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Office of Education Infrastructure Services

STEM Design Challenges for 21st Century Community Learning Centers (21CCLC) Final Evaluation Report

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EXECUTIVE SUMMARY

The research literature is replete with articles that extol the benefits of investing in STEM (science, technology, engineering, and mathematics) education.[1] Armed with this information, NASA (the National Aeronautics and Space Administration) has made it a mission to strengthen the Nation's future workforce, attract and retain students in STEM disciplines, and engage Americans in NASA's mission.[2] Motivated by research that continues to show that STEM education programs fuel an increased interest in STEM careers among America's youth,[3] NASA's goal of connecting with learners of all ages is anticipated to help the United States remain globally competitive and sustain a strong national economy.

Following the release of the NSTC's (National Science and Technology Council's) CoSTEM (Committee on STEM Education) Federal STEM Education's Five-Year Strategic Plan in May 2013, NASA and ED (the U.S. Department of Education) formed a collaboration to develop a highly innovative project that was intended to pair the extensive reach and infrastructure of ED with NASA's access to world-class subject matter experts and content. Together, the two agencies were able to support the shared CoSTEM goal of increasing and supporting the public engagement of youth by developing pilot programs. The 2013 collaboration between NASA and ED resulted in a pilot project using NASA Engineering Design Challenges, training and assistance, and technology-based supports to 21CCLC (21st Century Community Learning Center) sites located in the states of Colorado, Michigan, and Virginia. The goal for the interagency collaboration was to align resources between the agencies as well as to address the national need for a highly qualified STEM-educated workforce.

Building upon successes and key lessons identified in the pilot and working in close collaboration with ED, NASA proposed to expand the reach of this opportunity in FY2015 to more states and 21CCLC sites, by leveraging key strengths, opportunities, and recommendations for project enhancement identified during the pilot. ED and NASA coordinated to create a series of EDCs (engineering design challenges) designed to provide authentic standards-based investigations that allows students to engage in the process of solving problems like today's engineers. These EDCs provide students with opportunities to gain tangible skills that are essential in STEM careers. Students are presented with a challenge or problem and, using the engineering design process, work in teams to complete activities and experiments to develop solutions to the original problem. These challenges facilitate teamwork, problem solving, and brainstorming ideas very similar to what real-world engineers encounter. The engineering design process is a cycle of steps that leads to the development of a new product or system. The cycle repeats and continuously refines and improves the product or system.

As part of the EDCs, students had the opportunity to participate in live connections with subject matter experts, including NASA scientists and engineers, in order to support the development of their designs. Additionally, students created a brief video (3-5 minutes in length) as their final product, showcasing how they followed the engineering design process to complete the challenge. ED leadership and NASA SMEs (subject matter experts) reviewed submitted student video work products and selected seven exemplar videos, representing seven states and five of the six challenges. Exemplar video teams were

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[1] President's Council of Advisors on Science and Technology (PCAST, 2012). Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics. Washington, DC: Executive Office of the President.
[2] NASA (2013). About NASA's Education Program. Retrieved from http://www.nasa.gov/offices/education/about/index.html.
[3] Sahin, A. (2013). STEM Clubs and Science Fair Competitions: Effects on Post-Secondary Matriculation. Journal of STEM Education: Innovations & Research, 12(1), 5-11.

given the opportunity to present their challenge during a Live Webinar culminating event that included panelists from NASA and ED, but also parents, administrators, and fellow students.
Phase 2 of collaborative work between NASA and ED was designed to do the following:

- Support 21CCLC sites in 10 states (up from three in pilot).
- Offer six engineering design challenges designed for 21CCLC audiences (up from three in pilot)
- Provide a blended PD (professional development) strategy to support facilitators in the implementation of the challenges with one F2F (face-to-face) training session in each participating state and follow-on sessions through technology.
- Provide over 100 opportunities (up from 10 in pilot) for 21CCLC sites to engage with scientists and engineers through a range of technology-based experiences.

The second phase of implementation incorporated several major enhancements based upon pilot evaluation data collected in 2013. Major program improvements included:

- Collaboration with ED to build a centralized web and scheduling infrastructure to facilitate scientist and engineer connections.
- Revision to the common template for challenges and expansion of available content offerings.
- Increase in the frequency and availability of scientist and engineering connections while refining the delivery model.
- Enhancements to training for NASA scientists and engineers to support high-quality engagement with students.
- Expansion of the help desk and technical assistance to sites.

Evaluation Purpose and Key Questions

The NASA Office of Education contracted with Paragon TEC, Inc., to conduct an objective, third-party evaluation of the Phase 2 collaboration with the intent to document program implementation, conduct formative evaluation activities that provide information to guide program improvement, and conduct summative evaluation activities to assess student outcomes. In addition to providing details about the scope of implementation, this report summarizes key findings from that evaluation study to inform the next stage of development for the NASA-ED collaboration.

Key evaluation questions guiding the study included:

1. *To what extent was the Phase 2 pilot implemented as planned?*
2. *To what extent did 21CCLC activities meet program quality expectations for out of school STEM?*
3. *Do students completing a NASA Challenge demonstrate increased positive attitudes toward STEM?*
4. *Do students describe a quality engineering design process in their final product (i.e., video)?*

Implementation

The external evaluator, in collaboration with the NASA project team, documented the implementation of the Engineering Design Challenges activities as outlined in the inter-agency agreement. Data sources included project implementation logs and records maintained by NASA staff and site information form data collected from sites, as well as interviews conducted with site staff. Key findings are shared below.

To what extent was the Phase 2 pilot implemented as planned?

Phase 2 began in January 2015. Throughout the implementation of Phase 2, support in a variety of forms was offered to 21CCLC facilitators and students including a blended approach for PD (professional development) encompassing a face-to-face training within each state and webinars; student connections with NASA scientists and engineers; and a help desk to assist site facilitators with content and technology questions. During implementation, many sites requested an extension of the challenge deadline date -- some due to late starts created by inclement weather, others because of the frequency of student meeting times. Table 1 summarizes the major implementation activities and original planned and revised dates.

