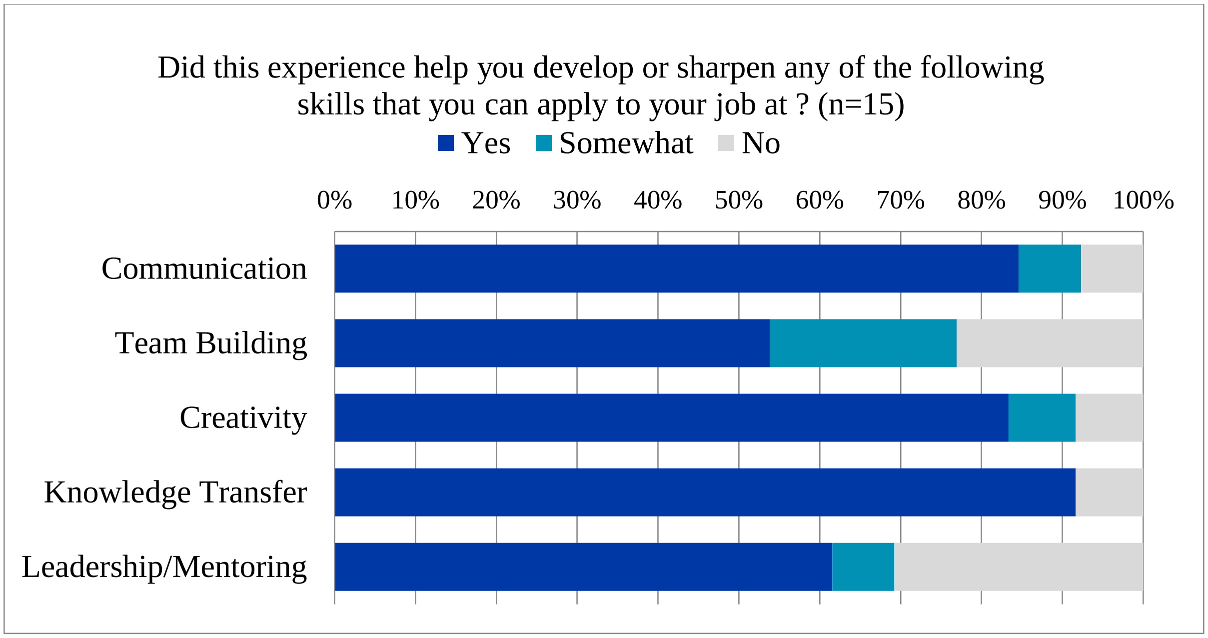
In this section, we explore the implications of corporate-sponsored skills-based volunteerism as one lever to improve employee engagement and develop employees' skills in communications, leadership and mentoring, and creativity. The data suggests that there is a reciprocal payoff in education-related skills-based volunteerism programs (see Figure 4. Professional Relationships for Engineers in the Design Challenge Volunteering Project). We draw from evidence that volunteers engage meaningfully with students, utilize their engineering and technical skills, and feel a sense of pride and purpose in their role at the company, while community partners gain access to working engineers and scientists.

Figure 5. Professional Relationships for Engineers in the Design Challenge Volunteering Project



We hypothesize that volunteers develop their personal skills and feel more connected to their work, their colleagues and teams, and the company. Using data extracted from *in situ* observational protocols and video transcriptions we triangulate this information with self-reported responses to pre- and post-surveys to describe evidence of the similarity between the context studied and those to which findings can be transferred.

Figure 6. Skills Development for Engineers in the Design Challenge Volunteering Project



In this study, similarity is drawn from common funds of engineering knowledge constant to the aerospace industrial population and volunteering efforts with elementary school children and their family members. All engineers agreed that the nature of design challenge and implementation activities did stretch their thinking, creativity, and organizational and project management skills (see Figure 5. Skills Development for Engineers in the Design Challenge Volunteering Project). But many pointed out that it was in three main areas that they felt their personal skills were particularly sharpened: communication, teaching and mentoring, and creativity.

1. Communications Skills

Most engineers mentioned in their post-event discussions (debriefs and exit interviews) that they were challenged by having to describe complex concepts relating to what they work on every day into terms that were accessible to non-technical parents and young children. These findings align with data collected from the observation protocols and exit interviews, which indicated that engineers were generally successfully in communicating with students and their families in this program but at times struggled to refrain from using jargon and to simplify complex technical or engineering concepts.

