



Center for Collaborative Education

Transforming schools for student success

Science, Technology, Engineering, and Math (STEM) Diversity Campaign: Final Evaluation Report

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About CCE

The Center for Collaborative Education (CCE) was founded in 1994 with the mission of transforming schools to ensure that all students graduate college- and career-ready, and are prepared to become compassionate, contributing global citizens in the new century. We work at the school, district and state levels to:

- Create learning environments that are engaging, collaborative, democratic and equitable;
- Build capacity within districts and schools to adopt new practices that promote student-centered, equitable learning for students and educators
- Catalyze systemic change at the school and district levels through district and state-level policy and advocacy support

CCE's service model involves activities in three areas: (1) district and school design; (2) rigorous, culturally responsive, and relevant instruction and assessment, and (3) research, policy, and advocacy. We partner with leadership, practitioners, policy makers, and others to develop and support educators capable of designing and implementing systems that weave together the three essentials of effective learning—curriculum, instruction and assessment—and that inspire students to pursue deep, meaningful work.



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Executive Summary

The STEM Diversity campaign (SDC) was launched in 2013 with the ultimate goal of increasing the number of women and underrepresented minorities in the STEM workforce at the DoD. It seeks to do this by focusing on three imperatives: (1) improving awareness of STEM career opportunities within the DoD, (2) developing the math and science skills of underrepresented groups, and (3) increasing knowledge of DoD STEM career pathways among underrepresented groups. The primary components of the SDC are the STEM DC Pilot and the 30 Under 30 Communications Campaign. In January 2015, BEST contracted with the Center for Collaborative Education (CCE) to conduct a retrospective and formative evaluation of the SDC and its components.

Key Findings

The SDC was implemented successfully and key components of the program are ongoing

Overall, the implementation of project activities, including participant recruitment, teacher training, and creation of materials for the communications campaign was well-coordinated and successful. The program activities around the DC STEM pilot were implemented by 2014 and are ongoing. Research and focus groups, for the 30 Under 30 communications campaign, began in early 2015, and the production of the promotional role model videos and the development of the YouTube channel for the 30 Under 30 communications campaign is ongoing. The campaign's YouTube channel had a "soft" launch earlier this spring (Spring 2016) with expected delivery the final product in the summer.

The SDC was successful in creating strong and mutually beneficial partnerships with schools and partner organizations

For the DC STEM Pilot, BEST partnered with seven STEM program organizations; seven public schools in DC, Baltimore County, and Prince George's county; and the University of the District of Columbia (UDC)). These partnerships were mutually beneficial and the alignment of goals and effective communication also were key to strong partnerships. To recruit schools, project staff forged relationships directly with schools, which was a very effective recruitment strategy. Taking the time and effort to connect directly with school principals and staff contributed to the close relationships formed between BEST and partner schools. Additionally, partner program providers indicated that the relationships that BEST has with schools was pivotal in their participation and successful implementation of their program.

The SDC provided high quality STEM learning experiences for students and teachers

By partnering with high quality program providers, BEST was successful at bringing immersive STEM learning experiences to students in underserved communities and providing teachers with meaningful



professional development that promoted hands-on learning. Engaging students in active hands-on STEM learning increased interest in STEM subjects and exposed students to the potential for STEM careers. Working with teachers to integrate active hands-on STEM experiences into the curriculum ensured that students would continue be exposed to high quality content, even after the DC STEM Pilot was completed.

The SDC is helping to “put a face on the DoD”

The 30 Under 30 communications campaign is a step towards “putting a face on the DoD”. Campaign materials, including “role model” videos feature young STEM professionals showing the “cool things” they do as part of their jobs, highlight different types of STEM jobs, describe the various sources of support for further education at the DoD, and highlights that there are opportunities for STEM professionals at all levels of education to work in the DoD. The materials were developed using feedback from the campaign’s target audience. The eventual success and impact of the campaign will depend on key next steps around dissemination and promotion to ensure that the campaign reaches its target audience.

Recommendations

Building on the positive outcomes described in this report, we make the following recommendations:

Recruiting and Working with Partner Schools

- The project should continue to work with current partner schools and strengthen support and commitment by facilitating or providing more extended opportunities for students to participate in STEM activities. Events for students could include: STEM clubs or after-school activities, and school events, like career fairs, where DoD early-career role models attend to speak directly with students about their experiences.
- Recruitment efforts that highlight the STEM content covered and activities will be successful in generating high participation rates since the majority of participants indicated that this was very important in their decision to participate.
- The project should continue to recruit partner schools and participants by forming close relationships with principals and school “champions” since this is an effective recruitment method. Just under half (43%) of participants learned about the program from an educator at their school.
- The project should also use past participants to recruit for and promote future teacher professional development events as the majority (88%) of participants indicated that they were very likely to recommend programs to colleagues.
- The project should continue to provide educators with access to hands-on curricula and materials as these are key incentives for participation and increase the likelihood that teachers will integrate new learning into their instruction.



Working with the DoD and Partner Organizations

- The project should continue to work with its current partners and recruit additional partner programs that provide high-quality, hands-on learning for students and teachers. When recruiting new partners who offer programs for teachers, the emphasis should be on longer-length programs that provide active and hands-on learning with expert instructors as these were program elements that were directly related to the quality of learning and gains in knowledge for teachers.
- The project should continue funding and, if possible, increase resources for professional development and concentrate efforts in particular schools and geographic areas. Increased funding can increase the number of teachers trained to build the critical mass of educators in particular schools and communities who can successfully implement high quality, hands-on STEM learning with their students. Additional funding also could support professional development programs of longer length and extend the content covered to include more technology and computer science options.
- The project should aim to form more partnerships or relationships with student clubs/professional associations (e.g. National Action Council for Minorities in Engineering (NACME), Society of Hispanic Professional Engineers (SHPE), and Society of Women Engineers (SWE) that are some of the trusted messengers of target audience.
- The project would be helped by identifying a “champion” within the DoD to enhance the communication and collaboration within and across the various DoD offices and services. Ideally, this champion would help to continue to refine and articulate the value of having diversity in STEM in the DoD and have direct communication channels to recruiters and other personnel who work to recruit and hire for the DoD workforce.

Reaching Broader Audiences

- The project should consider targeting students in STEM at community colleges to raise awareness of DoD STEM opportunities and career pathways. Large numbers of first-generation students including majorities of students of color and women enroll in community colleges and a small but substantial number of STEM majors begin their postsecondary careers at community colleges.
- The project should also consider including more specific efforts or activities targeting women and girls in STEM.

Additionally, two areas for improvement for the SDC/DoD diversity initiatives include: the need for a longer-term investment and commitment from the DoD, so program outcomes and success could be tracked longitudinally, and the importance of continued and consistent collaboration within the DoD to foster greater engagement across the organization around diversity issues.



Introduction

Science, technology, engineering, and math (STEM) knowledge and skills are increasingly important in the 21st century economy. According to the Bureau of Labor Statistics, the number of new STEM positions is expected to increase by 13% between 2012 and 2022; an increase of 1 million new jobs (Vilorio, 2014). At the same time, the United States is becoming increasingly racially and ethnically diverse: 43% of millennial adults are non-White and, according to the U.S. Census Bureau, by 2043 the country is expected to be majority non-white (Pew Research Center, 2014). In response to this growing diversity, the Department of Defense (DoD) needs to recruit and retain a demographically diverse STEM workforce to maintain global competitiveness and be inclusive of the population it serves (Lim, Haddad, Butler, & Giglio, 2013). Currently, however, the DoD STEM workforce does not reflect the demographic diversity of the country. According to a report by the RAND Corporation, African Americans and Latinos comprise only 15% of the DoD STEM workforce (Lim, Haddad, Butler, & Giglio, 2013). Additionally, women make up only 29% of STEM workers at the DoD.

With these conditions in mind, the Department of Defense (DoD) released an organizational diversity and inclusion strategic plan in 2012 addressing workforce diversity, workplace inclusion, and force sustainability. In turn, leaders from DoD's Deputy Assistant Secretary of Defense for Research and Engineering (ASD[R&E]) and the Office of Diversity Management and Equal Opportunity (ODMEO) working collaboratively conceptualized and sponsored the STEM Diversity Campaign.

The STEM Diversity campaign (SDC) was launched in 2013 with the ultimate goal of increasing the number of women and underrepresented minorities in the STEM workforce at the DoD. It seeks to do this by focusing on three imperatives: (1) improving awareness of STEM career opportunities within the DoD, (2) developing the math and science skills of underrepresented groups, and (3) increasing knowledge of DoD STEM career pathways among underrepresented groups (see Figure 1: Logic Model of STEM Diversity Campaign). To accomplish these goals, the SDC works to leverage DoD resources within communities with a significant DoD presence and collaborates with stakeholder organizations that work with underrepresented groups.

The SDC initially included four program components:

1. **The “30 Under 30” communications campaign:** a media campaign to increase awareness of the DoD as an employer of choice for STEM graduates from underrepresented groups, including women, African Americans, Latinos and Native Americans
2. **The DC STEM pilot:** a K-12 STEM education outreach program for students and schools in underserved communities that offers interactive, culturally-relevant STEM activities in order to foster students' interest in STEM careers



3. **The Million Women Mentoring program:** a program to recruit senior women leaders at the DoD to champion the efforts of more junior female colleagues
4. **The Native American study:** a comprehensive investigation of the STEM landscape in American Indian communities that provides recommendations on how the DoD can work as a partner to encourage more American Indians to pursue a career in STEM

In January 2015, BEST contracted with the Center for Collaborative Education (CCE) to conduct an evaluation of the SDC. This final evaluation report focuses on the analysis of data collected for the STEM DC Pilot and the 30 Under 30 Communications Campaign. The mentoring component and further outreach based on the Native American study were ultimately tabled.

Organization of the Report

The report is organized into four main sections:

- **Section 1** focuses on the evaluation design, data collection and analysis and measures.
- **Section 2** presents the findings of the two major components of the SDC (the DC STEM pilot and the 30 Under 30 Communications Campaign).
- **Section 3** includes a discussion of the findings.
- **Section 4** presents conclusions and recommendations.

The report also includes several appendices.



Figure 1: Logic Model for STEM Diversity Campaign

The goal of the SDC is to align Department-wide resources around a shared commitment to increase the participation of historically underrepresented groups in the DoD STEM workforce to enhance and accelerate the quality and diversity of the DoD STEM workforce. The SDC has three main objectives: (1) To support a portfolio of initiatives that lead to STEM career pathways into DoD; (2) to foster the development of STEM skills with particular focus on mission critical Science and Technology (S&T) priorities, through the engagement of community-based DoD volunteers; and (3) raise awareness of DoD career opportunities by showcasing diverse role models at the cutting edge of defense innovation.

Major program components and activities	Target Population(s)	Short Term Outcomes	Medium Term Outcomes	Long Term Outcomes/Impact
<p>DC STEM Pilot: Collaborate with partner organizations to offer professional development that provides training and resources in hands-on STEM learning activities to STEM teachers in school districts with large number of underrepresented students.</p> <p>Provide culturally relevant, active learning and hands-on activities intended to stimulate interest in STEM careers among underserved K-12 students, teachers, and parents in the DC region.</p> <p>Identify and recruit partner schools in DC region based on established selection criteria</p> <p>30 Under 30 Communications Campaign Conduct focus groups with target student audience in pilot sites for research on campaign message development.</p> <p>Identify and interview “30 under 30” DoD STEM professionals from historically underrepresented groups as role model candidates from across the services for campaign.</p> <p>Create online public campaign (video, website, YouTube channel) to engage target audiences.</p>	<p>Primary external audiences: Undergraduate and graduate students in STEM</p> <p>African American, Hispanic, American Indian, and female middle and high school students, their math and science teachers, and parents.</p> <p>Communities around the country in which DoD has significant science and technology presence</p> <p>Internal audiences: DoD stakeholders including senior science and engineering professionals who influence internship, recruitment and hiring; and those who volunteer for community STEM activities; technical directors, directors of research, public affairs offices at labs in pilot areas.</p>	<p>Teachers gain knowledge and skills</p> <p>Students increase awareness of and interest in STEM</p> <p>Increased STEM interest and knowledge of STEM opportunities among middle and high school students</p> <p>Increased awareness among K-12 students and parents in targeted communities of DoD as advocate of STEM diversity</p> <p>Increased awareness of DoD as employer of choice among STEM majors and STEM professionals</p> <p>Enhanced collaboration among DoD stakeholders</p>	<p>Teachers implement more hands-on STEM learning activities in their classrooms.</p> <p>Improved STEM skills among underrepresented middle and high school students</p> <p>Increased visibility of DoD as an advocate of STEM diversity</p>	<p>Improved awareness of DoD STEM career opportunities</p> <p>Increase in STEM skills among underrepresented populations</p> <p>Increase in knowledge of DoD STEM career pathways among underrepresented populations.</p>



Section I - Evaluation Design & Methods

The evaluation had two primary tasks. One, to provide a retrospective of the SDC, and two, conduct a formative assessment of the design, development, and implementation of the SDC initiative.