Table 1. Implementation Timeline

Implementation Activity	Original Date (2015)	Revised Date (2015)
Face-to-face professional development training	January 5 to 30	January 5 to February 6
Professional development webinar training	February 2 to 13	February 2 to 13
Scientist and engineer connections	February 13 to April 15	February 13 to April 29
Challenge deadline date—video submissions due	April 16	April 30
Student showcase participants announcement	Week of April 27	Week of May 11
Virtual student showcase	May 8	May 28

Engineering Design Challenges: The EDCs (Engineering Design Challenges) developed by NASA and implemented through Phase 2 were designed to tap into students' innate curiosity through real-world situations and to challenge students to take ownership of tasks. In the process of designing solutions, students are allowed to innovate, apply science concepts, and work collaboratively with other students. Table 2 briefly describes how each of seven essential features relates to the design process used by professional engineers. Each of the activities offered through the challenges incorporate these seven elements. The challenges had a limited number of materials and resources, a fixed amount of time, and specific parameters or guidelines to follow. Students were able to immerse themselves in engineering practices, learn why they are central to engineering, and understand and appreciate the skills of an engineer.

Table 2. Seven Essential Features of Engineering Design (adapted from Capobianco, Nyquist, & Tyrie, 2013)

Feature	Description
Goal-oriented	The goal is centered on client and/or end user needs. Can be a person, company, or organization.
Authentic content	The challenge addresses a real problem and provides a useful solution.
Constraints	The problem is framed by rules, conditions, or regulations such as cost, time, and materials.
Familiar materials	Engineers must be familiar with their tools, equipment, and materials to use them effectively.
Solution is a product	Engineering design-based problems yield prototypes of processes that can be replicated.
Multiple solutions	Many solutions balance available resources, time, safety, and cost constraints.
Teamwork	Modern engineering is complex and diverse. It usually requires more than one person's expertise.

Major Supports: To support implementation, NASA provided a variety of resources to participating sites, which were organized into planning, implementation, and recognition activities as shown in Table 1. In January 2015, over 170 representatives from 80 sites attended the state-based In-Person Professional Development designed to prepare instructional staff for engineering design challenge implementation. Webinars, on-demand video training, a facilitator guide, and help desk support also provided training and implementation support to sites. The implementation phase occurred between February and April 2015. Out of the 80 sites, 61 (71%) participated in scientist and engineer connections with NASA, and 61 sites submitted final student products. Sites submitted a total of 136 student videos in which teams of students explained their unique solution to a design challenge and the process that they used to develop a final recommendation. Of the 61 sites completing the challenge, 78% of sites submitted two or more videos. State-level data on training and implementation is provided in Table 3.

Table 3. Site Registration and Challenge Completion

State	Sites Attended F2F PD	Participants Attending F2F PD	Sites Participating in Scientist and Engineer Connection	Sites Providing Final Student Work Products (Video)
California	9	20	5	5
Colorado	6	9	5	4
Florida	8	21	7	6
Michigan	9	31	7	8
Montana	8	10	5	5
New Jersey	10	20	6	8
Oklahoma	8	24	8	6
Rhode Island	6	12	6	6
Virginia	7	12	6	7
Wisconsin	9	18	6	6
Total	**80**	**177**	**61**	**61**

Student connections with NASA scientists and engineers through various media was a popular feature of the challenges. Connections were designed to introduce students to STEM careers, support instructional staff in discussing STEM content, and foster discussion around the engineering design process (i.e., brainstorm solutions, discussion of potential revisions, etc.). Scientist and engineer connections were scheduled originally to take place for 8 weeks; however, this service was extended to 10 weeks because of inclement weather that impacted the schedule of many participating states. To prepare scientists and engineers for connections, NASA scheduled multiple training opportunities covering a number of developmental appropriate presentation strategies. During those 10 weeks, 119 connections were made. Audience sizes per connection were intentionally left small, with the average event engaging students from 1.4 sites to maintain high levels of collaboration and interactivity.

Table 4. Scientist and Engineer Connection Usage, by Month

Category*	February	March	April	Total
Virtual connection events	15	65	39	119
Students attending	165	547	409	1121
Educators attending	21	117	58	196
Parents attending	0	13	1	14

*Numbers include repeat participants as sites had students attend multiple connections.

At the McNeel 21CCLC site – The McNeel site was one of several profiled in case studies conducted by the evaluator. The after-school curriculum was heavily focused on college and career exploration, and after-school instructors facilitated hands-on activities around this focus. The challenge was the first formal STEM activity conducted at this site, which was in its first year of implementation as a 21CCLC site.

McNeel facilitators and students were able to participate in multiple NASA Virtual SME sessions. Facilitators reported that students understood the "why" after talking with the SMEs -- that is, they understood why they were working on the challenge and recognized that there were careers where similar challenges or problems were worked on. Site staff observed that NASA scientists communicated with students on their level and used visual models or videos to help students understand difficult concepts. Overall, instructors felt that the Virtual SME Connections made an impact on the students and after attending those, the challenge became real to them.

To what extent did 21CCLC activities meet program quality expectations for out of school STEM?

Quality of Challenge Implementation: To assess the degree to which facilitated STEM Challenge experiences met accepted quality standards for out of school STEM, the third-party evaluator conducted observations in a subset of participating 21CCLC sites. Observations were conducted by the external evaluator using the Dimensions of Success observation tool,[4] a nationally validated protocol that tracks the quality of STEM out of school learning opportunities and pinpoints strengths and weaknesses using 12 indicators across four domains as follows:

1. **Features of the Learning Environment** (Organization, Materials, Space Utilization)
2. **Activity Engagement** (Participation, Purposeful Activities, Engagement with STEM)
3. **STEM Knowledge and Practice** (STEM Content Learning, Inquiry, Reflection)

[4] The DoS (Dimensions of Success) observation tool defines 12 indicators of STEM program quality in out-of-school time (e.g., afterschool, summer camps, etc.). It was developed and studied with funding from the NSF (National Science Foundation) by the PEAR (Program in Education, Afterschool and Resiliency), along with partners at ETS (Educational Testing Services) and Project Liftoff. For more information about DoS, please visit http://www.pearweb.org/tools/dos.html.