> *Observer in Puget Sound: Technical words and concepts were effectively simplified and related to concepts the students could understand. Example: stiffness and deflection [was simplified to] how a diving board made of rubber versus wood would bend.*

Observer in Southern California: The first engineer described the objective of the design challenge and [the company's] participation in spaceflight and airplanes in a manner that the students could relate to. He used examples such as food for energy, elastic, etc. The second engineer seemed to struggle at the beginning and the students seem disinterested. Her vocabulary seemed at a higher level than they [could] relate to; however, she adjusted quickly and they began to pay closer attention. The third engineer seem[ed] to relate to [the students] by using examples such as "when I was your age..."

Observer in Puget Sound: List of difficult words [the engineers used]: Cantilever, deflection, panel, spirals, ribs, target, loading, ratio. Neither parents nor children had any connection to these terms. Some of the diagrams helped, but there was a lot of confusion about what to do.

Simplifying complex component of one's work is challenging in general, but is especially difficult for engineers who typically think and speak in advanced technical environments and solve complex, multi-dimensional problems on a daily basis. While many engineers talked about being forced to simplify or even "dumb down" their presentations, they all agreed that the exercise was very worthwhile because it forced them to be mindful of their audience's knowledge (or lack thereof) of the topics.

Exit Interview with Engineer in Southern California: Delivering the presentation at the Family Science Session was great, especially to try to simplify the ideas about complicated topics and present them to kids is a skill that requires going above and beyond speaking capabilities. We give presentations all the time at work, but typically to people who are beyond our realm of knowledge and capability or the same. But if you are pitching to people who don't know about the topic you're discussing from a complicated pedestal, you aren't going to communicate well.

In addition, engineers mentioned that they were challenged to be cognizant of the fact that many of their colleagues or customers with whom they interact on a daily basis may not understand the content to the level that they do, and that they may be reluctant to ask questions or request explanations lest they appear to be uninformed. This fear, they mentioned, has the potential to create unnecessary tensions and stresses on teams and relationships in the workplace, as well as can constrain creative problem-solving across functions and programs.

2. Teaching and Mentoring Skills

Engineers are not de facto teachers. While almost all of the volunteers informed us that they had volunteered before, it was often with older audiences and never in a situation like this where families, siblings, and, elementary school children were involved. All engineers expressed surprise at the level of skill that was required to communicate and to engage these children, not merely because they were so young but, in addition, there were language barriers, cultural barriers and often screaming babies in the room at the same time. Nevertheless, it was quite common to elicit information during the exit interviews that corroborated evidence that these volunteer engineers enhanced their teaching and mentoring skills because of the training and "dry run" trials in front of peers and teaching experts. The following excerpts, taken from transcripts of observer notes make visible some of the mentoring and teaching nuances pertaining to the changes that occurred for the engineers in the course of presenting their design challenge.

> *Observer in Southern California: [The engineers] asked lots of simple questions. [For example:] "Is yours going to land on water or land?" But [they] could have asked more "cause and effect" type questions, [such as] "What do you think would happen with tennis balls? with a balloon? Could you use another material? How would [it] change if landing on water?"*

> *Observer in Puget Sound: The engineers didn't solve the problems that the children presented but helped them understand that they could try another tack and their suggestions were well received. This made space for the children to be creative and generative. Children were immersed in the engineering method. Make a plan, design and build, test redesign and try again.*

We noted earlier that engineers impressions of the value of students asking questions seemed to diminish during the course of the presentation from 84% in pre-survey to 60% post-survey. This we suggest is an outcome of student engagement and the messiness of teaching and learning in an active, often chaotic environment where hands-on activities and freedom to fail is an anchored instructional tool. It follows then, that most students were perceived to be so enthralled in the build and test process that their questions seemed simple or non-existent. Observational data, however, maintain that children had plenty questions related to their design challenges; questions that were directed at peers, parents and sometimes at the engineers. In summation, volunteer engineers became immersed in pedagogical, methodological and classroom management challenges in the execution of a focused design challenge.

3. Creativity Skills

Data suggests that engineers' creativity improved as a result of their participating in this skills-based volunteerism program. Creativity is commonly defined as the capacity to come up with something novel and useful. Everyone involved was stretched in areas of ideational invention, team building, communication, planning and implementation, in order to bring the project to conclusion. This included engineer volunteers who were tasked with developing accessible design challenges, parents who in most cases were solving design challenges for the first time alongside their children, and students who were coming to the Family Science program for the first time.