Task I- Retrospective Evaluation of the SDC

The purpose of the retrospective was to document the origin, history, and initial development of the STEM Diversity Campaign (SDC); to evaluate how and to what extent the project has been implemented based on the original goals and objectives; and to document the evolution and current status of the project, including unexpected or unintended outcomes. The evaluation addresses the following key questions:

1. How and why did the SDC begin?
2. How has the project evolved from its beginning to today?
3. What is the current status of the project?

Task II- Formative Assessment of SDC initiatives

The formative assessment of the SDC will focus on the design, development, and implementation of each SDC initiative and focus on the following key questions:

1. How is the program being implemented? What events and activities are happening as part of the program?
2. How and to what extent is the project attracting the intended target audience(s)?
3. Are participants satisfied with program experience?
4. Did program participants improve their knowledge, skills and/or awareness related to STEM, STEM career opportunities, and DoD STEM career pathways as a result of program participation?

Data Collection and Analysis

The data collection for the evaluation included both qualitative and quantitative data using teacher surveys, interviews with a variety of stakeholders, observations of teacher professional development activities, and document review. Each of these is described in more detail below.

Teacher Survey

The Center for Collaborative Education (CCE) developed and administered a survey to teachers participating in the STEM DC Pilot-sponsored teacher professional development programs from



Summer 2015 to Spring 2016. Survey topics included reasons for participation, goals for participation, satisfaction with the professional development activities, quality of the learning experience, participant knowledge, and instructional practice, as well as participant demographics and teaching experience. The survey took approximately ten minutes to complete and was administered either online or on paper to all participants' post- activity. The survey was customized for different programs as was warranted. A common version of the survey is included in Appendix A.

Teacher Survey Response Rate

We collected 169 survey responses from participants across the various teacher professional development programs. The overall response rate to the survey was 39%. The largest number of respondents attended SeaPerch (n=65), Science of Baseball (n=53), ASM Camp (n=24), and MATHCounts (n=15). There were fewer than 10 total responses from participants from HENACC, SeaGlide, and i2 Learning. These programs had fewer participants than the other programs and lower response rates. Due to the low number of responses from these programs, we cannot report reliable provider-level results for these three programs. However, the responses from participants from these three programs were included in descriptions and analyses that examined DC STEM Pilot teacher outcomes as a whole.

Analysis of Teacher Survey Data

The analysis of the teacher data focused on four major areas:

- Participant/teacher demographics and recruitment
- Participant satisfaction with professional development activities
- Teacher reports of impact of the professional development on their knowledge and instructional practices
- Relationship between program elements and program outcomes

Descriptive statistics (e.g., means, standard deviations) were calculated for participant demographics and recruitment. Descriptive statistics were also calculated, overall and by program provider, for participant ratings of their satisfaction and the impact of the professional development on their knowledge and instructional practice. A multivariate analysis of variance (MANOVA) was conducted to identify any statistically significant differences in participant ratings of satisfaction and impact on knowledge and instructional practice between the different program providers. Post-hoc analyses were used to identify specific programs that fared significantly better or worse than average on these outcome variables.

Finally, a path analysis was performed to identify program elements that were significantly related, directly or indirectly, to program outcomes. For this study, we were interested in three main program



outcomes: the quality of learning, the impact on teacher knowledge, and the impact on teaching. We theorized that the quality of learning would affect teachers' knowledge gains, and that both the quality of learning and knowledge gains would affect teaching. These three outcomes were measured using composites of survey items. All of the outcomes composite variables had sufficient reliability (Cronbach $\alpha > 0.75$) (see Appendix B for additional details on the survey data analysis).

Observations of Professional Development and Student Activities

Ethnographic observations were conducted at the SeaPerch training in Tulsa (October 2015) and at the Science of Baseball training (March 2016). Observers attended all sessions of both events, participated in activities, talked informally with participants, and took notes throughout the event. These notes were then qualitatively analyzed for content and themes that were consistent across professional development program. This analysis was informed by the research on best practices in STEM teacher development (Brown, 2009; Davis, 2003; Linn, Clark, & Slotta, 2003). The final analysis was turned into case study vignettes to provide a narrative structure to the description of the events (see pp. 23-26). CCE also observed a Viva Technology workshop for students at Columbia Heights Education Campus in Washington, DC (April 2015). The observer used the Out of School (OST) observation STEM indicators instrument.

Stakeholder Interviews

The other major data collection element of the study were semi-structured phone interviews with various SDC stakeholders, including representatives of partner organizations, participating schools, and higher education institution, the DoD, and BEST staff. All stakeholders received an email invitation to participate in the interviews during Spring 2016. Interviews were conducted by CCE research staff using a protocol developed in collaboration with BEST staff (see Appendix C for list of stakeholders and interview protocol). Interviews generally ranged from 30-45 minutes and included the following topics:

- Participant background and experience in STEM education
- Involvement/Role in the SDC
- SDC events and activities
- Participant perception of SDC progress, successes, and challenges
- Future of the SDC

Limitations of the Evaluation

There are several limitations to the evaluation. First, the primary data sources (e.g. the survey) represent respondents' self-reported perceptions and judgments about their learning, knowledge gains,



and changes in instructional practice. To try to mitigate these issues, in some cases, a researcher observed teacher professional development activities, which helped to enhance the richness and validity of the data.

The second limitation is related to teacher participation in data collection, which is a potential external validity limitation in this evaluation study. A total of 437 teachers took part in the STEM DC pilot during the evaluation period, and 169 teachers completed surveys for a response rate of 39%. Additionally, there were fewer than 10 total responses from participants from HENACC, SeaGlide, and i2 Learning and as a result we cannot report reliable provider-level for data for these three programs.

As a result of these limitations, as well as the relatively short time length of the initiative, the findings described in this report should be interpreted as preliminary.



Section 2 - Findings & Results

This section presents the major findings of the study based on teacher survey data from participants in the DC STEM pilot, observations of project activities, and telephone interviews with project stakeholders, including DoD leaders, partner program representatives, educators from partner schools, and project staff. We also include student survey data supplied by GMiS and findings from focus groups supplied by Market Tree LLC. First, we describe the major findings related to the DC STEM pilot and then report on findings for 30 Under 30 communications campaign.

The DC STEM Pilot

The DC STEM pilot is a STEM awareness education program designed to engage underserved K-12 students, teachers, and parents through culturally-relevant, active learning, and hands-on activities intended to stimulate interest in STEM education and careers. The underlying rationale of the program is that early and consistent interaction and engagement with students in targeted communities like Washington, DC will help to foster awareness of the numerous opportunities that require a background in math and science, as well as promote among students the importance of staying engaged in STEM subjects as they progress through high school, college, and careers. The pilot program is aligned with the three key imperatives of the SDC to: 1) build STEM awareness, 2) develop STEM skills and 3) increase awareness and knowledge of STEM career pathways into the DoD.

DC STEM Pilot Partner Programs

For the DC STEM pilot, BEST collaborated with seven partner programs to conduct STEM educational programs for students and deliver professional development to teachers. The partners included:

American Society for Metals (ASM). ASM conducted two week-long summer “materials science camps” for 60 Baltimore and DC area teachers. At the camps, teachers learned methods/strategies to make teaching math and science more exciting and accessible to students using the materials science principles.

Carderock Naval Surface Warfare Center (SeaGlide). The Carderock Naval Surface Center hosted a SeaGlide professional development program for eight teachers. The program focused on helping teachers learn how to build SeaGlide units, which are autonomous underwater vehicles, with students.

i2 Learning. i2 Learning ran a free STEM summer program for 57 students at Southwest Academy, a STEM magnet school in Baltimore that serves primarily low-income African-American students. The program engaged students in hands-on learning in engineering and computer science. The program also included professional development for six teachers where they learned how to use project-based learning in STEM subjects.



Partner Programs (continued)

Great Minds in STEM (GMiS). GMiS conducted seven Viva Technology workshops for 750 students at Baltimore and DC area middle and high schools. Viva Technology is a hands-on STEM learning experience designed to engage students, teachers and parents with STEM activities challenges that engage their interest in the application of technology and expose them to career options in science and engineering. GMiS also sponsored a group of Baltimore and DC area teachers to attend the 2015 HENACC conference and present at a roundtable on STEM education.

MATHCOUNTS. MATHCOUNTS conducted two professional development programs for 30 Baltimore and DC area middle and high school teachers and 30 teachers in Harlem. The goal of MATHCOUNTS teacher programs is to expose teachers to MATHCOUNTS lessons and activities to make math fun and engaging for their students. MATHCOUNTS also conducted a “math bingo” event for students as part of the US Science and Engineering festival.

USNA STEM Center (SeaPerch). The U.S. Naval Academy STEM Center for Education and Outreach held seven professional development sessions for approximately 120 teachers on underwater robotics and exploration. The sessions were held in the DC- and Baltimore-areas, as well as in Tulsa, OK and Albuquerque, NM. The primary goal of the session was to train educators on how to build SeaPerch robots with their students in order to engage students in hands-on learning about engineering and underwater exploration. Participants were provided with tools and starter kits in order to be able to build the SeaPerch units themselves.

Science of Sport. The Science of Sport conducted two professional development programs for 94 teachers on the Science of Baseball. The sessions were held at the Washington Nationals Ballpark in Southeast Washington, D.C. The goal of the program was to support teachers in using concepts and topics from baseball in order to engage students in hands-on learning in STEM subjects. Participants were provided with 20 lesson plans and materials to implement the lessons. Science of Sport also conducted hands-on learning activities with students at the USA Science and Engineering festival.

USA Science and Engineering Festival Sneak Peek. Prior to the official opening of the USA Science and Engineering Festival, the program hosted 250 middle school students from Prince George’s County, Baltimore County, and the Quantico DoDEA schools. Students participated in hands-on STEM activities in the morning with MATHCOUNTS and Science of Sport, attended a lunch with STEM role models, and toured the DoD exhibit pavilion after lunch.

Participating Schools and Student Demographics

The DC STEM Pilot was successful in recruiting schools and attracting students from its intended target audiences. BEST recruited the following seven schools from the DC metro region to participate in the program:

- Ballou High School (DC Public Schools)
- Columbia Heights Educational Campus (DC Public Schools)



- H.S. Woodson High School (DC Public Schools)
- McKinley Tech Middle School (DC Public Schools)
- Oxon Hill Middle School (Prince George’s County)
- Southwest Academy (Baltimore County)
- Thomas Johnson Middle School (Prince George’s County)

The schools enroll large numbers of low-income students (83% eligible for subsidized lunch) and significant populations of English language learners (12%) and students with disabilities (17%). African-American/Black students (66%) make up the majority of students in partners schools, followed by Latino/Hispanic students (28%), Asian (4%), White, (1%), and Other (1%) (see Table 1).

Table 1: Student Demographics of Partner Schools in the DC STEM Pilot

Student Enrollment	Ballou	Columbia Heights	Woodson	McKinley Tech	Oxon Hill	Southwest Academy	Thomas Johnson
Total Enrollment	755	1384	639	202	593	801	1000
African-American/Black	97%	32%	100%	96%	60%	76%	56%
American Indian	0%	0%	0%	0%	0%	0%	0%
Asian	0%	2%	0%	0%	6%	12%	3%
Latino/Hispanic	2%	65%	0%	4%	29%	8%	37%
White	1%	1%	0%	0%	2%	2%	2%
Other	0%	0%	0%	0%	3%	2%	1%
Subsidized Lunch	99%	86%	99%	78%	71%	70%	73%
Students with Disabilities	33%	9%	28%	20%	19%	16%	11%
English language learners	0%	31%	1%	2%	12%	0%	15%

Source: Maryland State Department of Education and DC Public Schools

More than 800 students from the participating schools took part in the student programs provided by Great Minds in STEM and i2 Learning through the DC STEM pilot. Participating students were predominantly African-American/Black (67%) and Hispanic/Latino (18%) with smaller number of Asian (7%), White (3%), American Indian (2%), and students of other race/ethnicity (3%). Students were roughly evenly divided by gender (52% male and 48% female).

Student Outcomes

The DC STEM Pilot program also met its goal of engaging students in hands-on STEM learning and exposing students to potential STEM careers. Results of student surveys administered by GMiS as part of their Viva Technology programs (students were surveyed before the Viva Tech program and



immediately after) showed that students reported positive immediate-term outcomes related to their STEM career knowledge and STEM career ambitions as a result of participating in the Viva Technology program. GMiS provided CCE with summaries of survey results for the Viva Technology programs conducted at Ballou, Columbia Heights, Woodson, and McKinley Tech, which we describe here:

- Viva Technology had the largest impact on students' STEM career knowledge. Students went from having very little knowledge of STEM careers (i.e., what engineers and scientists do) to 58% strongly agreeing that engineers/scientists work on machines and computers, 55% strongly agreeing that engineers/scientists work with other people to solve challenging problems, and 63% strongly agreeing that engineers/scientists work on things to help the world.
- After participating in the Viva Technology program, 81% of students reported that going to college was important to them and 88% intended to go to college immediately after high school (pre-survey data was not reported for this indicator).
- Before the Viva Technology workshop, 32% of students agreed that they planned to study science, engineering, or math in high school. This increased to 46% after the workshop. There was also an increase in the number of students who strongly agreed that they “like math and science” and that studying math and science benefits them in other school subjects.