4. **Youth Development in STEM** (Relationships, Relevance, Youth Voice).

The twelve Dimensions of Success were rated using a four-level rubric to determine the range of quality associated with each dimension. Of the six sites that received DoS observations, four sites (67%) had scores of "3" (reasonable evidence present) and "4" (compelling evidence present) on all dimensions; one site (17%) had all 4's (compelling evidence); and one site (17%) had scores of "2" (inconsistent evidence present) and "3" (reasonable evidence present) across all dimensions. Table 5 displays individual scores below. Table 5 also shows the average scores by dimension. Of the six sites visited, sites scored lowest, on average, in the Youth Development in STEM Dimensions of Relevance and Youth Voice and highest on the Dimensions of Inquiry and Relationships. NASA intends to use this type of input to adjust its training strategy.

Table 5. Dimensions of Success Site Scores, by Site and Overall

Dimensions	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Average
Organization	4	4	2	4	4	4	**3.7**
Materials	4	4	2	4	3	4	**3.5**
Space Utilization	4	3	3	4	3	4	**3.5**
Participation	4	4	2	4	4	3	**3.5**
Purposeful Activities	4	4	2	4	4	4	**3.7**
Engagement with STEM	4	4	2	4	3	4	**3.5**
STEM Content Learning	4	4	2	4	3	4	**3.5**
Inquiry	4	4	3	4	4	4	**3.8**
Reflection	4	4	2	4	3	4	**3.5**
Relationships	4	4	3	4	4	4	**3.8**
Relevance	4	3	2	4	3	4	**3.3**
Youth Voice	4	3	3	4	3	3	**3.3**

OUTCOMES

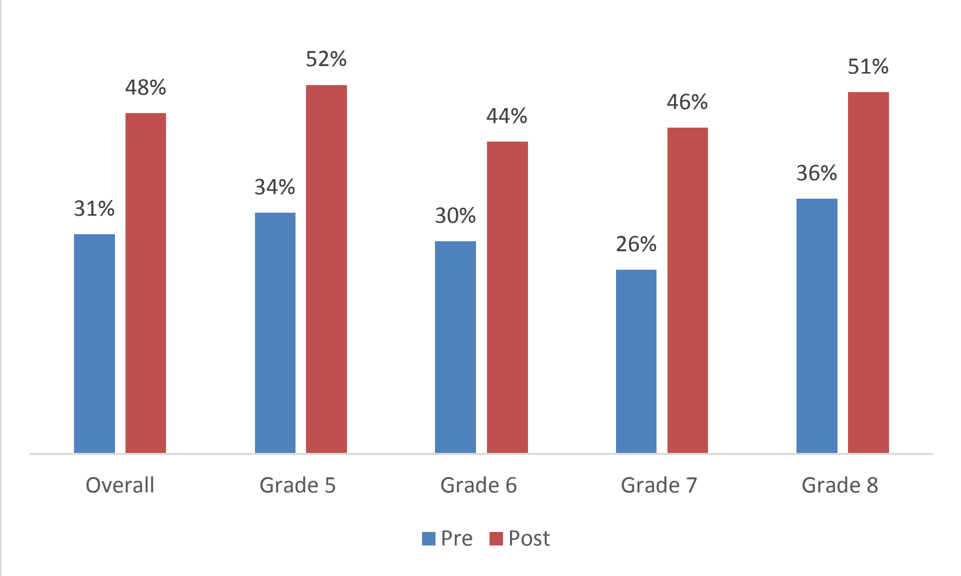
The evaluation study assessed the degree to which the challenges yielded student-level outcomes. Desirable student outcomes that NASA hoped to realize were an improvement in students' interest in STEM and a demonstrated understanding of the engineering design process.

Interest in STEM was assessed through a research-based scale on a pre-post survey instrument administered across all participating sites. Student understanding of the engineering design process was documented through an analysis of open-ended responses on the post-survey and also through an in-depth analysis of a subset of presentation videos created by students and facilitators using a scoring rubric that measures the engineering design process. Key findings are presented below.

Do students completing a NASA Challenge demonstrate increased positive attitudes toward STEM?

Student Interest in STEM: Improved interest in STEM can be documented through a change in students' participation in other STEM activities. The student pre-post survey, administered across all 21CCLC participating sites, included two multiple-selection question items that inquired about students' participation in other STEM activities. The question items and answer options were adapted from the High School Longitudinal Study of 2009 Student Baseline Survey, with two additional answer options adopted from the Noyce Enthusiasm for Science scale and the Assessing Women and Men in Engineering Rating Scale for Sense of Community. Answer options included extracurricular science and technology activities, such as science competitions and using kits or materials to do experiments or build things at home. Student pre-survey responses were obtained from 62 sites (81%) and post-survey responses from 56 sites (73%). Analysis of pre-post student responses demonstrated that students' self-reported participation in other STEM activities increased from 31% at pre-test to 48% at post-test, which is presumably a result of the STEM challenge. This finding was robust and statistically significant for students' participation in specific STEM activities: Students were likely to have increased their attendance of science clubs (13% to 20%, $z=1.97$, $p=.049$, $OR=1.51$), science competitions (12% to 19%, $z=3.36$, $p<.001$, $OR=2.03$), and science camps or after-school activities (13% to 22%, $z=4.12$, $p<.0001$, $OR=2.10$). The change was in the same direction but only marginally significant for attending a science study group or a program where they were tutored (6% to 10%, $z=1.71$, $p=.087$, $OR=2.18$). Further, this finding of an increase in students' participation in other STEM activities was fairly uniform across participating grade levels (see Fig. 1). This important finding suggests that students were more likely to engage in science activities, presumably as a result of the program. This is an important objective of STEM engagement activities and likely speaks to their continued involvement in science that will help foster scientific skill development.