Engineers described improved creativity from two perspectives: (i) design constraints, and (ii) what we refer to as reverse mentoring. While many engineers acknowledged that they creatively solve problems in their work, this project pushed them to be creative in simpler, yet still challenging ways given the tight design constraints—they were only allowed to use inexpensive household items under a couple dollars for their engineering design challenges. Further, engineers' creativity was inspired by the creativity they witnessed from the students and families at the Family Science Nights. Recognizing a creative idea or concept in another human being is a powerful event, but being in a position to foster another's creative expression is a truly inspiring situation and one which accounts for much of the reward and excitement that engineer volunteers described in their exit interviews and debriefs. The excerpts below illustrate how the scope and structure of this program stretched the engineers' creativity and emergent thinking.

> *Engineer 1: YouTube videos really piqued my attention to creativity—looking for what materials to use. People simplified things and helped me figure out how to make complex ideas accessible to children.*

> *Engineer 2: [This experience] harkened back to experiences as kids… but also I had to think on a completely different level. It was an opportunity to think outside of the box, spark creative thinking.*

> *Engineer 3: Definitely sharpened my skills around creative thinking… developing age-appropriate challenges and coming up with something so complicated like a satellite simplified to a point where you still could learn something valuable but still can do it in an hour. That in itself was very challenging and the only way was to come up with a really creative solution. Doing things on the cheap makes you be creative. We made landing gear out of springs, balls, paper clips, etc.*

> *Engineer 4: It was great to force us to make 2 prototypes since it made the students think of new ways of designing things and being more creative.*

> *Engineer 5: What builds creativity isn't just me…but in seeing what the kids do. The kids built things that I would've never imagined myself.*

Impact on Sponsoring Company

While the engineers in this skills-based volunteerism program directly benefited from their experiences, the sponsoring company is also positively impacted in several ways: (1) increased employee engagement, (2) pipeline development, (3) company reputation, and (4) reverse mentoring. We discuss these benefits here.

Employee Engagement

The data from the post-surveys and exit interviews suggest that the engineers' self-drive and motivation were amplified as a result of their participation in this skills-based volunteerism program. This has collateral impact in the workplace and is expressly important for issues of self-esteem, retention, job satisfaction, and other aspects of corporate life that can have repercussive effects through the enterprise.[17,18] All engineers were actively recruiting new members and would highly recommend this activity to their colleagues and friends.

> *Engineer Mentee in Southern California: I would definitely recommend this program, but it does take a lot of time. People are really busy at [the company]. It's one of those things that we just need to change the culture of [the company]. A lot of the old-school companies and aerospace companies need a culture change – and it starts with activities like this. The way we work, network, think, engage, etc. – this is one way to keep employees. It's great that I was put with someone like a Tech Fellow but then work together at the same level.*

> *Engineer in Southern California: The level of preparation and corporate involvement was much higher from [the company] than I had expected: there were observers, several-hour training sessions, etc. When I had done things like this before, either you were given a canned lesson to go present with students or you were left to your own devices without as much involvement or*

training. It was very interesting to be a participant and I'm curious to see the results of the assessment of the project.

Engineer Mentee in Southern California: Any of these projects that can take you outside of your function is great for the company and the individual. I personally believe that to build accountability among employees they need to work together first before working on a project together. It builds the relationship – I've already seen this happen on other projects at Company. The networking factor: asking for help, knowing someone who can do this work in some other place at the company, etc.

1. Pipeline development, especially of diverse students

Companies have made considerable investments in promoting STEM-related education initiatives through programs that inspire students in STEM fields. However, the impact of these efforts has not lived up to expectations. The literature is replete with failed attempts to map new landscapes for what it means to engage future engineers.[19]

Through this skills-based volunteerism program, engineers were exposed to underserved populations with whom they typically do not engage on a day-to-day basis. In the pre-survey, most engineers (61%) agreed or strongly agreed that they knew how to be culturally aware when volunteering with diverse communities. However, there was a significant difference between the pre- and post-surveys in how the engineers expected the program to improve their cultural awareness: 61% agreed or strongly agreed that they expected the experience to improve their cultural awareness in the pre-survey as compared to 87% agreeing or strongly agreeing in the post-survey that the program did strengthen this attribute.

Exit Interview with Engineer in Southern California: The engagement with the parents and students definitely helped my mentoring skills. The language barrier was challenging for me. [My engineer partner] did a phenomenal job – memorized a bunch of the kids' names, talked with them in Spanish and English – and is something I wish I had more skills in. That inspired me to be a stronger mentor in those types of environments. In Southern California, having knowledge of Spanish is a huge asset and something I need to work on to be a more effective mentor.