CCE also conducted an in-person observation of a Viva Technology program at Columbia Heights Educational Campus, in Washington DC. A summary of the observation follows:

Engineering for Earthquakes

The Viva Technology student workshop was an all-day event led by a team of three presenters from Great Minds in STEM (GMiS). The event took place in the school gym and included about 90 students, ten college coaches, and four teachers –one of whom remained for the entire event while the others rotated in and out over the course of the day. Several BEST staff members were also present throughout the day. The students were overwhelmingly African-American and Latino and balanced by gender (male and female). Students were either invited to participate by a STEM teacher or, in some cases, students said they were required to attend and some were nominated by a teacher.

The goal of the Viva Technology student workshop is to increase student STEM skills and knowledge and raise awareness of STEM careers. Students role play an occupation (engineers on this occasion) and work in teams of 8-10, led by college coaches (STEM majors from local colleges who have been recruited and prepped in advance for their roles) and compete to achieve a task. The task for the workshop was to have teams design and construct a building that could withstand an earthquake. The teams were provided with building materials, prompts, and support (although not solutions) from the workshop facilitators and the college coaches. Students also could earn “Viva” dollars throughout the day for answering questions and prompts – the dollars were popular since they could be used in a raffle at the end of the day for a variety of education prizes, ranging from thumb drives, wireless



speakers, and other technology devices and gadgets. Students spent most of the day working on their design and construction in teams, with breaks for lunch and a guest appearance by a DoD spokesperson who spoke about his background in STEM and career at the DoD and took questions from students.

Overall, the workshop rated highly on facilitating team work and participation for students. Across teams, students collaborated to complete the task, asking questions and working as a team in a friendly and relaxed manner. It was clear that they were enjoying themselves even when they were stuck, or their buildings collapsed and they had to “go back to the drawing board.” Students were learning through hands-on activities and were encouraged to make connections to real-world concepts and situations.

The workshop was well-organized and lively. The workshop facilitators, with assistance from the college coaches, managed the large group well and encouraged everyone to get involved by actively engaging students and recognizing their efforts and positive peer interactions. The activities were challenging to the students and, at a few points, some teams became discouraged and essentially “abandoned” the task to socialize, and the college coaches struggled to get them back on task. But, in all cases where this happened, the teams eventually got back on task and all teams had a “building” at the end of the day to test on the earthquake simulator table and compete for bragging rights if their building was standing after all the shaking.

Teacher Demographics and Roles

The DC STEM program also was successful in attracting a racially/ethnically diverse group of STEM teachers from across the grade spans: 43% of teachers were White, 34% were African-American or Black, 8% were Asian, 3% were American Indian, 3% were Hispanic or Latina/o, and 8% were multiracial or other race/ethnicity. The majority of participants were women (72%) and two-thirds (68%) had either a master’s or doctoral degree.

Almost half (46%) of the participants were science teachers (e.g., Biology, Chemistry, Earth Science, or Physics), a third (34%) were math teachers with a smaller share of Engineering (12%) or Technology (17%) teachers participating. High school teachers (45%) were well represented among participants, while there were smaller portions of middle school teachers (28%), elementary school teachers (9%), elementary/middle school teachers (5%), middle/high school teachers (8%), and K-12 teachers (4%).

Teacher Recruitment and Reasons for Participation

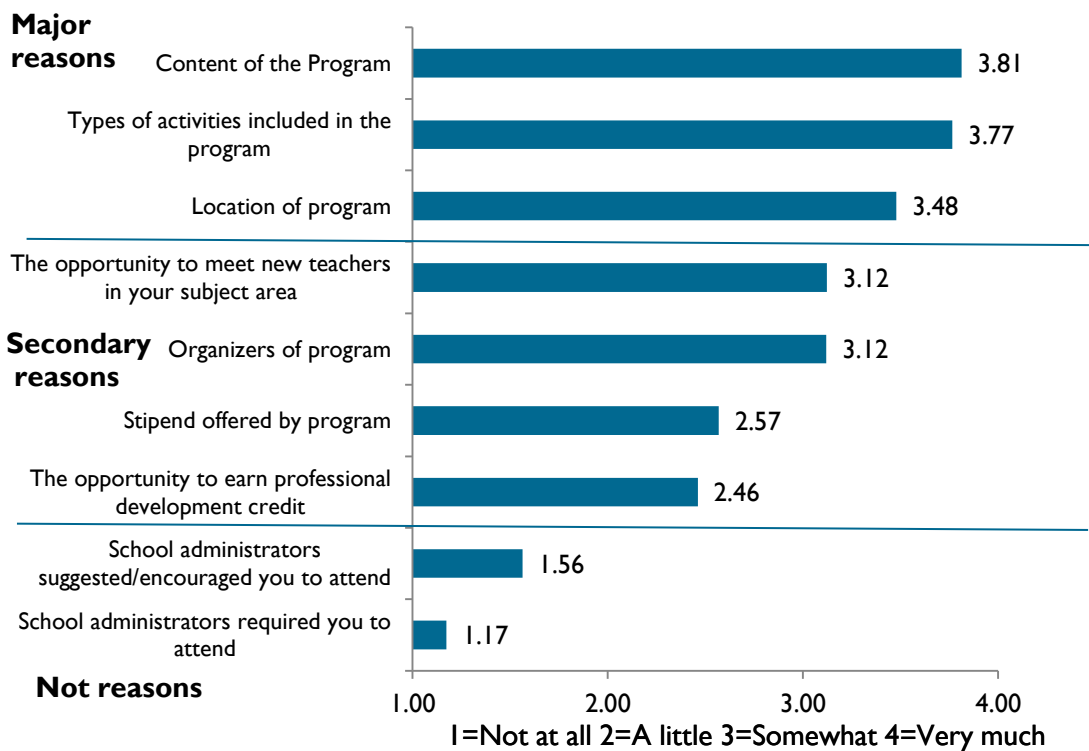
Participants learned about the program through a variety of channels. Most participants heard about the professional development program from another educator either in their school (43%) or from educators outside of their school (18%). A significant portion also heard about the program through e-



mail newsletters (22%). A small share of teachers learned about the program from their participation in past programs (7%), solicitation flyers (4%), and social media (1%).

Participants were motivated to attend largely because of the program content and activities. On a scale of 1-4 where 1= “not at all” and 4 = “very much”, content of the program (3.81), types of activities included in the program (3.77), and the location of the program (3.48) were the top reasons for taking part (Figure 2). Having an administrator either require or suggest attending was a key factor in the decision to participate only for very few teachers.

Figure 2: Average Teacher Ratings for Reasons for Attending DC STEM Pilot Professional Development Programs



Teacher Satisfaction with and Outcomes of Professional Development Activities

Overall, teachers were very satisfied with the professional development programs with a majority (61%) rating the quality of the program as “much better” than other teacher professional development programs they had attended. When asked “What aspects were better than other professional development program they had attended?” respondents identified the following aspects of the program:

- Resources provided by the program providers



- Opportunities to engage in hands-on learning activities
- Direct classroom applications
- Expertise of the instructors

One participant observed, “It was hands-on and quite interesting. The content was appropriate to the content that I teach. I will be able to use the things I learned in this PD in my classroom.” Another participant noted that, “the content and knowledge of the presenters was high caliber.”

A majority of participants (88%) gave a rating of either 9 or 10 when asked how likely they would be to recommend the program to a colleague. High satisfaction with the quality of the programs was consistent across providers. ASM, SeaPerch, Science of Baseball, and MATHCOUNTS all received ratings of 9 out of 10 or higher for instructor expertise, organization of the program, the program facilities, and the style of learning.

“It was hands-on and quite interesting. The content was appropriate to the content that I teach. I will be able to use the things I learned in this PD in my classroom.”

Quality of Learning

Overall, participants also rated the quality of learning as high. Participants “strongly agreed” (87%) that the professional learning was engaging, they were able to drive their own learning process (67%), they were able to make connections to classroom practices (75%), and they had opportunities to share with other teachers (75%). These characteristics are all consistent with the research on what makes for effective teacher professional learning (Desimone, 2009).

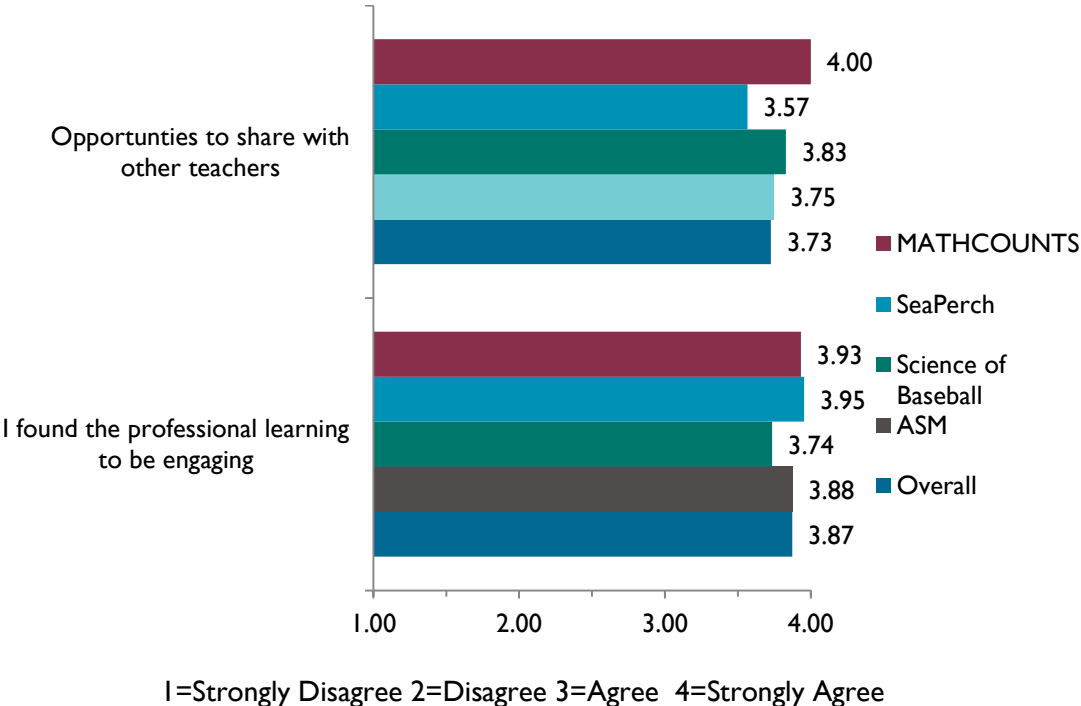
To examine whether there were differences in learning outcomes between programs, we conducted a multivariate analysis of variance (MANOVA), which is used to identify and measure differences between groups on multiple outcome measures simultaneously. This analysis was conducted for all teacher outcomes examined in this study including perceptions of the quality of learning, gains in knowledge, and changes in instructional practice. More information about the analysis can be found in the technical appendix (Appendix B).

Although overall ratings for quality of learning were high, there were still significant differences between programs in participants’ perceptions of the quality of learning. We found that there were significant differences between programs in how engaging participants found the learning ($p=0.006$) and the opportunities to share ideas with other teachers ($p=0.003$) (Figure 3). Science of Baseball participants had lower than average ratings for finding the learning engaging (Effect size=-0.41 standard deviations, $p=0.003$) and SeaPerch participants had lower than average ratings for opportunities to share their ideas with other teachers (Effect size=-0.32 standard deviations, $p=0.009$). One SeaPerch participant observed that one way the program could be improved would be “to have a chance to collaborate to work on ways to include the program activities in our existing curriculum.”



MATHCOUNTS participants, in contrast, had higher than average ratings for the opportunities to share with other teachers (Effect size=0.56, $p=0.026$). In survey comments, participants noted that they appreciated the opportunities to learn from other teachers in their schools, as one teacher observed, “the program was extremely interactive and highly engaging because it provides opportunity for group input.”