Figure 1. Change in Students' Self-Reported Participation in STEM Activities, Overall and by Grade



Qualitative findings, which were based on open-ended responses students gave on the post-survey about the program, further documented favorable attitudes among the students toward STEM. Specifically, students overwhelmingly had favorable responses toward the program. Eighty-eight percent of students said that they would recommend this program to their friends, and 41% said they would recommend it because "it was fun," suggesting that their attitudes toward STEM were favorable and that they were engaged and excited about STEM programming.

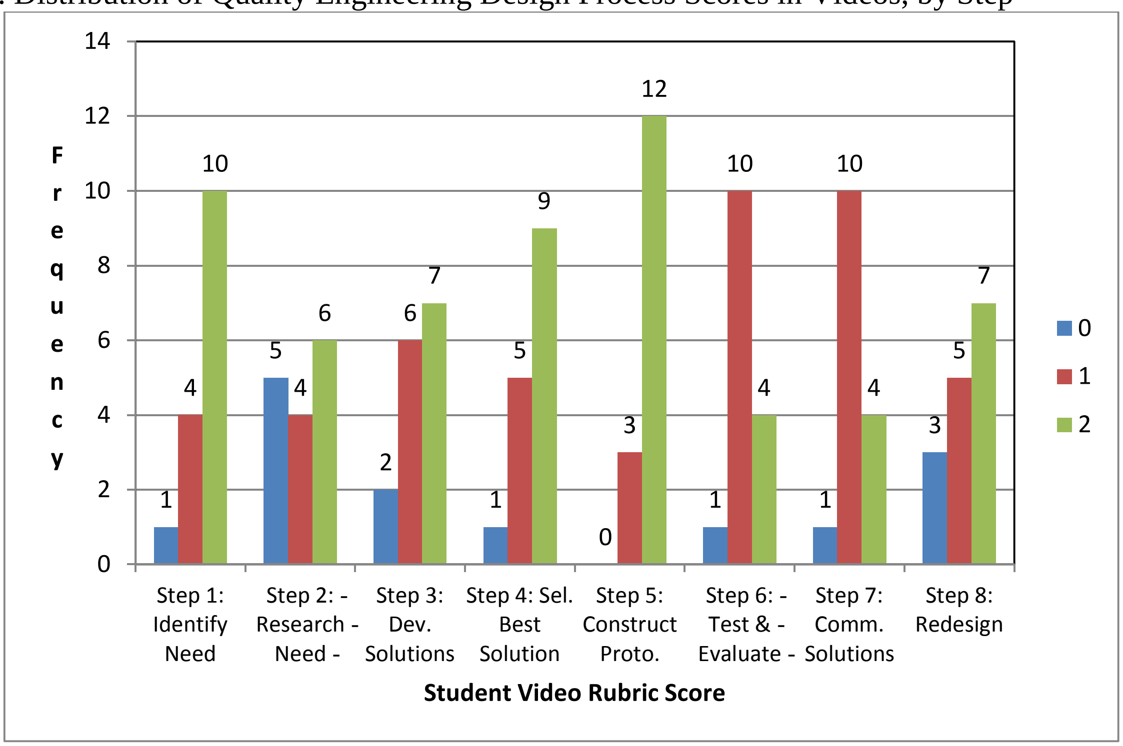
An important component of the evaluation was to solicit review and input from a panel of nationally recognized experts in STEM education. The external evaluator convened an ERP whose function was to advise the team and the Technical Monitor on the evaluation, including review of and feedback on the student work assessment and the evaluation report, including feedback on measures, methods, and implications of findings. The ERP was comprised of five individuals who are recognized experts in STEM education, research, and evaluation.

Do students describe a quality engineering design process in their final product (i.e., video)?

Student Understanding of Engineering Design: Students' understanding of engineering design was assessed through examination and analysis of a subset of student work presented through student- and facilitator-produced videos. Assessment of a quality engineering design process was performed by using a rubric based on the eight steps of the engineering design process as well as the implementation guidance provided to the sites in the Educator Guides. Members of the ERP (Expert Review Panel) convened to support this evaluation and participate in establishing the coding and categories for ratings. Rubric scores for each step in the design process were as follows: 2 = All criteria are met; 1 = Some criteria are met; 0 = None of the criteria are met. Rating categories for overall scores were determined based on coders' perceptions of cut-offs for a clear demonstration of the engineering design process. Specifically, those scoring a total of 5 and under did not clearly demonstrate an understanding: those scoring between 6-8 understood certain elements or steps of the design process but not the entire process; those scoring between 9-11 understood the engineering design process but didn't explain a few key concepts in depth; and those scoring between 12-16 demonstrated a rich understanding of the design process. A sample of fifteen videos were selected randomly from the pool of videos submitted to NASA for analysis.

The analysis found that the majority (87%) of videos demonstrated a good or excellent demonstration of the engineering design process. Of the 15 student videos, two (13%) presented videos that were rated as a poor demonstration of the engineering design process (total scores between 0 and 5); seven (47%) presented videos that were rated as a good demonstration of the process (total scores between 9 and 11), and six (40%) presented videos that were rated as an excellent demonstration of the process (total scores between 12 and 16). Further analysis found that students' understanding of certain steps in the engineering design process was stronger than others. As illustrated in Figure 2, student videos scores are highest on the Construct a Prototype step, followed by Identify Need, Select the Best Solution, Develop Solutions, Test and Evaluate and Communicate Solutions, and Redesign, Research Need.

Figure 2. Distribution of Quality Engineering Design Process Scores in Videos, by Step



Qualitative findings, which were based on open-ended responses students gave on the post-survey about the program, also demonstrated student understanding of the engineering design process. Although open-ended questions were not asked about engineering design, students responding to a question about what they liked best about the STEM Challenge often focused their responses on engineering design process steps, such as constructing a prototype, researching the need, testing and evaluating, and designing and redesigning. As Figure 3 demonstrates, constructing a prototype was the most frequent response, with 228 students describing this step of the engineering design process in their response. Figure 3 presents frequencies for other frequent themes for this question. In addition to demonstrating interest in the engineering design process, the incorporation of steps from the engineering design process into an open-ended response with answer option prompts also suggests that students were familiar with the process steps.