Not only were engineers exposed to underserved populations, but in addition, students and their families developed relationships with them during family science STEM events, thus able to hone skills in curiosity, creativity, and persistence. In fact, data from an evaluation of the nonprofit partner's similar out-of-school program indicates that as a result of participating, both students and their parents report having a better understanding of science and engineering, students are more interested in science at school, and their parents are more apt to encourage their children to become scientists and engineers in the future.[20]

2. Company Reputation

While proactively engaging in corporate community programs like this is not without cost, there is evidence to suggest that corporate senior leaders should not dismiss these efforts and, in fact, it appears they would do well to embrace such an approach.[21] In many studies, including meta analyses, findings suggest that firms that promote volunteerism in their workforce benefit in ways beyond a pure bottom line outcome.[18] Further, these activities provide visible signals from which stakeholders infer various positive characteristics of corporate entities, thus creating an avenue to increase overall corporate reputation.[18]

> *Engineer Mentor in Southern California: I would absolutely recommend this program: 1) [I'm a] strong believer that we need to give back in various ways, more than donating money or serving soup, but investing in the future; 2) This program is trying to focus on engineering design process…This was the first program that I saw that was teaching engineering design processes. We as engineers can do better when going into schools to give examples of what they do at work every day.*

3. Reverse Mentoring

One of the key and most promising benefits to the sponsoring company for skills-based volunteerism programs is the effect of reverse mentoring.[22] Through reverse (or reciprocal) mentoring, volunteers not only share their expertise and knowledge in science and engineering with their technical colleagues, but they also gain valuable, creative insights and ideas from the students and families with whom they engage. This type of mentoring fosters knowledge transfer, a critical need for many companies whose workforces are predicted to have high turnover and/or retirement rates in the near future. But most important reverse mentoring is a clear example of adaptive expertise—that all-important mind shift that helps companies reach twenty-first century goals of excellence and competitive advantage.[23]

> *Engineer in Southern California: [Children] don't have preconceived notions about what's possible… which [preconceived notions] can lead to fixed mindsets. This situation is like reverse mentoring, where we can learn from the children as they learn from us. The advantage is obvious, I remain fresh and childlike in my approach to engineering and what is possible. This could be transferred to our work situations. The trouble is, over time, I become set in my ways, but being paired up with a younger, less experienced engineer helps me be more open-minded. The longer I am at the aerospace company, the more I tend to become set in my ways. We may miss opportunity for great innovation that we wouldn't have otherwise been open to.*

In addition, reverse mentoring advances change at the corporate level through individual mind shift. In this study, engineers were asked if they agreed that mindset is influenced by individual traits such as attainment, preference, goal setting, belonging, resilience, social capital, and self-control. Data from the pre-survey indicates that approximately 62% of respondents agreed or strongly agreed with this statement. Reverse mentoring requires trust of each party where one is willing to step outside his/her comfort zone and try new ways of thinking, working and being.[24]

Discussion

In the course of studying this skills-based volunteerism program, several topics have arisen that warrant additional discussion and research: (1) program scalability and feasibility, (2) overcoming diversity and bias, and (3) social network activation.

1. Program Scalability and Feasibility

The project was built on a significant body of work conducted by the partnering nonprofit organization in the last five to seven years in underserved communities located across the United States.[25] Prior research has shown that this model is effective in engaging underserved students and parents in informal STEM education though hands-on activities that engage the children's curiosity and natural desire to learn.[26] Furthermore, there are empirical findings that describe a positive change to participants' attitudes and behavior around science exploration and engineering design challenges.[27] While the nonprofit's evaluation results indicate that the model increases the engineers' engagement, communication, and leadership skills,[27] there are challenging issues with regard to time commitment, return on investment and feasibility to scale a program of this nature. How will the educational environment, strained as it is with standards, measurement and achievement goals, manage outside influences from industry that seem to increase pressure in a constricted timescale? Will industry leaders continue to support the long-term advantages of fostering a STEM pipeline with a stream of young applicants whose futures are forever changed by engineer volunteers?

2. Diversity and Bias

Many students in the United States do not have access or awareness of high-quality, STEM-related programs due to socioeconomic barriers and related challenges, thereby excluding them from the STEM career pipeline that would improve their economic stability and mobility. In response, many educators depend on volunteer-led programs to drive awareness and engagement of STEM among their students.[28-30] Yet these challenges cannot be addressed only by teachers and in the classroom; out-of-school programs are an essential ingredient for change, where one-on-one mentoring and "zone of proximal development" hand-holding can happen.[31,32] There is evidence that hands-on programs, coupled with positive and encouraging teaching and facilitation techniques, have considerable impact on student growth and achievement.[17,29,33]

Community-based programs effectively connect diverse segments of society enable relationship-building and dialogue across societal barriers. In this skills-based program, students and their families from mostly low-income, minority, and underserved communities connected directly with working engineers from a multinational company. Prior to these engagements, many students and their families were unaware of what engineering entailed and had never met, let alone engaged in a hands-on project, with an engineer. Similarly, engineers may have encountered underlying biases[34] they had about working with low-income or minority populations, including their science and engineering knowledge, aptitude for learning, or creativity.