Figure 3: Average Teacher Ratings of Quality of Learning, by Program Provider



Impact of Program Participation on Teacher Knowledge and Instructional Practice

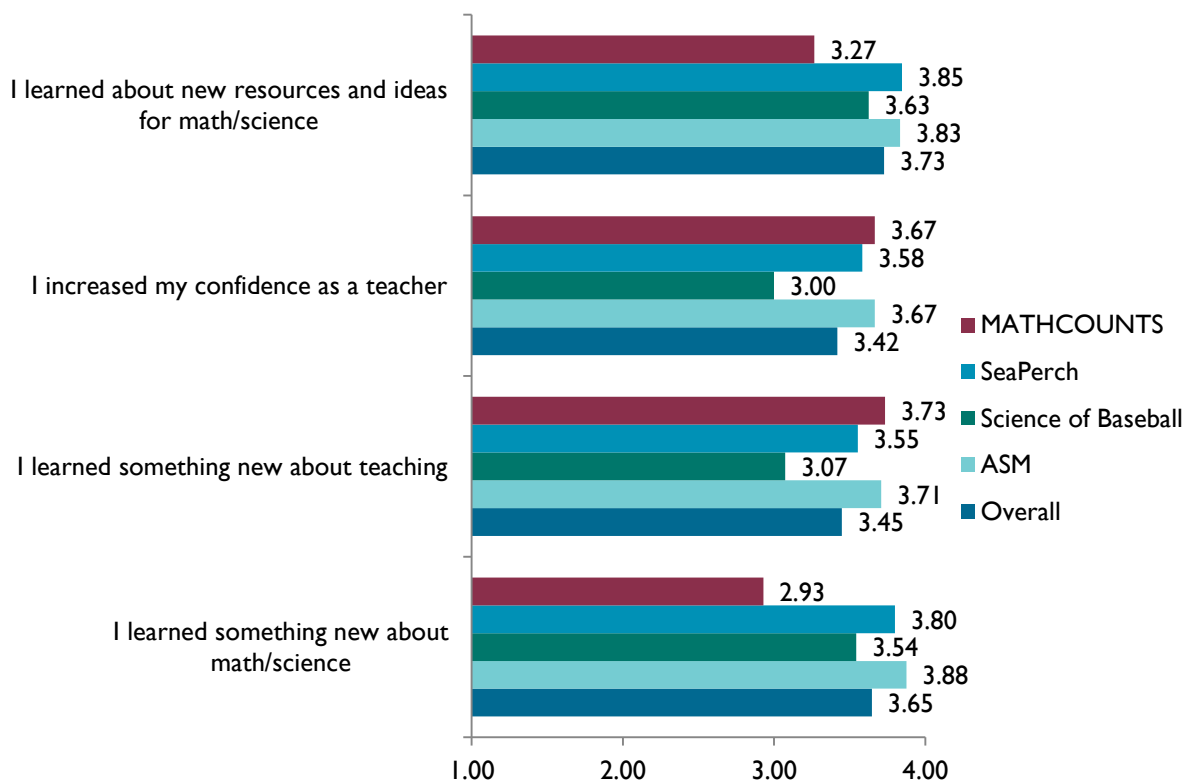
Overall participants felt that the program improved their content knowledge and would have a positive effect on their teaching. Almost three-quarters of participants (73%) “strongly agreed” that they learned something new about math or science and that they learned about new resources and ideas for teaching math or science (76%), while 57% “strongly agreed” they learned something new about teaching. More than half of participants (53%) also strongly agreed that the program increased their confidence as a teacher. Participants’ comments reflected these sentiments: a high school math teacher commented that “I walked away with so many more activities and ideas than I thought I would!” While a high school biology teacher said that, “I now feel more confident in my abilities to start doing more hands-on STEM activities with my students.”



Though the overall reported impact of all providers on teacher knowledge was high, there were significant differences between providers across all four knowledge outcomes ($p < 0.001$) (Figure 4). MATHCOUNTS participants had lower ratings than average for having learned something new about math or science (Effect size=-1.11 standard deviations, $p < 0.001$) and learned about new resources for teaching math or science (Effect size=-0.98 standard deviations, $p < 0.001$). However, these responses may be artificially low because the original survey question only asked about gains in knowledge related to science, which is not covered by the MATHCOUNTS curriculum.

For outcomes related to knowledge about teaching/instructional practice, ASM Camp participants were more likely than average to report learning more about teaching (Effect size=0.36 standard deviations, $p = 0.065$) and increased confidence in teaching (Effect size=0.35 standard deviations, $p = 0.067$). MATHCOUNTS participants also report higher than average increases in knowledge about teaching (Effect size=0.47 standard deviations, $p = 0.067$) and confidence (Effect size=0.41, $p = 0.095$). Participants' open-ended responses on the survey support these results. One ASM camp participant observed, "I gained many hands-on activities but also ways to make more interdisciplinary connections." Similarly, a MATHCOUNTS participant said they would recommend the program to other teachers because, "it provides an opportunity for teacher practitioners to build capacity."

Figure 4: Average Teacher Ratings of Knowledge Gains, by Program Provider



1=Strongly Disagree 2=Disagree 3=Agree 4=Strongly Agree



In contrast, Science of Baseball participants reported lower than average gains for learning something new about teaching (Effect size=-0.52 standard deviations, $p<0.001$) and increased confidence as a teacher (Effect size=-0.59 standard deviations, $p<0.001$). In survey comments, a number of Science of Baseball participants stated that they wanted more time to review the lessons and explore connections to their particular content areas. For example, one participant said that they “wished there had been a little more time to go through a few more the lessons,” while another while another suggested “a multi-day program to give more in-depth time with the resources.”

Impact on Teaching/Instructional Practices

Participants also reported that they anticipated that the program would have a positive impact on their teaching. More than half of respondents (55%) said they thought the program “was a good start and

“I will not go back to teaching any courses that are textbook only.”

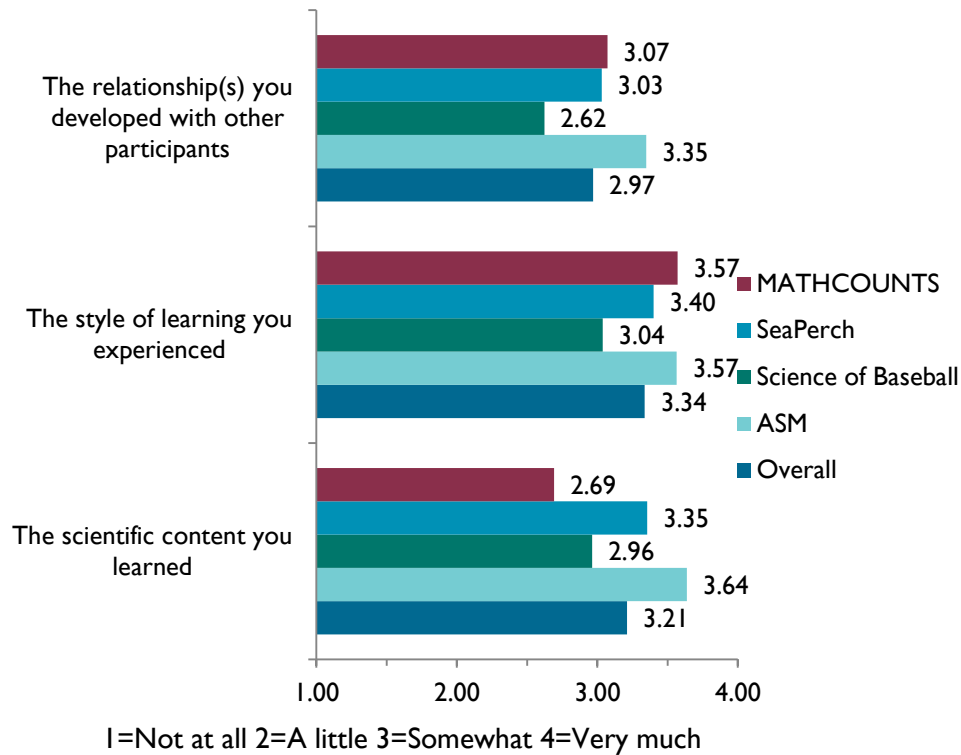
they planned to use the ideas in the classroom,” while 21% felt that the program gave them “everything I need to use the new ideas in my classroom.” Only 1% of participants thought that the ideas they learned would not work well in their classroom. The majority participants thought what they specific activities they participated in (62%) and the resources they learned about (59%) would “very

much” impact their teaching and almost half (49%) thought the style of learning they experienced would affect their teaching. As one middle school math teacher wrote about the program, “This will make my teaching more hands on.” Another high school engineering teacher commented that, “I will not go back to teaching any courses that are textbook only.”

Smaller, but still substantial numbers of teachers (40%) thought the content they learned about and the relationships they developed with the organizers (34%) and other participants (33%) would positively affect their teaching. One middle school science teacher commented that the program “has allowed me to help at-risk, rising 9th graders to build their self-confidence using skills they have not used before.” We found significant differences between providers as to how much participants anticipated different aspects of the program would affect their teaching. Specifically, there were significant differences between providers on to what extent participants thought the content they learned ($p<0.001$), style of learning they experienced ($p=0.003$), and the relationships they developed with other participants ($p<0.001$) would affect their teaching (see Figure 5).



Figure 5: Average Teacher Ratings of Impact on Teaching, by Program Provider



Examining participants’ perceptions of individual programs, Science of Baseball participants reported lower than average ratings on the impact of the relationships they developed with other participants (Effect size=-0.38 standard deviations, $p=0.004$), the scientific content they learned (Effect size=-0.31 standard deviations, $p=0.017$), and the style of learning they experienced (Effect size=-0.38 standard deviations, $p=0.005$).

MATHCOUNTS participants had higher than average ratings for the impact on teaching of the style of learning they experienced (Effect size=0.53 standard deviations, $p=0.060$), but lower than average ratings for scientific content learned (Effect size=-0.48, $p=0.083$). This may be due to the survey questions focus on specifically scientific content.

ASM Camp participants reported greater than average ratings for the relationships they developed with other participants (Effect size=0.55, $p=0.008$) and the scientific content they learned (Effect size=0.51, $p=0.014$). ASM Camp was the longest professional development program offered by the DC STEM pilot, which may have resulted in more opportunities for teachers to explore ways to connect what they learned to their teaching.



Notably, several participants commented (in response to an open-ended survey question) that they did not think the program would have a meaningful impact on their teaching. Some reasons that participants mentioned included that the level of the activities they learned about were either too easy or difficult for their students, that the content they learned about did not fit their subject area, and that they lacked the resources in their school to meaningfully implement the activities with their students.

Relationship Between Design Elements of Professional Development and Participant Outcomes

As part of the analysis, we also conducted a path analysis to examine how and which specific elements of the professional development were related to key outcomes—quality of learning, impact on teacher knowledge, and instructional practice/ teaching. The results indicated:

- The quality of the instructors/instructor expertise (Effect size=0.16 standard deviations, $p=0.085$) and participants' satisfaction with the learning style (e.g., opportunities for active learning) (Effect size=0.23 standard deviations, $p=0.007$) were directly related to participants' quality of learning.
- Participant satisfaction with the pace (Effect size=0.20 standard deviations, $p=0.005$), other participants (Effect size=0.15 standard deviations, $p=.023$) and the overall length of the program (Effect size=0.20 standard deviations, $p<0.001$) were directly related to gains in/impact on knowledge, while instructor expertise (Effect size=0.07, $p=0.098$) and learning style (Effect size=0.095, $p=0.015$) affected participants' knowledge via their effect on the quality of learning.
- Although none of the program elements included in the analysis were directly related to teaching/instructional practice, instructor expertise, pace, learning style, and length all indirectly affected teaching via their effects on the quality of learning and gains in/impact on knowledge.

Overall, the results of the path analysis suggest that having expert instructors and hands-on, engaging activities help to enrich the quality of the learning experience for participants. The pace of the program and the length of the program are associated with gains in knowledge. While none of the program elements included in the analysis were directly related to teaching/instructional practice, both the quality of the learning experience and gains in knowledge appear to be mediating factors related to teaching. Therefore, this suggests programs that possess elements that are positively related to the quality of learning and gains in knowledge could also have a positive relationship to teaching/instructional practice.



Case Study: NOAA/SeaPerch Workshop (Tulsa, OK)

The Sea Perch workshop for teachers took place at the University of Tulsa, a pretty, gold-bricked campus about 15 minutes outside of downtown Tulsa in a newly renovated building that houses the Engineering Department. The first day's session starts at 4 pm; teachers slowly trickle into the room. Altogether, there are approximately 30 teachers in the room.

The workshop facilitators are all from the US Naval Academy STEM Center at the Naval Academy in Annapolis, Maryland. Angela Moran is a professor at the Naval Academy and the director of the STEM Center. Along with Angela, there are two other facilitators and six Naval Academy midshipmen who provided assistance to teachers during the program.

The training started around 4:15 pm with the facilitators asking participants about their expectations for the program. Participants mentioned wanting to start a robotics club at their school, integrating robotics into their afterschool program, and being exposed to more types of robotics.



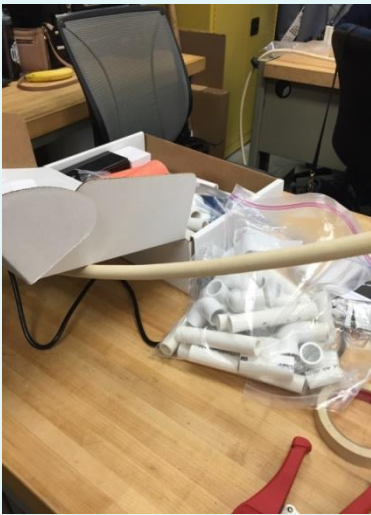
One of the facilitators accurately described the first night as “fast and furious” because there were so many different activities. Teachers were guided through a series of experiments that they could use with their students to teach them about nautical concepts. All of the learning was hands-on, where teachers completed the actual experiments they would use with their students. For example, in one experiment participants were given a box with holes and told that they needed to create a surface map of the bottom of the box using an unsharpened pencil to measure the “depth” of the box at different points. The goal was to use this information to create a graphical representation of the depth of the ocean surface. In another activity, participants created a pressure sensor using a piece of aluminum foil, two pieces of card stock, a battery, and a LED light.