Figure 3. Themes for What 21CCLC Students Liked Best About the NASA STEM Challenge

Theme	Frequency	Percentage
Constructing a Prototype	228	47%
Working as a Team/ With Friends	77	16%
Researching the Need/ Talk With SMES	71	14%
Having Fun With Science	41	8%
Testing & Evaluating	40	8%
Designing/ Redesigning/ EDP	31	6%
Brainstorming a Solution	27	6%

Note: N = 488. Percentages will not equal 100% because percentages have been rounded; some students did not respond; some students mentioned multiple themes in their response; and some responses did not fit a common theme.

CONCLUSION

NASA intends to use information from the evaluation report to continue to refine the design and operations of future STEM programming developed for 21CCLC sites. Within the broader context of COSTEM, findings should be used by both NASA and ED to help inform other federal agencies as they develop opportunities designed to improve student understanding of engineering design, out of school STEM engagement or programs that develop relationships between scientists, engineers, and students. The evaluator developed recommendations for consideration in support of future implementation. A full set of recommendations can be found in the final report. Examples include:

1. NASA should continue to use the DoS observation instrument to assess the quality of implementation but supplement that measure with others, including in-depth interviews and regular feedback.
2. An advantage to the review of student videos was that students felt comfortable talking about the EDP steps in their own words, which could be argued as an objective assessment of what they learned. NASA should consider adapting the current student work product criteria as well as the rubric and pairing it with alternative methods for assessment of student work products, including journaling and logs of daily activities as well as available apps and data systems.
3. NASA should continue to consult with the type of leaders in the field on the emerging area of K-12 engineering evaluation found in the Expert Review Panel to both refine strategies and instruments and increase the rigor of the evaluation.

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INTRODUCTION AND BACKGROUND

The research literature is replete with articles that extol the benefits of investing in Science, Technology, Engineering and Mathematics (STEM) education.[5] Armed with this information, the National Aeronautics and Space Administration (NASA) has made it a mission to strengthen the Nation's future workforce, attract and retain students in STEM disciplines, and engage Americans in NASA's mission.[6] Motivated by research that continues to show that STEM education programs fuel an increased interest in STEM careers among America's youth[7], NASA's goal of connecting with learners of all ages is anticipated to help the United States remain globally competitive and sustain a strong national economy.

The U.S. Department of Education (ED) also had a keen interest in STEM education. By 2011, ED was experiencing success with running 21st Century Community Learning Centers (21CCLC) that provided out-of-school academic enrichment programs for children, particularly children from high-poverty and low-performing schools[8]. In May 2013, the National Science and Technology Council's (NSTC) Committee on STEM Education (CoSTEM) issued the Federal STEM Education's Five-Year Strategic Plan (the Plan). The Plan outlined "five priority STEM education investment areas where a coordinated Federal strategy could be developed, over five years, designed to lead to major improvements in key areas" and noted "identifying, using, and sharing evidence-based approaches" as a coordination approach across Federal investments in STEM education.[9] Based on this plan, high-quality STEM activities were incorporated into enrichment programs. It was believed that this initiative would serve to expose students to inquiry-based experiential activities that would supplement their core academic subjects and increase their preparation for postsecondary education and careers in STEM-related disciplines[10].

As a lead Federal Agency, ED had been playing a major role in improving PreK-12 STEM instruction by "supporting partnerships among school districts and universities, science agencies, businesses, and other community partners to transform teaching and learning."[11] Following the release of the Plan, it was not surprising that NASA and ED formed a collaboration to develop a highly innovative pilot project that was intended to pair the extensive reach and infrastructure of ED with NASA's access to world-class subject matter experts and content. Together, these two forces were able to support the

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[5] President's Council of Advisors on Science and Technology (PCAST, 2012). Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics. Washington, DC: Executive Office of the President.

[6] NASA (2013). About NASA's Education Program. Retrieved from http://www.nasa.gov/offices/education/about/index.html.

[7] Sahin, A. (2013). STEM Clubs and Science Fair Competitions: Effects on Post-Secondary Matriculation. Journal of STEM Education: Innovations & Research, 12(1), 5-11.

[8] Lineburg, M., & Gearheart, R. (2013). Educating students in poverty: Effective practices for leadership and teaching. Abingdon, Oxon, UK: Routledge.

[9] National Science & Technology Council. (NSTC, 2013). Federal science, technology, engineering, and mathematics (STEM) education 5-year strategic plan. Washington, DC: Executive Office of the President.

[10] Ibid

[11] Ibid

shared CoSTEM's goal of increasing and supporting the public engagement of youth by developing pilot programs. It was thought that NASA Education's portfolio of STEM projects could augment ED's out-of-school STEM programming efforts. The 2013 collaboration between NASA and ED resulted in a pilot project utilizing NASA STEM Challenges, training and assistance, and technology-based supports to sites located in the states of Colorado, Michigan, and Virginia. To support the extension of STEM programming to ED's out-of-school programs, NASA Education provided three NASA-developed STEM Challenges as well as support to ED's 21CCLC grantees in the three aforementioned states. The goal for the interagency collaboration was to align resources between the agencies as well as to address the national need for a highly qualified STEM-educated workforce.

During the 2013-14 school year, NASA collaborated with the three states to provide dynamic and engaging STEM Design Challenges to students in 21st Century Community Learning Center (21CCLC) afterschool programs. This was Phase I of the pilot project. Building upon successes and key lessons identified in the first phase of the pilot and working in close collaboration with ED, NASA proposed to expand the reach of this opportunity to more states and 21CCLC sites, leveraging key strengths, opportunities and recommendations for project enhancement identified during the Phase I of the pilot. For the 2014-2015 school year, NASA implemented a second phase of the pilot project.