Conclusion

This collaboration of industry, research partners, and nonprofit partners explored the benefits of a skills-based volunteering model for engineers, their employers, education partners, and students and families. We primarily focused on the impact of these programs on volunteering engineers in an effort to investigate the business case for companies considering investments in employee community engagement efforts for both company and community impact. The conceptual underpinnings of the program centers on professional engineers trained to develop and teach open-ended engineering design challenges to underserved children and parents in Family Science Nights held in local community-based settings.

Findings note several key advantages for engineers from both a professional and personal standpoint. Examples of professional skills include simplifying the communication of complicated science and technical concepts, working in teams, transferring knowledge (albeit fundamental, basic knowledge) to non-technical audiences and to their engineering partner, and developing adaptability in a highly variable learning environment (i.e., the out-of-school, community-based program). As a result of these individual results, there are very real and measurable results for sponsoring corporate entities—findings, which reinforce corporate local and global community engagement programs that leverage corporate assets and returns that are both meaningful and accountable. Preliminary findings suggest a reciprocal payoff in education-related skills-based volunteerism programs: community partners gain access to working engineers and scientists, while engineers develop their skills and feel more connected to their work, their colleagues and teams, and the company. Additional data, including longitudinal data collected from post-post-surveys, is forthcoming and necessary to determine more concrete conclusions on the impacts to the engineer, sponsoring company, and community partners.

Future Research

Maintaining and improving the U.S. (STEM) workforce is a multifaceted challenge with serious implications for economic, immigration, labor, and education policy.[36] Too many middle school students are diverted or drop from a STEM career paths and too often these students belong to underrepresented groups.[26,37] This project examines an industry-academic recruitment and retention strategy – a strategy of deliberately engaging social perceptions and experiences with industry engineers – and its impact on students' social networks. This work is guided by an underlying rationale that a systemic understanding of interactions between students, parents, teachers, and engineers, in educational contexts will result in measurable improvements in STEM scholar retention. Future work seeks to ascertain how higher education policies can be designed to engage components of interactions like those described here. Social network experts, are committed to the view that it is the interacting members who make the maintenance and reproduction of social assets possible.[38] Realistic research, based on detailed data from community/industry case studies, may help educators, policy makers and administrators plan for a successful process of adaptation and translation of best practice, rather than a one-model-fits-all "scale up" of a particular intervention. For future direction, we propose continuous rigorous programs involving social network analysis protocols to identify possible alternatives, potential problems, unintended consequences, and overall qualitative features of change that could take place under local context.[39] Guided opportunities are already under development for more engineers in corporate-supported skills-based volunteerism programs that are scalable, sustainable, and that can produce meaningful community impact.

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Appendices

Appendix 1: GCC Family Science Exit Interview Protocol

1. What motivated you to volunteer for this skills-based volunteer experience? Did it satisfy that purpose? If so, how? If not, why not?
(*Positive Open ended warm up question to have the engineer reflect back over the program and dredge up what was memorable to him/her)*

2. What was the most surprising or challenging part of the skills-based volunteer experience for you: (i) presenting at the Family Science session, (ii) building a design challenge (iii) teaching elementary school students and (iv) collaborating with your partner(s)?
(The "surprise" question usually elicits deeper information with regard to ordinary experiences – get to see it from a new perspective)

3. Did this experience affect your professional relationship with your engineering partner? If so, how?
(An effort to understand what positive or negative impacts such partnered engagements may have on professional relationships. Follow-on probe on whether knowledge transfer, communication or mentoring (or learning) have improved (or declined) with partner as a result)

4. Did this experience help you develop or sharpen any skills that you can apply to your job at Company: effective communication, team building, leadership, mentoring, knowledge transfer, creativity?
(This question can be used to lead into a follow on probe with regard to respondents' thoughts about effect of the experience on workplace creativity, innovation)

5. Would you recommend this program to others at your Company? Why or why not?
(Follow on probing questions like this: Would you like to participate in more Company sponsored volunteer programs and partnerships if they were available; and what work-related (or otherwise) barriers exist to participation in volunteer opportunities?)