Before each experiment, the facilitators walked the teachers through the process step-by-step. There were also instructions in the guide handed out to teachers. Throughout the evening of activities, the facilitators circled around the room and coached teachers as needed. After each activity, the facilitators paused for some brief reflection and asked participants to offer suggestions about how they could use this with their classes. Because of the pace of the program, there was not a great deal of time for participants to share ideas with other teachers or to discuss the concepts behind or the different scientific phenomenon participants were observing in the experiments.



NOAA/SeaPerch Workshop (continued)

Day 2 of the training started with an early breakfast and a quick division into groups of 2-3 people to work on their SeaPerch units. Each group received a kit with all of the equipment needed to build a SeaPerch including PVC pipes, electrical controls, an engine, and propeller blades. The instructors used a skill-based approach to teach the groups on how to build the models. An instructor would model a skill, and teachers then replicated this action. Instructors floated around the room and were available to answer questions or address problems.



SeaPerch units required a significant amount of technical skills to build successfully. Participants had to cut and drill PVC pipes, solder electrical equipment, and waterproof electrical motors. None of the skills were beyond the capabilities of a “beginner” but there was a learning curve with some of the technical skills. Facilitators offered only brief explanations of why certain design elements needed to be built in particular ways in order the SeaPerch units to work.

Participants built their SeaPerch with varying degrees of skills and confidence. Some participants had built a SeaPerch previously and were very confident in their technical skills. Others were clearly struggling with building the SeaPerch and often had to turn to the facilitators for help. There was enough support in place so no group fell too far behind or became too lost in the process. Most groups completed their SeaPerch units before lunch.

At lunch, Angela led a discussion about how teachers can implement SeaPerch in their schools. The discussion covered a number of topics like how to address the problem of limited resources (e.g., asking a hotel if you can use their pool) and how to differentiate or modify building the SeaPerch for different age groups and different ability levels. Some participants seemed very confident that they were going to be able to use the units with their students while others were not as sure.

After lunch, participants tested out their SeaPerch units at a nearby pool. The SeaPerch units moved easily in the water—both back and forth and up and down. The instructors put rings in the water and had the SeaPerch units “capture” and move the rings.

Overall, the mood at the end of the day was overwhelmingly positive and many teachers appeared excited to go back to their classrooms and use the SeaPerch units with their students.



Case Study: Science of Baseball (Washington, DC)

The Science of Baseball workshop was held on a rainy Saturday in early March 2016 in a function room attached to the Washington National stadium that was covered with Nationals logos and pictures of players. Around the room, there were 5-6 tables with 8-10 chairs with pre-assembled kits next to each chair. There was a projector and a large screen set up in the middle of the room.



Participants slowly trickled in before the start of the session and, by 10:15 am; the room was about 90% full. The facilitators began the event by asking everyone to introduce themselves and share what motivates their kids and their favorite baseball team. Most of the participants said they teach in Maryland or Northern Virginia with a small number saying they taught in DC public schools. Teachers shared that their students were motivated by real world examples, active learning, and relationships with their teachers. Some teachers also mentioned external motivators such as food or grades.

The facilitators then introduced themselves and described their organization, Science of Sport. The organization was founded by Richard Valerdi, a professor at the University of Arizona. The goal of the organization is to work with professional sports teams to use sports to teach kids about STEM subjects. They are currently working with a few major league baseball teams and one major league soccer team. The program works directly with students and also conducts professional development for teachers.

The facilitators then outlined the structure of the program. All teachers received a binder containing twenty lessons designed by the Science of Sport. The facilitators explain that they will briefly walk teachers through the structure of the lessons and then teachers will have opportunities to work in small groups to discuss extensions, adaptations, and modifications they would make to each lesson to make it meet the needs of their students. The facilitators warn teachers that they won't be completing all the lessons at this training as they did not want teachers to "drink from the firehose."

The lessons were structured around different aspects of baseball. For example, one lesson used a warm-up routine where baseball players run from home plate to the left field foul pole, across the field to the right foul pole, and then back to home plate. The lesson provided the distances of the foul poles from home for each ballpark so students can calculate the total distance traveled by using the Pythagorean Theorem. The facilitators demonstrated how you can also have students measure the distance themselves in Google Earth.



Science of Baseball (continued)

Once participants broke out into smaller groups, teachers came up with a number of ways the lesson could be adapted for their students. One teacher suggested having students convert the units to metric and practice using significant digits. Another teacher expanded the lesson by having students break up the entire field into triangles so they could measure the perimeter of the field. Others suggested adding in a real-world component by having students measure the field themselves and compare their measurements to their own calculations.

Over the course of the day, participants reviewed 10 out of the 20 lessons in the same manner. The review of the lesson was engaging; the facilitators often used videos or props to describe different concepts such as the effect of humidity on a baseball's flight path or why a knuckleball appears to defy gravity (it is because of the lack of spin). The activities went smoothly and were well-organized. All the materials were handed out before hand and everything teachers needed was clearly identified. The organizers clearly explained the concepts in the curriculum and the presentation was easy to follow.

The small-groups worked well in terms of giving teachers opportunities to share ideas and practices. Teachers came from a variety of different school settings, grade levels, and subject areas so they had many different perspectives on how to modify the lesson. Teachers thought of many ways to extend the concepts in the lesson by having students apply the concepts to real-world examples or explain the scientific principles underlying a particular phenomenon. The small groups also provided a more intimate setting to meet the other participants.

The lessons provided though useful probably could benefit from some tuning. Many of the questions students were asked were simple recall questions and were not necessarily aligned to the scientific or mathematical standards in the lessons. For example, students were asked to research the length of Joe DiMaggio's record consecutive games hitting streak. Other questions probed deeper, but were not relevant to the topic. For instance, students were asked how they would respond to the effect of the high altitude on baseball flight paths if they were the owner of the Colorado Rockies. One of the teachers mentioned to the facilitators that they felt that this might be distracting for students because it would drive their attention away from the focus of the lesson.

The day also had a number of "fun" opportunities built into it. Before lunch, participants were given a tour of the Washington Nationals baseball stadium and we were able to see the locker room and the press area. The ballpark tour was fun and participants generally appeared to be in high spirits (lots of group selfies, people soaking in the baseball minutiae). After lunch, the organizers put on a "bubble-gum blowing" competition where teachers competed to see who could blow the largest bubble-gum. The setting definitely had a "wow" factor that was unlikely to be replicated in a school setting.



The 30 Under 30 Communications Campaign

The underlying rationale for the 30 Under 30 communications campaign is that, by reaching out to historically underrepresented groups with well-crafted messages and appealing role models with whom target audiences can identify, the DoD would improve its chances of attracting a more diverse technical workforce. Externally, the campaign sought to raise awareness of the DoD as a committed advocate of STEM and an employer of choice among women, African-Americans, Latinos/Hispanics, and Native Americans. The campaign sought to leverage local goodwill created by targeted outreach efforts to engage diverse applicants in DoD STEM careers. The campaign is aligned with two of the three key imperatives of the SDC to: 1) build STEM awareness and 2) increase awareness and knowledge of STEM career pathways into the DoD.

In order to achieve these goals, a primary objective of the 30 Under 30 communications campaign component was to develop and disseminate a public awareness campaign to encourage college and university students in STEM to consider a career within the DoD, using a diverse group of “30 under 30” DoD early-career STEM professionals as the primary messengers. BEST communications staff commissioned six geographically targeted focus groups to learn the campaign’s target audience thoughts about diversity and working for the DoD. Based on these findings, BEST communications staff created videos and developed a website and YouTube site to house the campaign videos.

Campaign’s Target Audience Thoughts about Diversity and Working for the DoD

Six , two-hour, focus groups were held in Washington, DC; Huntsville, AL; Dayton, OH; Albuquerque, NM and San Diego, CA in January-February 2015. Each group included 6-10 college students studying STEM subjects, ranging in age from 18-30. All participants were U.S. citizens. In total, 55 students participated in the focus groups. The focus groups included students from all underrepresented groups within the DoD STEM workforce.

The following is a summary of the results of the six focus groups conducted January-February 2015 based on a report compiled for BEST by MarketTree, LLC:

- Focus group participants had a somewhat negative reaction to the word diversity although, when asked to vote for one of several possible campaign taglines, a majority of participants chose “diversifying a stronger America”.
- Overall, there was a lack of awareness of DoD career opportunities and participants expressed several common misconceptions about working for the DoD, such as they would work only on weapons development or other “top secret” projects.



- There was also some confusion about what civilian jobs in the DoD were or meant and concerns about the hiring process. Participants expressed that they thought the hiring process was long, arduous, and could lead to a loss of privacy due to background checks.
- The best or most trusted messengers for this group included their professors and advisors, student groups and/or professional associations, as well as current early-career STEM professionals working at the DoD.
- Focus group participants said that message(s) that would be most effective would focus on the “cool things they [STEM professionals at the DoD] can do”, incorporate examples of types of jobs available across the DoD, and include the experiences of current employees. Messages should include racially/ethnically diverse men and women – including White males, and should not be framed exclusively as efforts to attract women and/or minority students.

Developing the Campaign Message and Identifying the Best Messengers

Working in collaboration with DoD personnel, BEST staff was able to successfully identify and recruit early career STEM professionals from across the Air Force, Navy, and the Fourth Estate entities to be featured in the communications campaigns as “role models”. Sixty role models were filmed and produced into “vignettes” which are featured and available on the campaign’s [YouTube channel](#). The campaign had a “soft” launch in the Spring 2016 and BEST plans to collect website analytics and to actively promote and disseminate the videos. Dissemination and promotion efforts will need to be evaluated over time. A [website](#) was also created to support DoD recruitment efforts.

Summary

Overall, the main findings of this study demonstrate that the key activities and events, including the recruitment of intended audiences (schools, students, teachers, and program partners) of the SDC were successfully implemented. Data from teacher and student surveys show that participants were very satisfied with the program and reported positive near-term outcomes related to knowledge and skills for teachers and knowledge and awareness of STEM careers for students. In the next section, we discuss the implications of the findings and identify the successes and challenges of the SDC.



Section 3 – Discussion

The main findings of this study provide support for the continuation and expansion of the STEM Diversity Campaign. Although a few of the components of the original plan were tabled, two key components were implemented successfully. The SDC also demonstrated many of the key design elements of effective STEM programming. First, the program identified a well-defined need to increase the diversity of the DoD STEM workforce and addressed these needs through targeted programming and recruitment. Second, the program has been particularly successful in forming positive and strong partnerships with various STEM organizations as well as partner schools. Third, the program sponsored STEM activities that were appropriate for the target audience(s) with students reporting greater interest in STEM careers and teachers reporting significant changes in their knowledge and teaching practices. The materials created for the communications campaign successfully integrated the key findings from the focus groups and the campaign is currently poised to move to the next level to track engagement of key audiences. In this section, we discuss how and where the SDC was particularly effective as well as some of the challenges the project faced.

The SDC was implemented successfully and key components of the program are ongoing

Overall, the implementation of project activities, including participant recruitment, teacher training, and creation of materials for the communications campaign was well-coordinated and successful. The program activities around the DC STEM pilot such as the various teacher professional development activities and Viva Technology programs for students were implemented by 2014 and continued over the course of the project. For the 30 Under 30 communications campaign, research and focus groups began in early 2015, and the production of the promotional role model videos and the development of the YouTube channel for the 30 Under 30 communications campaign is ongoing. The YouTube channel had a “soft” launch earlier this spring (Spring 2016) with expected delivery the final product in the summer.

The SDC was successful in creating strong and mutually beneficial partnerships

For the DC STEM Pilot, BEST partnered or collaborated with seven STEM program organizations, public schools in DC, Baltimore County, and Prince George’s county, and the University of the District of Columbia (UDC)). In some cases, there was already a long-standing, pre-existing relationship with the partner organization and BEST and/or the DoD, and in other cases the

“We have been talking about improving diversity in our program, and the partnership with BEST is a perfect fit.”

- Jeane Deatherage, SM Materials Education Foundation



partnership was more recent and prompted by a desire of the partner organization to reach new or broader audiences with its work.

The partner organizations, schools and universities also highlighted how participation in the SDC was mutually beneficial. Not only did they gain resources (funding), and access to broader audiences but they saw this work as a high profile opportunity that would build their credibility and reputations as well.

“Well, the most important thing that is garnered from that relationship for us, and not to sound self-serving is it’s a stamp of approval. If a program like the STEM Diversity Campaign that comes out of the OSD, or the DoD Program Office says that what you do is of value, and we’re going to promote that, and use that, that’s a stamp of approval, and that is for us a great way to leverage our resources, and bring in additional funding.”

– Angela Moran, STEM Director for the Center for Education and Outreach, U.S. Naval Academy

The alignment of goals and effective communication were key to strong partnerships

“Both our visions, and missions are aligned. We work for the good of the people. And how we partner is to, again, to inspire, to ensure that we create aware, inspiration, motivation, and skills, so that the next generation of STEM talent is something that we can take some credit for.”

– Lupe Alvarado, Great Minds in STEM

The alignment of goals and visions and effective communication were key to building strong partnerships and the overall success of the project implementation. In interviews, stakeholders from the various partner organizations pointed out that the alignment of the organization’s own vision and mission and that of the STEM Diversity Campaign was a major reason for partnering with the SDC.