Phase II of the collaborative work between NASA and ED was designed to accomplish the following:

- Support 21CCLC sites in 10 states (up from 3 states in the pilot);
- Offer 6 engineering design challenges designed for 21CCLC audiences (up from three challenges in the pilot) ;
- Provide a blended professional development (PD) strategy to support facilitators in the implementation of NASA challenges with one F2F (face-to-face) training session in each participating state and follow-up sessions through technology; and
- Provide over 100 opportunities (up from 10 in the pilot) for 21CCLC sites to engage with scientists and engineers through a range of technology-based experiences during an 8-week implementation cycle scheduled between February and April.

Phase II implementation incorporated several major enhancements based upon pilot evaluation data collected in 2013. Major program improvements included:

- Collaboration with ED to build a centralized web and scheduling infrastructure to facilitate scientist and engineer connections.
- Revision to the common template for challenges and expansion of available content offerings.
- Increase in the frequency and availability of scientist and engineering connections while refining the delivery model.
- Enhancements to training for NASA scientists and engineers to support high-quality engagement with students.
- Expansion of the help desk and technical assistance to sites.

21CCLC Engineering Design Challenges

The U.S. Department of Education and NASA's Office of Education worked together to create an Engineering Design Challenge (EDC) that gets students involved in using the engineering design process (EDP) to complete the Engineering Design Challenge. The EDC serves as an authentic standards-based investigation that allows students to engage in the process of solving problems like today's scientists and engineers are utilizing and gain tangible skills that are essential in STEM careers. An EDC is developed to help students understand the engineering design process. Students are presented with a challenge or problem and, using the design process, work in teams to complete activities and experiments to develop solutions to the original problem. These challenges facilitate teamwork, problem solving, and brainstorming ideas very similar to what real-world engineers encounter. The engineering design process is a cycle of steps that leads to the development of a new product or system. The cycle repeats and continuously refines and improves the product or system. In this challenge, students should complete each step and document their work as they develop and test their design. To do this, students need to perform each of the steps in the EDP and repeat the cycle, as often as time and resources allow to develop the best end product. Some steps, like "Researching the need or problem", will only need to be briefly revisited to confirm that teams are still on track. Other steps, like "Test and evaluate the solution", will need to be completely redone. NASA provided six STEM Challenges from which participating sites could choose:

1. Spaced out Sports,
2. Design a Crew Exploration Vehicle,
3. Packing up for the Moon,
4. Radiation Exploration Challenge,
5. Why Use Pressure Suits, and
6. Parachuting onto Mars.

Please see Appendix A for a description of the six challenges.

Each of NASA's STEM Challenges included the following materials for effective implementation:

1. Description of Challenge,
2. Educator Guide,
3. Challenge Checklist for Instructors,
4. Introductory Videos for each challenge,
5. Sample PowerPoint Presentation,
6. Educator Helpful Hints,
7. Student Instruction Sheet,
8. Rubric,
9. Video Submission Instructions, and
10. Extension Links

As part of the Challenge, students had the opportunity to participate in live connections with subject matter experts (or SMEs), including NASA scientists and engineers, in order to support the development of their designs. Additionally, students created a brief video (3-5 minutes in length) as their final product, showcasing how they followed the engineering design process to complete the NASA

Challenge. ED Leadership and NASA SMEs reviewed all submitted student video work products and selected seven exemplar videos, representing seven states and five of the six challenges. Exemplar video teams were given the opportunity to present their challenge during a Live Webinar Culminating event that included video judges from NASA and ED, but also parents, administrators, and fellow students.

EVALUATION DESIGN AND APPROACH

For the evaluation component, the NASA Office of Education contracted with Paragon TEC, Inc. to conduct an objective, third party evaluation that comprised three sub-studies: 1) Implementation Evaluation, 2) Formative Evaluation, and 3) Summative Evaluation, intended to document challenges and successes with program implementation, conduct formative evaluation activities that would provide information to guide program improvement, and conduct summative evaluation activities to assess student outcomes. The Paragon TEC Team, comprised of evaluators from both Paragon TEC and Pacific Institute of Research and Evaluation (PIRE) collaborated to prepare this report.

The objectives of the NASA STEM Challenge evaluation were to:

1. Describe program operations and the approaches used by selected sites in implementing the NASA STEM Challenge program (Implementation Sub-Study);
2. Provide formative feedback from instructors/site coordinators and students that will enhance or improve program activities (Formative Sub-Study); and
3. Estimate changes in youth outcomes (e.g., student engineering design skills and STEM attitudes) from before to after participation in the NASA STEM Challenge (Summative Sub-Study).

This evaluation design employed a stakeholder-oriented evaluation approach. At the onset of the evaluation, stakeholders were identified and directly involved in the design, implementation, analysis and report development phases of the evaluation. This approach ensured that:

1. The central questions, the information the stakeholders most want to know, would be addressed;
2. The stakeholders would establish a sense of ownership in the evaluation process and in the results, increasing the likelihood that the results will be used; and
3. The stakeholders' level of interest in the resulting analysis would remain high throughout the process, and a partnership would be created among the people serving different functions in the program.

For this evaluation, the stakeholders were identified as: participating students, state and site coordinators and instructors, trained evaluators and staff from NASA and ED. Throughout the duration of the program, the evaluation team received feedback from the stakeholders through regularly scheduled meetings and through various data collection activities, including feedback forms, questions submitted to the Help Desk, Expert Review Panel meetings, and other activities.

RESEARCH QUESTIONS

In order to assess the program components and provide data for which NASA sought answers, the following research questions were developed:

Please note: the research questions were modified on December 5, 2014 based upon guidance from the US Department of Education. The 21CCLC Evaluation Plan was revised to reflect these changes, and the current report reflects the approved research questions.

Implementation Evaluation

1. To what extent was the Phase 2 pilot implemented as planned?
2. What variations in pilot implementation were found at the state and site levels?
3. To what degree were stakeholders satisfied with pilot implementation?
4. What barriers or challenges were faced in pilot implementation?
5. What successful practices were identified in pilot implementation?
6. To what extent did 21CCLC activities, including SME interactions, meet program quality expectations for out of school STEM?