Appendix 2: GCC Family Science Observation Protocol

About the Observer Role

As an observer, you play a critical role in assessing the impact and effectiveness of the company engagements in skills-based volunteerism opportunities for employees and local communities. In this role, you will take notes about the company engineers who have volunteered their skills and time to prepare to communicate effectively, facilitate the Family Science course, collaborate with his/her fellow engineer volunteer and help students and their families accomplish the learning objectives of the design challenge.

Lesson Objectives

1. Company engineers clearly communicate the design challenge to students and their families
2. Company engineers practice soft skills in communication, leadership, facilitation and team building
3. Company engineers demonstrate how they work together to explain complicated, shared technical knowledge while impacting local communities

Today you will see engineers share a hands-on project in which students will build something. The basic caveats would be that it must be i) something that can be reproduced, ii) demonstrated, iii) aligns to basic science and engineering principles, and iv) it was built by you, staff, and/or students. These projects can range from design – build processes, technical design of mechanical/manufactured products to innovative techniques for textile work. An artistic flair is welcomed.

Instructions

This observation protocol consists of 2 parts:

1. The **observation table** you will fill out during the family science night, and
2. The **questionnaire,** which you will complete immediately following the family science night.

Upon completion please give the completed forms to your local GCC focal.

Instructions for each part of the observation protocol are included in the following sections.

THANK YOU FOR YOUR ASSISTANCE IN OBSERVING ENGINEERS AT THIS FAMILY SCIENCE SESSION!

PLEASE GIVE YOUR COMPLETED OBSERVATION TO THE GCC FOCAL AT THE SESSION.

OBSERVER NAME: ______________________ SITE: __________________ DATE: ________ ENGINEER 1: _________________ ENGINEER 2: ____________________

Skills-based Volunteerism Pilot: Observation Table

Conversational Analysis									Engagement 1 = none 2 = some 3= most or all		
Time	Engineer Monologue	Engineer Question	Engineer Response	Student Question	Student Response	Student/ Parent Interaction	Question Difficulty 1 = easy 2 = medium 3 = hard	Type of Question 1 = clarifying 2 = related 3 = unrelated	Students	Parents	Engineers
5:30-5:35											
5:35-5:40											
5:40-5:45											
5:45-5:50											
5:50-5:55											
5:55-6:00											
6:00-6:05											
6:05-6:10											
6:10-6:15											
6:15-6:20											
6:20-6:25											
6:25-6:30											
6:30-6:35											
6:35-6:40											
6:40-6:45											
6:45-6:50											
6:50-6:55											
6:55-7:00											
7:00-7:05											
7:05-7:10											
7:10-7:15											
7:15-7:20											
7:20-7:25											
7:25-7:30											

OBSERVER NAME: ______________________ **SITE:** _________________ **SESSION DATE:** _________

ENGINEER 1: __________________ **ENGINEER 2:** _____________________ **TOPIC:** ______________

Presentation/Context

	1 Strongly disagree	**2** Disagree	**3** Neutral	**4** Agree	**5** Strongly agree
Engineer clearly explained key concepts without jargon and in simple, understandable language for students and their families	☐	☐	☐	☐	☐
The engineers' teaching methods emphasized interactive and experiential learning	☐	☐	☐	☐	☐
Presentation material only contained content that was absolutely necessary for the learning process (i.e. cognitive load)	☐	☐	☐	☐	☐
Engineers effectively worked together in presenting and facilitating throughout the 2-hour session	☐	☐	☐	☐	☐

Comments *Describe how effectively the engineers presented during the Family Science session by recording specific examples that demonstrate how each engineer simplified their work and helped students and families understand the underlying concepts (e.g., demonstration that did X effectively, use of visuals or examples and how the company engineers represented the company).*

Logistics

	1 Strongly disagree	**2** Disagree	**3** Neutral	**4** Agree	**5** Strongly agree
Families were on task and engaged	☐	☐	☐	☐	☐
Engineers knew what they had to do at all times	☐	☐	☐	☐	☐
All families had time to build, test, and redesign with time for reflection	☐	☐	☐	☐	☐

Comments *Describe how the engineers managed logistics of the Family Science course, including specific examples of time management, distribution of tasks, engagement of the audience and management or communication with both their fellow engineer, focal and/or the parent volunteers.*