Open and candid communication highlighted by the responsiveness of the BEST team also contributed to successful collaboration. BEST and program partner representatives as well as schools where events took place, communicated (whether by email, phone or in-person) regularly, and sometimes daily as events approached.

The targeted recruitment of and working directly with schools also helped form strong relationships



The project staff were able to successfully recruit schools not only from the DC public schools (DCPS) but from several school districts in Maryland (Baltimore County and Prince George’s County), and is planning to continue work with schools in Harlem as well. When BEST encountered a few roadblocks

“...connections to the schools and the administrators; that’s a big thing. You know, there are a lot of places where it was BEST’s contact. If it were not for BEST’s contact, we never would have been introduced to the school administrator. We would never have been able to get into the school to host the event.”

– Lou DiGioia, Executive Director, MATHCOUNTS

in their initial strategy to work with the District of Columbia Public Schools leaders to identify schools to be part of the DC STEM pilot, project staff were instead able to forge relationships directly with schools (primarily through introductions from DoD personnel). However, while forging relationships with individual schools and school staff was time-consuming, it turned out to be very effective recruitment strategy working directly with schools, and probably contributed to the close relationships formed between BEST and partner schools. Partner program providers indicated that the relationships that BEST has with schools was pivotal in their participation and successful implementation of their program.

“..it’s the most impressive part of the campaign I have seen, quite honestly, over the years, and that is in building relationships...”

– Clarence Johnson, Director (ODMEO), Department of Defense

Although at the outset BEST staff had some difficulty coordinating outreach to schools with DCPS due to changes in leadership etc., BEST continues to communicate with the DCPS STEM chief about the work of the SDC and she has concurred that the schools that are involved are a high priority based on the target audience of the SDC and for the district.

The SDC provided high quality STEM learning experiences for students and teachers

By partnering with high quality program providers, BEST was successful at bringing immersive STEM learning experiences to students in underserved communities and providing teachers with meaningful professional development that promoted hands-on learning. Engaging students in active hands-on STEM learning increased interest in STEM subjects and exposed students to the potential for STEM careers. Working with teachers to integrate active hands-on STEM experiences into the

“I think it was very successful. There were students who were sixth graders at the time, and now they’re eighth graders, and they’re still talking about that event, and students are coding.”

–Djuana Henderson, math teacher at Mc Kinley Tech middle school



curriculum ensured that students would continue be exposed to high quality content, even after the DC STEM Pilot was completed.

“It taught me a lot about engineering and how it applies to the real world.”

–Student participant from Viva Technology workshop

“It opens a new side of me I never knew I had.”

–Student participant from Viva Technology workshop

“Every now and then I need a spark to ignite my soul for teaching. Something that so excites me it brings me back to the first year I taught and how excited I was to be in the classroom. The SeaPerch training was that for me this year. The spark that ignites a fire that excites me and my love of teaching.”

–SeaPerch Teacher participant

The SDC is helping to “put a face on the DoD”

Another key strength of the SDC is related to the 30 Under 30 communications campaign. The main campaign video is a step towards “putting a face on the DoD” by featuring current employees talking about their own experiences. The video, which features Maynard A. Holliday, Senior Technical Advisor, DoD as the narrator, incorporates the key feedback from the focus groups. Specifically, the video features young STEM professionals showing the “cool things” they do as part of their jobs, highlights different types of STEM jobs, and explains that there is support for further education and that there are opportunities for STEM professionals at all levels of education (i.e. you don’t have to have a Ph.D. to work in the DoD). However, the eventual success and impact of this component of the SDC will depend on the extent to which campaign materials are disseminated and used across the DoD staff in their recruitment efforts. In interviews, it was not clear to some DoD stakeholders, including some who had helped recruit role models, how the campaign materials and role models themselves were being utilized and if and how the professionals featured in the videos were being involved in recruitment activities.

Challenges/Areas for Improvement

While some early challenges eventually presented unanticipated opportunities, we describe a few areas for improvement based on feedback from various project stakeholders. Across stakeholder groups, two prime areas for improvement emerged in interviews: 1) the need for a longer-term investment and commitment, including measuring success longitudinally, and 2) the importance of collaboration within the DoD to foster greater engagement across the organization around diversity issues.



The Need to “Think About the Long-Game”

As one DoD stakeholder put it, there is a “need to think about the long-game” in order to see the kinds of outcomes and eventual impact that the DoD wants and needs. According to stakeholders, part of the longer-term commitment would be demonstrated by more and/or stable funding, at least some of which would support the tracking and measuring of program outcomes over time.

“I think if the DoD has the fortitude for a long-term commitment, and provides the resources to take on the challenge to groom some extraordinary students over many years to become part of our workforce - I think that would serve the Department of Defense well.”

–James (Jim) Rohr, National Marine Mammal Foundation and former navy researcher at SPAWAR Systems Center Pacific

Stakeholders also recognized that part of a longer-term commitment would mean getting even greater buy-in and engagement from across the DoD community. There was good collaboration generally with the Air Force, Navy, and Fourth Estate entities with the project and an effort was made to engage all the services. Additionally, several DoD stakeholders noted that greater (more timely and consistent) collaboration between the OSD and the services could help to clarify what indicators the DoD cares about and what it is the services may already know.



Section 4 –Conclusions & Recommendations

The formative evaluation of the STEM Diversity Campaign (SDC) was designed to provide BEST and project stakeholders with a study of the implementation and near-term impacts of program participation on participants and to provide an initial assessment of the experience of partner organizations and schools. While the study is limited in some ways, the results are useful in answering some of the key evaluation questions and in providing insights and recommendations to support the continuation and/or expansion of the program.

Overall, the BEST staff in collaboration with its partners successfully completed most of the proposed tasks, including:

- Developing and maintaining successful relationships with several schools in Washington, DC, Prince George’s County and Baltimore County in Maryland.
- Offering a range of high-quality and engaging teacher professional development programs that provide resources and materials to teachers.
- Recruiting teachers from Washington, DC and Maryland school districts who work at schools serving large populations of underserved student populations in STEM—a key target audience for the SDC.
- Supporting the implementation of Viva Technology programs for students at the partner schools.
- Conducting research to support development of a public awareness communications campaign about STEM career opportunities in the DoD targeted to college/university students.
- Creating campaign materials that incorporated key findings and conclusions from the focus groups.

Although a few of the original components of the SDC were tabled (the women’s mentoring project, the Native American study and STEM competition) and were not implemented, the main two components the DC STEM pilot and the 30 Under 30 communications campaign were successfully implemented. As a result of the project, teachers and students in several school districts in Washington, DC and Maryland had access to STEM training in hands-on-activities, materials, and resources, which they would not otherwise have access to in their schools and communities. The SDC exposed several hundred teachers and students to scientific and engineering content and concepts through hands-on activities and collaboration. Teachers and students found the activities to be engaging and educational (see Table 2 and Table 3 for current status of project components).

Additionally, as a result of the project, several communications materials were created, including a website and a YouTube site housing DoD role model videos. The materials were developed using feedback from the campaign’s target audience. Once all materials are completed and available, key next steps will be dissemination and promotion to ensure that the campaign reaches its target audience. Building on the positive outcomes described in this report, we make the following recommendations:



Recruiting and Working with Partner Schools

- The project should continue to work with current partner schools and strengthen support and commitment by facilitating or providing more extended opportunities for students to participate in STEM activities. Events for students could include: STEM clubs or after-school activities, and school events, like career fairs, where DoD early-career role models attend to speak directly with students about their experiences.
- Recruitment efforts that highlight the STEM content covered and activities will be successful in generating high participation rates since the majority of participants indicated that this was very important in their decision to participate.
- The project should continue to recruit partner schools and participants by forming close relationships with principals and school “champions” since this is an effective recruitment method. Just under half (43%) of participants learned about the program from an educator at their school.
- The project should also use past participants to recruit for and promote future teacher professional development events as the majority (88%) of participants indicated that they were very likely to recommend programs to colleagues.
- The project should continue to provide educators with access to hands-on curricula and materials as these are key incentives for participation and increase the likelihood that teachers will integrate new learning into their instruction.

Working with the DoD and Partner Organizations

- The project should continue to work with its current partners and recruit additional partner programs that provide high-quality, hands-on learning for students and teachers. When recruiting new partners who offer programs for teachers, the emphasis should be on longer-length programs that provide active and hands-on learning with expert instructors as these were program elements that were directly related to the quality of learning and gains in knowledge for teachers.
- The project should continue funding and, if possible, increase resources for professional development and concentrate efforts in particular schools and geographic areas. Increased funding can increase the number of teachers trained to build the critical mass of educators in particular schools and communities who can successfully implement high quality, hands-on STEM learning with their students. Additional funding also could support professional development programs of longer length and extend the content covered to include more technology and computer science options.
- The project should aim to form more partnerships or relationships with student clubs/professional associations (e.g. National Action Council for Minorities in Engineering (NACME), Society of Hispanic Professional Engineers (SHPE), and Society of Women Engineers (SWE) that are some of the trusted messengers of target audience.



- The project would be helped by identifying a “champion” within the DoD to enhance the communication and collaboration within and across the various DoD offices and services. Ideally, this champion would help to continue to refine and articulate the value of having diversity in STEM in the DoD and have direct communication channels to recruiters and other personnel who work to recruit and hire for the DoD workforce.

Reaching Broader Audiences

- The project should consider targeting students in STEM at community colleges to raise awareness of DoD STEM opportunities and career pathways. Large numbers of first-generation students including majorities of students of color and women enroll in community colleges and a small but substantial number of STEM majors begin their postsecondary careers at community colleges.
- The project should also consider including more specific efforts or activities targeting women and girls in STEM.



Table 2: Current status of 30 Under 30 Communications Campaign

Activity/Output	Status	Ongoing/Future plans
<p>Conduct focus groups with target student audience in pilot sites for research on campaign message development.</p>	<p>Achieved (completed) Six focus groups with college/university students from across the country were conducted. A summary report of findings was created to inform development of campaign materials.</p>	
<p>Identify and interview “30 under 30” DoD STEM professionals from historically underrepresented groups as role model candidates from across the services for campaign.</p>	<p>Achieved (completed)</p>	<p>Future plans should involve the 30 Under 30 role models who are featured in the videos in activities sponsored by the DoD (e.g. college recruitment events, events involving K-12 students etc.) as “messengers” to help raise awareness of DoD as an advocate for diversity and an employer of choice.</p>
<p>Create online public campaign (video, website, YouTube channel) to engage target audiences.</p>	<p>Partially achieved (in progress) Several campaign materials have been developed, including a website, and several videos housed on a YouTube channel, which had a “soft launch” in early Spring 2016. Post production work on additional video material is ongoing as of May 2016. Available materials incorporate the key feedback from the focus groups about most effective messages and best messengers.</p>	<p>More evidence is needed (e.g. social media and website analytics) to document dissemination and audience engagement across various platforms.</p>



Table 3: Current status of the DC STEM Pilot

Activity/Output	Status	Ongoing/Future plans
Identify and recruit partner schools in DC region based on established selection criteria.	<p>Achieved (continuing)</p> <p>BEST successfully identified and recruited several schools in DCPS with student populations that match the SDC target audience. BEST efforts also expanded to include schools in Prince George’s and Baltimore county in Maryland.</p>	BEST continues to identify additional schools in the DC metro region and MD schools districts where there are already partners with plans to expand to other regions (e.g. New York City and Virginia school districts).
Collaborate with partner organizations to offer professional development that provides training and resources in hands-on STEM learning activities to STEM teachers in urban school districts with large number of underrepresented students.	<p>Achieved (continuing)</p> <p>A diverse group of more than 400 STEM teachers from partner schools have participated in teacher professional development activities. Teachers reported high levels of satisfaction, gains in knowledge and skills as well as plans to integrate new activities and more hands-on learning into their instruction as a result of program participation.</p>	Additional data from participants, such as teacher observations, are needed to document changes in instruction. Future data collection should also track participants over time, if possible.
Provide culturally-relevant, active learning and hands-on activities intended to stimulate interest in STEM careers among underserved K-12 students, teachers, and parents in the DC region.	<p>Achieved (continuing)</p> <p>More than 800 students from partner schools participated in seven VIVA Technology and an i2 Learning programs. Participating students reported greater understanding and interest in STEM careers immediately after participating in the program (Viva Technology).</p>	Future data collection should track students longitudinally to determine if students’ initial increases in interest in STEM careers persist over time.



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Appendix A: SDC Teacher Survey

STEM Diversity Campaign Professional Development Workshop Teacher Survey

This survey is part of an evaluation of the STEM Diversity Campaign, which is being conducted by the Center for Collaborative Education (CCE).

The purpose of this survey is to learn more about your experience participating in teacher professional development as part of the STEM Diversity Campaign. Your responses will help inform future professional development programs.

All your individual responses will be kept confidential and will not be shared with anyone outside of the Research and Evaluation team at CCE.

Thank you for your participation!