Summative Evaluation

1. Do students completing a NASA Challenge demonstrate increased positive attitudes toward STEM?
2. Do students describe a quality engineering design process in their final product (i.e., video)?

Limitations

The timeline for this project restricted the identification and development of new data collection instruments that would require OMB clearance as required by the Paperwork Reduction Act. NASA's available age-appropriate student survey with Paperwork Reduction Act clearance incorporated STEM attitudinal scales with a heavy emphasis on interest in science. Members of the Expert Review Panel identified a possible weak alignment between the survey instruments and the engineering design focus of this project, which may have impacted findings. While the ERP makes a fair observation that should be considered in future implementation, it should be noted that the STEM Attitudes Scale did include a subscale of four items intended to ascertain student enthusiasm/interest in engineering (called "Interest in Design and Hands-On STEM Activities"). See pages 42-43 for a more detailed description of this scale.

It is important to note that the reporting depth for the original research questions was negatively affected by the inability to receive OMB Clearance for the Instructor/Site Coordinator Feedback Form and the Student Feedback Form due to the tight timeline of the current study. Responses to implementation research questions 1 through 5 were negatively impacted as a result. Because of this limitation, the findings presented for these research questions should be interpreted with caution, as the data available to answer these questions comprised a limited sample of six sites. Had feedback forms been collected, this evaluation would have likely had a representative sample from which to report findings for these research questions and draw conclusions. Still, the findings presented under the aforementioned research questions provide preliminary evidence that will inform wider dissemination of 21CCLC.

Data Sources

The following data sources were utilized to answer the study's research questions:

- Site Information Forms (Appendix B)
- Student Participation Logs (Appendix C)
- Student SME Interaction Logs (Appendix D)
- STEM Attitudes Survey Pretests (Appendix E)
- STEM Attitudes Survey Posttests (Appendix F)
- 6 DoS Observations, using the DoS Rubric and Guide (Appendix G)
- 6 In-depth Site Interviews, using the In-Depth Interview Moderator Guide (Appendix H)
- 16 Student Video Final Work Products, using the Student Work Assessment Rubric (Appendix I)

Evaluation Design

The evaluation contained three sub-studies, which were designed to address the study's evaluation questions. Methods and analyses for these sub-studies, as well as a more thorough description of the measures, will be described later in this document within the appropriate sub-study sections.

Implementation Sub-study

The purpose of the implementation sub-study was to ensure that the project's strategies were conducted as planned, to document the degree to which, and how, targeted audiences were engaged throughout implementation, and to provide information to NASA and ED to guide improvements to the project implementation.

Specifically, this sub-study primarily represents a discrepancy evaluation that compared the actual implementation of the 21CCLC at each site ("what is") with both expected implementation standards as well as stakeholder expectations ("what should be") in each of the evaluation sites. In order to conduct this discrepancy evaluation, both qualitative and quantitative data, as well as anecdotal evidence from communication with sites, were collected through participation logs and program documents. This enabled the evaluation team to assess how the implementation of the program activities occurred in the 21CCLC sites and help identify areas for improvement. Implementation data were collected using the following instruments:

- Site Information Form from all sites (Appendix B)
- Project Activity/ Student Participation Logs from all sites (Appendices C and D)
- Posttest STEM Attitudes Youth Survey from all sites (Appendix F)
- Dimensions of Success Observations from 6 sites (Appendix G)
- In-Depth Interviews with Coordinators and Instructors from 6 sites (Appendix H)
- Program documentation/ artifacts and discussions with site staff from all sites

Additionally, two evaluation team members, who were trained and certified in the Dimensions of Success (DoS) observational protocol, visited a sample of six sites to observe the NASA Challenge implementation using the DoS rubric. This rubric enabled the observers to assess the extent to which 21CCLC activities met program quality expectations for out-of-school STEM programs. The interviews note above were conducted up to two weeks after the DoS observations and within the implementation time period. These in-depth interviews with site coordinators and instructors from the six sites provided rich data about implementation barriers, challenges, and successes.

As previously noted, it was not possible to obtain planned feedback forms from site coordinators, instructors, and students due to not having adequate time to obtain OMB clearance. However, tracking and log data was used to assess implementation of the program activities that occurred in the 21CCLC sites. Feedback related to stakeholder satisfaction was also obtained from students via the STEM Attitudes Post-survey.

Summative Sub-study

The purpose of the summative evaluation was to assess the degree to which the project met its intended outcomes as described in the project plan, including whether participation in the NASA Challenge was associated with increases in students' attitudes toward STEM and the quality of the engineering design process (EDP) demonstrated through final student work (video) products.

STEM Attitudes were assessed through a pre-post survey instrument that was developed and piloted with fourth graders through NASA's Summer of Innovation project in order to measure interest and enthusiasm for science and engineering (Martinez, Linkow, Velez, & DeLisi, 2014). More information on these measures is included in the summative section. Sites were given the option of online or paper-pencil survey administration. See pages 42-43 for a more detailed description of this scale.

The evaluation team created a video scoring rubric (See Appendix I) for the student work assessment that rated the quality of the engineering design process demonstrated in the student work videos which were approximately 3-5 minutes in length. See pages 52-53 for a more detailed description of this measure.

The evaluation design for the summative evaluation sub-study was a single group pre-post-intervention-only design targeted to all participating students. Quantitative and qualitative data analyses also focused on the degree of student participation in the NASA Challenge, the quality of students' engineering design process, the quality of the student final products, and changes in students' attitudes toward STEM. In order to conduct the summative evaluation, data was collected through:

- Site Information Form from all sites (Appendix B)
- Pretest and Posttest STEM Attitudes Youth Survey from all sites (Appendices E and F)
- Assessment of student work products using an evaluative scoring rubric from six sites (Appendix I)

Exhibit 1, on the following page, presents the evaluation framework used for each of the evaluation sub-studies, and describes the data collection instruments used to answer each of the evaluation questions.