Design Challenge					
	1 Strongly disagree	**2** Disagree	**3** Neutral	**4** Agree	**5** Strongly agree
Engineers showed a minimum of 2 prototypes for the design challenge	☐	☐	☐	☐	☐
Engineers were well organized with pre-planned with developmentally appropriate activities consisting of engineer-facilitated and students-initiated activities	☐	☐	☐	☐	☐
Project facilitation involved modeling, coaching and scaffolding (e.g., moving students from scientific principles to design application)	☐	☐	☐	☐	☐
The delivery facilitated theory and practical learning of skills that meets the needs and challenges of the current world	☐	☐	☐	☐	☐
Design challenge enhanced students' creativity and innovative problem solving and team work	☐	☐	☐	☐	☐

Comments *Describe how the engineers clearly communicated and appropriately demonstrated the engineering design challenge for students and their families by recording specific examples of how they led the design challenge.*

1-on-1 Mentoring					
	1 Strongly disagree	**2** Disagree	**3** Neutral	**4** Agree	**5** Strongly agree
Engineers interacted with students and families during open build time	☐	☐	☐	☐	☐
Engineers encouraged students to learn from failures and recognize them as teachable moments	☐	☐	☐	☐	☐
Engineers interacted with the families in a friendly and respectful manner	☐	☐	☐	☐	☐
Engineers effectively communicated, role modeled and built rapport with students and families	☐	☐	☐	☐	☐

Comments *Describe how the engineers interacted with students and their families throughout the Family Science session by recording examples of what actions they took to encourage the students and support the parents.*

Appendix 3: GCC Family Science Pre- and Post- Survey Protocol

Dear volunteer,

Thank you for volunteering your time and expertise as a volunteer to create open-ended design challenges based on your work for elementary and middle school children. This program is a result of partnership between a nonprofit organization that created the Curiosity Machine (a digital platform where your design challenges will live) and the Family Science program (where you will be delivering your challenges in the coming weeks).

We ask that you provide feedback about your participation and experiences in our effort to improve these programs and understand the impact of this engagement on both the community and on you as committed volunteers.

This survey is meant to capture your perceptions and experiences as you were introduced to the program and prepared to deliver your challenges. Two more brief surveys will be sent to you AFTER you have delivered your challenge in a Family Science course and several weeks after your participation in this program has concluded.

All of the feedback gathered through these surveys, observations and interviews will help our companies maintain high teaching and learning standards and support improvements for future iterations of company engagement in this program. We welcome honest and candid feedback. Your responses will not be attributed to you personally.

Please note that participation in this survey is optional and that any responses will be kept confidential and anonymous.

*****We kindly request your responses to this survey by EOD <u>Monday, (date)</u>. This survey will take approximately 15 minutes.** ***

Please think of a **secret code** that you will use in all your responses to us -- this pre-survey and two post-surveys over the next few months. Please store it somewhere safe. Thank you.

Please remember your code for future retrieval.

My Secret Code:

Required.

Section 1: Background & Previous Experience

Q1. What types of education-related volunteering have you previously participated in? Select all that apply.

- ☐ Classroom presentations
- ☐ Science fairs
- ☐ After-school tutoring
- ☐ Serve as subject matter experts in classrooms (virtually or in-person)
- ☐ Hands-on learning program
- ☐ Open-ended design challenges
- ☐ Student mentoring or tutoring (virtually or in-person)
- ☐ *FIRST*® or similar mentoring program
- ☐ Other

Q2. Please select the statement below that most aligns with your previous teaching experiences.

- ☐ This is my first time teaching a design challenge to students of any age
- ☐ This is my first time teaching students in grades K-12
- ☐ I have taught a design challenge at least once before to students in grades K-12
- ☐ I previously have taught many design challenges to students in grades K-12

Q3. The following skills are associated with good design thinking: (Check all that apply)

- ☐ Design is an iterative loop process of divergent – convergent thinking
- ☐ A good designer must tolerate ambiguity and manage uncertainty
- ☐ Thinking as part of a team process is a critical social skill
- ☐ Understanding the “big picture” system thinking is critical to a good design

Section 2: Communication Skills & Attributes

Q4. Please rate the extent to which you agree or disagree with the following statements regarding your <u>communication skills and attributes</u>

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I have strong verbal communication skills.	☐	☐	☐	☐	☐
I believe listening is one of the most important aspects of effective communication.	☐	☐	☐	☐	☐
I have strong presentation skills.	☐	☐	☐	☐	☐
I am able to effectively ***explain*** technical concepts to non-technical people	☐	☐	☐	☐	☐

I believe that my body language (eye contact, hand gestures, and tone) all support the information I am conveying.	☐	☐	☐	☐	☐
I believe difficult technical concepts can be modeled for elementary school students	☐	☐	☐	☐	☐
I believe that empathy is critical for design thinking.	☐	☐	☐	☐	☐