Andresse St. Rose, Ed.D.
Joshua Littenberg-Tobias, Ph.D.
Center for Collaborative Education



Participation in the STEM Diversity Campaign Teacher Professional Development

I. Which **professional development programs** have you participated in with the STEM Diversity Campaign? [Select all that apply]

TWLC (NAVSEA)

08/04/2014

HENNAC Teacher Institute

10/01-10/04 2014

SeaGlide - Carderock

06/22-26 2015

SeaPerch

Baltimore - 04/02/2015

PGCC - 06/13/2015

Smith Center - 12/01/2014

ASM Camp

Howard - 07/14/2014

UDC - 07/13-17 2015

UDC - 7/20-24 2015

MATHCounts

Baltimore - 11/22/2014

i2Learning-Baltimore

07/20-31/2015



Please answer the remaining questions based on the STEM Diversity Campaign professional development program you participated in **most recently**.

2. How did you first hear about this program? [Select all that apply]

- From administrators at your school
- From other teachers at your school
- From other educators not at your school
- Solicitation Flyers
- E-mail Newsletters
- Social Media
- From participation in past STEM Diversity Campaign programs
- Other sources (please specify)

3. To what extent did the following factors influence your decision to participate in this program?

	Not at all	A little	Some what	Very much
Content of the program				
Types of activities included in the program				
Location of the program				
Organizers of the program				
Stipend offered by the program				
The opportunity to earn professional development credit				
The opportunity to meet other teachers in your subject area				
School administrators required you to attend				
School administrators suggested/encouraged you attend				



4. What other factors influenced your decision to attend this program?

Experience in the Program

5. On a scale of 1-10 where **1 indicates completely unsatisfied** and **10 indicates completely satisfied**, how would you rate the following aspects of your participation in this program?

	1	2	3	4	5	6	7	8	9	10
The expertise of the instructors providing the professional development										
The organization of the program										
The pace of the program										
The program facilities										
The food provided										
The style of learning										
The materials provided										
The other participants in the program										



6. To what extent do you agree or disagree with the following statements about your participation in this program?

	Strongly Disagree	Somewhat Disagree	Somewhat Agree	Strongly Agree
I found the professional learning to be engaging				
I was able to drive my own learning process				
I made connections between the activity and scientific content				
I made connections between the activity and classroom practices				
The organizers were responsive to my ideas and opinions				
I had opportunities to share my ideas and opinions with other teachers in the program				
I learned something new about science				
I learned something new about teaching				
I increased my confidence as a teacher				
I learned about new resources and ideas for teaching science				



7. Which of the following statements best describes the usefulness of this program? [Select one]

- It was a good start
- It was a good start, but I have a lot of questions
- It was a good start and I plan to use the ideas in my classroom
- It provided everything I need to use the new ideas in my classroom
- I don't think that the ideas provided will work very well in my classroom
- It's too soon to tell

8. What were your initial goals for participating in this program?

9. To what extent were you able to meet your goals?



Classroom Applications

Please answer Question 10 only if you participated in this program **BEFORE May 1, 2015**. If you participated in the program after May 2015 please skip to Question 11.

10. To what extent have the following aspects of this program influenced your teaching?

	Not at all	A little	Some what	Very much
The scientific content you learned				
The specific activities you participated in				
The style of learning you experienced				
The resources you learned about				
The relationship(s) you developed with the organizers				
The relationship(s) you developed with other participants				

Please answer Question 11 only if you participated in this program **AFTER May 1, 2015**. If you participated before then skip to Question 12.

11. To what extent do you **expect** the following aspects of this program will influence your teaching?

	Not at all	A little	Some what	Very much
The scientific content you learned				
The specific activities you participated in				
The style of learning you experienced				
The resources you learned about				
The relationship(s) you developed with the organizers				
The relationship(s) you developed with other participants				



12. Do you have anything else to add about how this program has influenced or will influence your teaching?

Feedback on Future Implementation

13. How did this program compare to other professional development programs you have participated in?

- Much worse
- Worse
- Somewhat worse
- About the same
- Somewhat better
- Better
- Much better



Please answer Question 14 only if you chose “Much worse”, “Worse”, or “Somewhat worse” on Question 13. If you selected another response option skip to Question 15.

14. What aspects were worse than other professional development programs that you have participated in?

Please answer Question 15 only if you chose “Much better”, “Better”, or “Somewhat better” on Question 13. If you selected another response option skip to Question 16.

15. What aspects were better than other professional development programs that you have participated in?



On a scale of 1-10 how likely are you to recommend this program to other teachers at your school?

Please answer Question 17 if you wrote **8 or higher** on Question 16. Otherwise skip to Question 18.

17. Why would you **recommend** this program to other teachers in your school?

Please answer Question 18 if you wrote **3 or less** on Question 16. Otherwise skip to Question 19.

18. Why would you **not recommend** this program to other teachers in your school?



19. What, if anything, would you change about this program

20. Do you have any recommendations or additional feedback for future programs sponsored by the STEM Diversity Campaign?



Participant Demographics

21. Prior to this school year (2015-2016), how many years have you taught?

- In education:
- Science or Math:
- In your current position:

22. What grade levels do you teach? [Select all that apply]

- Elementary School
 - Middle School
 - High School
 - Other (Please Specify)
-

23. What subjects do you currently teach? [Select all that apply]

- Biology
 - Biotechnology
 - Chemistry
 - Earth Science
 - Engineering
 - General Science
 - Math
 - Physics
 - Technology
 - Other [Please Specify]
-



24. What is your highest level of education?
- Associate's Degree (e.g., A.A., A.S.)
 - Bachelor's Degree (e.g., B.A., B.S.)
 - Master's Degree (e.g., M.Ed., M.A.)
 - Doctoral Degree (e.g., Ph.D., Ed.D.)
 - Other [Please Specify]
-

25. What is your gender?
- Male
 - Female
 - Transgender
 - Other [Please Specify]
-

26. What is your race/ethnicity?
- African-American or Black
 - Asian or Pacific Islander
 - Latino, Hispanic or Chicano
 - Multiracial
 - White
 - Other [Please Specify]
-

27. (Optional) If you are interested in being contacted for an interview by a researcher at CCE please provide your contact information below

First Name: _____

Last Name: _____

E-mail: _____

Phone Number: _____



Appendix B: Technical Report

Multivariate Analysis of Variance (MANOVA)

A multivariate analysis of variance (MANOVA) is a statistical analysis designed to be used with multiple dependent variables and a single categorical independent variable. A MANOVA allows for the exploration of multiple outcome variables simultaneously, reducing the likelihood of Type I error created by conducting multiple significance tests (Rencher, 2003).

For the analysis of teacher survey data for the SDC evaluation, we compared differences in teacher reported outcomes across the various program providers who were part of the DC STEM Pilot. A MANOVA analysis was conducted on three sets of outcomes variables: participant ratings of the quality of learning, participant self-reported knowledge gains (i.e. impact on knowledge), and participant perceptions of whether the program will influence their teaching practice (i.e. impact on teaching). Quality of learning was measured using the six items measuring learning quality (e.g., I found the professional learning to be engaging). Impact on teacher knowledge was measured using the four items that measured knowledge gains (e.g., I learned something new about teaching). Impact on teaching was measuring the six items that measured how much participants believed the programs would affect their teaching (e.g., The science/math content you learned). All three sets of outcomes variables were standardized prior to the analysis to estimate effect sizes using standardized units.

First, we conducted a multivariate significance tests to test the null hypothesis that there were no differences between providers on any of the sets of outcome variables. All of the multivariate tests were statistically significant ($p < 0.001$), so the null hypothesis was rejected, supporting the alternative hypothesis that that there were differences between providers on participant outcomes measures (Table 1).

Table 1: Multivariate Tests of Significance

Outcome Set	Number of Variables	Wilks' Lambda	p-value
Quality of Learning	6	0.721	<0.001
Impact on Knowledge	4	0.611	<0.001
Impact on Teaching	6	0.734	<0.001

Second, univariate statistical tests were used to identify specific individual outcome variables where there were significant differences across providers. Univariate statistical tests indicated significant differences for two program quality outcomes, three teaching outcomes, and all four knowledge outcomes (Table 2).



Table 2: Univariate Tests of Significance

Individual Outcomes	F Statistic	p-value
Quality of Learning		
I found the professional learning to be engaging	4.328	0.006
I had opportunities to share ideas with other teachers	4.851	0.003
Impact on Knowledge		
I learned something new about math/science	9.679	<0.001
I learned something new about teaching	8.043	<0.001
I increased my confidence as a teacher	10.573	<0.001
I learned about new resources and ideas for math/science	7.106	<0.001
Impact on Teaching		
The scientific content you learned	6.110	<0.001
The style of learning you experienced	4.857	0.003
The relationships you developed with other participants	5.840	<0.001

Finally, program providers with higher or lower than average ratings were identified by estimating marginal means for each provider on all outcome variables where univariate tests indicated significant variation across providers. Because the outcome variables were standardized, the estimated marginal mean was interpreted in terms of the difference in standardized units between participants ratings for that provider and the grand mean (i.e., the overall mean score of all SDC participants on the variable). Statistical significance tests were performed to identify program providers who received ratings that were significantly higher or lower than the grand mean (Table 3). In order to reduce the likelihood of spurious results, we only reported significant differences where there was also robust effect sizes (>0.3 standard deviations).

This analysis has several limitations. First, the sample only includes teachers who participated in SeaPerch, ASM Camp, MATHCOUNTS, and Science of Baseball programs because the other providers (e.g., SeaGlide, i2 learning) did not have a sufficient group size to generate reliable provider-level estimates. And within the restricted sample the group sizes for each provider were small, particularly for ASM Camp (n=24) and MATHCOUNTS (n=15). Small group sizes increase the likelihood of Type M error, where the magnitude of the effect size is exaggerated because of low statistical power (Gelman & Carlin, 2014). As a result, the estimated effect sizes for each program may be overestimates of the true program effect size.

Second, the wording of some of the survey questions, specifically those that focus on scientific content, may have artificially suppressed some of the participant ratings, particularly for MATHCOUNTS. This issue was addressed mid-way through data collection; however, a substantial number of participants took the survey using the original survey wording.

Third, due to time restrictions, we surveyed participants within a few weeks of completing the professional development program. As a result we cannot accurately assess the longer-term effects of programs on teacher knowledge and practices. It is possible that some programs may have longer-term effects that were not apparent to participants soon after completing the program.



Table 3: Estimated Provider Effects

Outcome	Standardized Effect (β)	Standard Error	p-value
Quality of Learning			
I found the professional learning to be engaging			
Science of Baseball	-0.409	0.137	0.003
I had opportunities to share ideas with other teachers			
SeaPerch	-0.321	0.122	0.009
MATHCOUNTS	0.561	0.250	0.026
Impact on Knowledge			
I learned something new about math/science			
MATHCOUNTS	-1.115	0.250	<0.001
I learned something new about teaching			
ASM Camp	0.361	0.194	0.065
MATHCOUNTS	0.470	0.254	0.067
Science of Baseball	-0.519	0.131	<0.001
I increased my confidence as a teacher			
ASM Camp	0.341	0.190	0.067
MATHCOUNTS	0.418	0.249	0.095
Science of Baseball	-0.590	0.128	<0.001
I learned about new resources and ideas for math/science			
MATHCOUNTS	-0.982	0.258	<0.001
Impact on Teaching			
The scientific content you learned			
ASM Camp	0.514	0.210	0.014
MATHCOUNTS	-0.476	0.272	0.083
Science of Baseball	-0.314	0.130	0.017
The style of learning you experienced			
MATHCOUNTS	0.530	0.280	0.060
Science of Baseball	-0.384	0.133	0.004
The relationships you developed with other participants			
ASM Camp	0.551	0.210	0.008
Science of Baseball	-0.377	0.130	0.004

Path Analysis

A path analysis is a type of structural equation model (SEM) that estimates the inter-relationships between observed measures. Path analysis affords the ability to break apart relationships among variables and evaluate the fit of theoretical models to the data (Schreiber et al., 2006).



The goal of the path analysis was to identify the elements of the professional development programs that most contributed, either directly or indirectly, to positive outcomes. We included the following seven program elements in the analysis: instructor expertise, organization, pace, facilities, learning style, other participants, and the materials provided. Participants rated each program element on a scale of 1-10, where 10 indicated complete satisfaction. We also included a “program length” variable that indicated whether the program was a single day or multi-day program.

The analysis also included three composite variables: quality of learning, impact on knowledge, and impact on teaching. Composite variables were created by averaging across survey items. All of the composite outcome variables had sufficient reliability and variability across participants (Table 4).

Table 4: Descriptive Statistics for Outcome Variables included in the Path Analysis

	Min	Max	Mean	Std. Dev	Cronbach Alpha (α)
Quality of Learning	2.833	4.000	3.750	0.321	0.802
Impact on Knowledge	2.000	4.000	3.560	0.510	0.778
Impact on Teaching	1.000	4.000	3.250	0.630	0.865

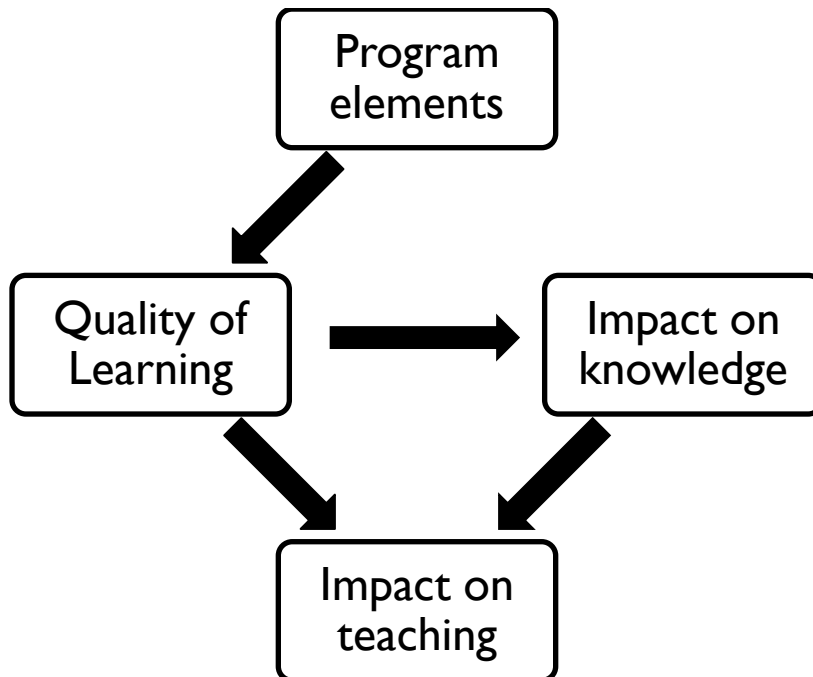
Figure 1 illustrates our theory of how program elements would affect teacher outcomes. We theorized that program elements would directly affect the quality of learning, the quality of learning would directly relate to the impact on teacher knowledge, and the quality of learning and impact on knowledge would directly relate to the impact on teaching. This theoretical model was used to specify the path analysis model. Model parameters were estimated using a full-information maximum likelihood (FIML) approach with missing data imputed (Allison, 2003). All estimated parameters were standardized in order to interpret the magnitude of the effect size.

After we fit the theoretical model, we conducted Lagrange multiplier tests to determine whether adding any additional parameters to the model would improve the overall fit. The tests indicated that three program elements—the pace of the program, other participants, and program length—had direct effects on the impact on teacher knowledge that were not accounted for by the quality of learning outcome. A chi-square difference test indicated that adding these parameters to the model significantly improved the overall fit compared to the original model ($\chi^2 = 29.64, df = 3, p < 0.001$).

The likelihood ratio test for the final model was not statistically significant, indicating that the model fit was not significantly different from a fully saturated model and the model fit the data well ($\chi^2 = 15.04, df = 13, p = .305$). All of the fit indices exceeded the threshold guidelines suggested by Hu & Bentler (1999), indicating that the model fit the data well (CFI=0.99, TLI=0.98, RMSEA=0.31).



Figure 1: Theoretical Model



Once the model was fitted, the direct and indirect effects for all parameters in the model were estimated. A direct effect indicates that there is a direct relationship between the two variables, controlling for the other variables in the model. An indirect effect indicates that a relationship exists between two variables but it is mediated through a third variable. The total effect is the combination of the direct and indirect effects. Table 5 presents all the direct and indirect from the final path analysis model.

The results of the path analysis indicated that:

- The quality of the instructors/instructor expertise (Effect size=0.16 standard deviations, $p=0.085$) and participants' satisfaction with the learning style (e.g., opportunities for active learning) (Effect size=0.23 standard deviations, $p=0.007$) were directly related to participants' quality of learning.
- Participant satisfaction with the pace (Effect size=0.20 standard deviations, $p=0.005$), other participants (Effect size=0.15 standard deviations, $p=.023$) and the overall length of the program (Effect size=0.20 standard deviations, $p<0.001$) were directly related to gains in/impact on knowledge, while instructor expertise (Effect size=0.07, $p=0.098$) and learning style (Effect size=0.095, $p=0.015$) affected participants' knowledge via their effect on the quality of learning.
- Although none of the program elements included in the analysis were directly related to teaching/instructional practice, instructor expertise, pace, learning style, and length all indirectly affected teaching via their effects on the quality of learning and gains in/impact on knowledge.



Table 5: Estimated Direct and Indirect Effects

Quality of Learning	Direct Effects		Indirect Effects		Total effects	
	Beta	p-value	Beta	p-value	Beta	p-value
Instructor expertise	0.164	0.085			0.164	0.085
Organization	0.071	0.532			0.071	0.532
Pace	0.098	0.303			0.098	0.303
Facilities	0.030	0.729			0.030	0.729
Learning style	0.235	0.008			0.235	0.008
Other participants	0.031	0.739			0.031	0.739
Materials provided	0.043	0.619			0.043	0.619
Length	0.045	0.507			0.045	0.507
Impact on Knowledge	Direct Effects		Indirect Effects		Total effects	
	Beta	p-value	Beta	p-value	Beta	p-value
Instructor expertise			0.066	0.098	0.066	0.098
Organization			0.029	0.534	0.029	0.534
Pace	0.197	0.005	0.039	0.310	0.237	0.003
Facilities			0.012	0.729	0.012	0.729
Learning style			0.095	0.015	0.095	0.015
Other participants	0.154	0.024	0.012	0.739	0.167	0.031
Materials provided			0.017	0.620	0.017	0.62
Length	0.205	0.001	0.018	0.510	0.223	0.001
Quality of learning	0.403	0.000			0.403	0.000
Impact on teaching	Direct Effects		Indirect Effects		Total effects	
	Beta	p-value	Beta	p-value	Beta	p-value
Instructor expertise			0.070	0.097	0.070	0.097
Organization			0.031	0.534	0.031	0.534
Pace			0.129	0.014	0.129	0.014
Facilities			0.013	0.729	0.013	0.729
Learning style			0.100	0.015	0.100	0.015
Other participants			0.081	0.108	0.081	0.108
Materials provided			0.018	0.62	0.018	0.62
Length			0.110	0.009	0.110	0.009
Quality of learning	0.249	0.001	0.178	0	0.427	0.000
Impact on knowledge	0.442	0.000			0.427	0.000



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Appendix C: SDC Stakeholder List and Interview Protocol

Dr. Segun Adebayo, Professor & Chair, Department of Mechanical Engineering University of the District of Columbia*

Lupe Alvarado, Senior Advisor to Special Initiatives, Great Minds in STEM (GMiS)*

Richard Baker, STEM outreach at Patterson Airforce Base*

Ethan Berman, founder, i2 camp and i2 Learning*

Jillian Blair, Engineering and Environmental Science Teacher, Columbia Heights Educational Campus

Victoria Bowen, CDP, Director, Diversity and Inclusion Management Department of the Navy*

Jeane Deatherage, American Society for Metals (ASM)*

Lou DiGioia, Executive Director, MATHCOUNTS*

Djuna Henderson, Math Teacher, McKinley Tech Middle School*

John James, Missile Defense Agency

Clarence Johnson, Director, Office of Diversity Management and Equal Opportunity (ODMEO)*

Claudia Johnson, Southwest Academy Magnet School for Science and Technology, Computer

Dr. Felicia Martin-Latief, STEM Supervisor, Prince George's County Public Schools

Angela Moran, Director, STEM Outreach, US Naval Academy (USNA)*

Dawn Person, Ballou High School, DC Public Schools*

James Rohr, NAVSEA engagement*

BEST staff

Karen Harper, Vice President, BEST*

Carlos Rodriguez, Senior Advisor, BEST*

Brenda Sullivan, Director of Communications, BEST*

John Yochelson, President, BEST

*interviewed as part of evaluation



STEM Diversity Campaign Stakeholders Interview Protocol

Introduction

Hi [Name] I am a researcher at the Center for Collaborative Education in Boston. We are conducting an evaluation of the STEM Diversity Campaign for BEST, and an important part of the evaluation is to talk to key stakeholders, like you, who have played an important role in the initiative. The goal of this interview is to hear from you about your involvement in the STEM Diversity Campaign, your overall experience and opinion about the impact of the program. Everything you say will be kept confidential and will not be shared with anyone outside of CCE (although we might publish quotes without identifying information as part of the final evaluation report). Do you have any questions before we begin? Do I have your permission to record this conversation for my records?

Background (Everyone)

1. First, please confirm your name, title and organization.
2. Tell me a little about yourself, how did you get to your current (professional) role/position?
 - a. Follow-up for previous experiences in STEM education and/or previous experiences with STEM diversity initiatives.
3. What about STEM or STEM education interested you? Why do you think you were drawn to this particular field?
 - a. Follow-up for interest in hands-on learning, opportunities for STEM careers, and increasing diversity in STEM fields.
4. Can you give an example of a particular STEM educational experience you have been a part of (either as a learner or teacher/instructor) that was particularly powerful? Why do you think it was so effective?

Planning and Development of the STEM Diversity Campaign (BEST & DoD Stakeholders Only)

1. Did you have a role in the initial planning and development of the SDC?
 - a. Follow-up for when (year) and how they became involved.
 - b. If not, please describe how you learned of the SDC?
2. If yes, please describe your involvement in the planning for the SDC?
If played a key role in initial development:
 - a. What was the initial vision of the SDC?
 - b. What were the initial goals for the program?
3. If less involved:



- a. How would you describe the planning process?
- b. What aspects worked well?
- c. What aspects did not work well?

Involvement in the STEM Diversity Campaign (Partner-Organizations Only)

1. How did you or your organization/school become involved with the STEM Diversity Campaign?
 - a. Did you reach out to them or did they reach out to you?
 - b. What role did you play in the decision-making process for your organization/school to become involved with the SDC?
 - c. [If person was a decision-maker] Why did you decide to collaborate with the STEM Diversity Campaign?
2. What were your expectations going into this relationship?
 - a. Follow-up for help with planning, access to resources, financial support, help with promotion and marketing
3. Who was your primary contact at SDC? How often did you talk to them?
4. How would you describe your relationship with them?
5. Can you think of an example of a time that you communicated really well? What do you think worked particularly well?
6. Can you think of an example where there was not good communication? Why do you think this occurred?
7. What did you learn about this kind of collaboration as a result of your involvement with the SDC?
8. Do you have any recommendations for the program staff/sponsors?

Progress of the SDC (BEST & DoD Stakeholders Only)

1. What was your role in the SDC program (BEST staff only)?
2. Describe your involvement in the SDC program?
 - a. How much time would you say you spent working (planning/attending events etc.) related to the SDC?
 - b. What did your involvement look like on a day-to-day (or other timing depending on their role) basis?
 - c. Who else did you work with?
 - d. Were there any significant challenges you face in fulfilling your role?
3. What do you think were the SDCs program's major accomplishments?



- a. Were there any program accomplishments that weren't anticipated?
4. How do you think the program did overall in achieving its goals?
 - a. What parts of the SDC do you think were successful? (Probe for examples)
 - b. What parts of the SDC could have been improved? (Probe for examples)
 - c. If you had to do it all over again, what would you do differently?
 - d. Were there any unanticipated changes (internal to BEST/DoD) that affected the program?

Your SDC Events (Partner-Organizations Only)

1. [If not covered previously] What event/s has your organization worked with the STEM Diversity Campaign on?
2. Can you describe this event/s a little bit?
 - a. What was the goal of the event/s?
 - b. Who were the participants? How many people participated?
 - c. Was this the target audience? To what extent was the target audience reached?
 - d. Do you think this event/s was successful? Why or why not?
3. What support did you the SDC provide for this event?
 - a. Follow-up for help with planning, access to resources, financial support, help with promotion and marketing.
4. How important was this support to the success of the event/s?
 - a. Could the event have happened without this support?
 - b. Is there anything else that the SDC didn't provide that would have been helpful?
5. Leading up to the event what was your communication like with the SDC?
 - a. How often did you talk to them?
 - b. How would describe your communication?
 - c. What worked well?
 - d. What did not work well?
 - e. Is there anything you would change in the future?

Going Forward (BEST & DoD Stakeholders Only)

1. Given the goals of the SDC, what was the main impact of the SDC/where was it most successful?
 - a. Follow-up for effects on DoD culture, relationships with other organizations, impact on the target audience(s)?
2. Where can you see this initiative, or similar DoD-sponsored STEM diversity initiatives, going in the future?



- a. What would you want to see expanded or improved?
- b. What continues to be the most pressing needs facing the DoD in attracting the target audience of the SDC?
- c. What, if any, other audiences do you think should be targeted?
- d. How do you think the initiative might produce real systemic change?

Going Forward (Partner-Organizations Only)

1. Looking into the future, where do you see your school/organization going in terms of programming around STEM education?
 - a. Follow-up for expansion of programming, looking for more funders, increasing the target audience, and targeting a more diverse audience?
2. In what areas do you think your school/organization can improve or expand in terms of STEM education? How do you think your organization should make those changes?
3. What role might future STEM diversity initiatives play into achieving those goals?
 - a. What would you think would be the most effective ongoing role for the SDC with your school/organization?

Wrap up (Everyone)

1. Do you have anything else to add about your involvement with the STEM Diversity Campaign?