Section 3: Teaching & Mentoring Skills & Attributes

Q5. Please rate the extent to which you agree or disagree with the following statements regarding your skills and attributes for <u>teaching and mentoring students</u>

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I effectively ***teach*** difficult concepts to non-technical people	☐	☐	☐	☐	☐
I can clearly define learning objectives for elementary school children	☐	☐	☐	☐	☐
Engineers often have expert ‘blind spots’ that make it difficult for them to teach basic principles to novices	☐	☐	☐	☐	☐
Student Mindset can be influenced by mentors	☐	☐	☐	☐	☐
Formative assessment should dynamically support classroom instruction	☐	☐	☐	☐	☐
Student questions are an integral part of the learning process	☐	☐	☐	☐	☐
A design space that includes impact on	☐	☐	☐	☐	☐

society increases conceptual understanding					
Hands-on design challenges, where students learn by actively “experiencing design” are fundamental to learning.	☐	☐	☐	☐	☐
I believe exposing students to the language of graphical representation (shape grammars, geometrical shapes, analytical mental models, how numbers represent design information) is critical to understanding the design process.	☐	☐	☐	☐	☐

Section 4: Community Engagement

Q6. Please rate the extent to which you agree or disagree with the following statements regarding your <u>engagement in community</u>

	N/A	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
I volunteer because I want to positively contribute to society	☐	☐	☐	☐	☐	☐
I volunteer because I want to help underserved communities	☐	☐	☐	☐	☐	☐
I volunteer in education because I want to inspire students through engineering	☐	☐	☐	☐	☐	☐
I am culturally aware when I volunteer with diverse communities	☐	☐	☐	☐	☐	☐
Volunteerism can contribute to professional skills development	☐	☐	☐	☐	☐	☐
Volunteerism can contribute to career advancement	☐	☐	☐	☐	☐	☐
I am proud to be an employee of this	☐	☐	☐	☐	☐	☐

company when I use my skills to volunteer in community					

Section 5: Volunteer Experience

Q7. Please rate the extent to which you agree or disagree with the following statements regarding your experiences as a volunteer in this Program

I think that Family Science experience will improve my professional skills in …

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Good communication skills	☐	☐	☐	☐	☐
Physical sciences and engineering science fundamentals	☐	☐	☐	☐	☐
Ability to identify, formulate, and solve engineering problems	☐	☐	☐	☐	☐
Systems integration	☐	☐	☐	☐	☐
Curiosity and persistent desire for continuous learning	☐	☐	☐	☐	☐
Self-drive and motivation	☐	☐	☐	☐	☐
Cultural awareness and competency	☐	☐	☐	☐	☐
Business acumen	☐	☐	☐	☐	☐
High ethical standards, integrity, (including global, social, intellectual, and technological responsibility)	☐	☐	☐	☐	☐
Critical thinking	☐	☐	☐	☐	☐
Willingness to take calculated risks	☐	☐	☐	☐	☐
Ability to prioritize efficiently	☐	☐	☐	☐	☐
Project management: supervising, planning, scheduling, budgeting, etc.	☐	☐	☐	☐	☐

Teamwork skills and ability to function on multidisciplinary teams	☐	☐	☐	☐	☐
Entrepreneurship and intrapreneurship	☐	☐	☐	☐	☐

Section 6: Open-Ended Feedback

Q8. Please share any other comments or feedback you have on your experience with this skills-based volunteerism pilot program to date.

Section 7: Demographic Information

Note: The information in this section will not be attributable to individuals, and will aid in our analysis of the data.

Q9: Current Position (Select all that apply)

- ☐ Engineer
- ☐ Tech Fellow
- ☐ Technical Mentee
- ☐ Manager
- ☐ Other
- ☐ Prefer not to answer

Q10: What type of engineer are you? (Select all that apply if you are an engineer)

- ☐ Electrical engineer
- ☐ Manufacturing engineer
- ☐ Aerospace engineer
- ☐ Structures engineer
- ☐ Systems engineer
- ☐ Other
- ☐ Prefer not to answer

Q11: Number of years working at this company (Select one)

- ☐ Less than 1 year
- ☐ 1 – 4 years
- ☐ 5 – 9 years
- ☐ 10 – 14 years
- ☐ 15 – 19 years
- ☐ 20 or more years
- ☐ Prefer not to answer

Q12: Gender (Select one)

- ☐ Male
- ☐ Female
- ☐ Prefer not to answer

Thank you for taking this post-survey and for volunteering your time to inspire and engage the next generation of scientists, engineers and innovators!