Exhibit 1: Evaluation Framework

Evaluation Question	Data Source/Instrument	Data Analysis Approach
Implementation Evaluation		
1. To what extent was the Phase 2 pilot implemented as planned?	• Project Activity/ Student Participation Log • Site Characteristics Form • Site Documents/Artifacts review; discussions with staff	• Descriptive statistical analysis of quantitative survey data; • Content/thematic analysis of feedback
2. What variations in pilot implementation were found at the state and site levels?	• Project Activity/ Student Participation Log • Site Characteristics Form • Site documents/artifacts review; discussions with staff	• Descriptive statistical analysis of quantitative survey data; • Content/thematic analysis of feedback
3. To what degree were stakeholders satisfied with pilot implementation?	• In-depth Interviews • Posttest STEM Attitudes Youth Survey Program documentation/ artifacts and discussions with site staff	• Coding and thematic analysis of transcripts
4. What barriers or challenges were faced in pilot implementation?	• In-depth Interviews • Program documentation/ artifacts and discussions with site staff	• Coding and thematic analysis of transcripts
5. What effective practices were identified in pilot implementation?	• In-depth Interviews	• Coding and thematic analysis of transcripts
6. To what extent did 21CCLC activities, including SME interactions, meet program quality expectations for out of school STEM?	• Dimensions of Success Observation Rubric • Program documentation/ artifacts and discussions with site staff	• Comparison of observations and expectations on 12 dimensions using DoS rubric
Summative Evaluation		
1. Do students completing a NASA Challenge demonstrate increased positive attitudes toward STEM?	• Pretest/Posttest STEM Attitudes Youth Survey	• Descriptive statistical analysis
2. Do students describe a quality engineering design process in their final product (i.e., video)?	• Observation of the final student products using scoring rubric	• Rating of engineering design process and skills • Descriptive statistical analysis including multi-level models such as HLM

Instructor/Site Coordinator Feedback Forms were a planned data collection source but are not included here or in the evaluation because we did not receive OMB clearance in time to collect these data.

Site Selection for Program Participation

An initial group of 10 States and 93 sites was selected by ED based on site interest, site availability for training, and site participation in the Phase I pilot. All of the 21CCLC sites participating in this collaboration provided services to students in grades five through eight in public schools and community centers serving students from low socio-economic backgrounds. Of the 93 sites initially identified by ED for potential participation, 84 sites completed registration forms, 80 sites attended the initial face to face training, and 77 sites began the Challenge, meaning they had made contact with the implementation team or the evaluation team, had a facilitator in place, and had students that were introduced to the Challenge. Student participation was voluntary and students were recruited from afterschool programs.

Of those 77 sites, 55 sites (71%) completed the Challenge and submitted a student video work product on time for review by the NASA and ED teams. As of June 12, 2015, 61 sites had submitted a student video, indicating a completion rate of 79 percent.

The final sample of 77 21CCLC implementation sites that participated in this pilot project, identified by state, are illustrated in Exhibit 2.

Exhibit 2: Sites Attending the Face to Face Training

State	Number of Sites
California	9
Colorado	6
Florida	8
Michigan	9
Montana	8
New Jersey	10
Oklahoma	8
Rhode Island	6
Virginia	7
Wisconsin	9

Evaluation Sample

The evaluation team developed a sampling plan to ensure that the evaluation questions in each sub-study were addressed as rigorously as possible, keeping in mind the various implementation schedules of the participating sites and study limitations. Participants in the evaluation included facilitators/instructors and site coordinators from each site as well as students in grades 5 through 8 who participated in the NASA STEM Challenges.

The sampling design for the formative and implementation sub-studies originally focused on all sites; however, this design was altered by the removal of two instruments from the evaluation design due to the inability to obtain Paperwork Reduction Act clearance. After this design change, the primary focus of these two sub-studies was on data collected during in-person site visits from a sample of six sites, ultimately chosen from Florida, New Jersey, Michigan, and Virginia based on careful analyses of the Site Information Forms that identified a sample of sites that either experienced “significant challenges” or “few challenges” as an attempt to obtain representative data from this small subsample. The site selection also included the following characteristics that were seen as important to maximize the diversity of the sample: a) students still implementing the Challenges; b) instructor’s experience teaching STEM afterschool programs; c) length of time the instructor taught any after school program; d) whether the instructor attended in-person training; e) the NASA Challenges chosen; f) SES level of surrounding county; and g) whether the site participated in the NASA Pilot/Phase I. All sites were located in impoverished areas, and both urban and rural school districts and afterschool community centers were visited.

The sampling design for the summative sub-study focused on obtaining data from all implementation sites in the 10 participating states, excluding Q4. For Q4 of the summative sub-study, the evaluation team utilized the sample of six sites and gathered classroom observation data and student work (video) assessment data from those six sites. For the student work assessment data, the evaluation team reviewed all 15 submitted videos from the six visited sites.

While the evaluation plan called for 100% site participation in the pre-post student survey administration, only 66 of the 77 implementation sites participated in this evaluation activity due to site non-response, late response, or local IRB issues.[12] Response rates for the 66 sites that had committed to participating in this evaluation activity are as follows:

- 62 sites (94%) submitted youth pre-tests.
- 56 sites (85%) submitted youth post-tests.

Expert Review Panel

An important component of the evaluation was to solicit review and input from a panel of nationally recognized experts in STEM education. The evaluation team established and convened an Expert Review Panel (ERP) whose function was to advise the team and Technical Monitor on the evaluation. The ERP was comprised of six individuals who are experts in STEM education, research and evaluation. Before nominating prospective members, the evaluation team evaluated each member for potential conflicts of interest by assessing whether each potential ERP nominee had a bias or financial interest in the outcome of the study. The team then submitted the list of 10 prospective members to NASA for final approval. Once the approval was granted, the team chose eight members with varying backgrounds and sent an invitation to each candidate to be a part of the ERP. All eight were interested in participating but two had to decline because they could not attend both meetings, which was a criterion of membership in order to maintain consistency.

The ERP met twice during the course of the project. The first meeting was in May 2015 to review the student work assessment rubric and a sample of the student work products (i.e., videos) as well as to practice using the rubric to rate student work videos on the engineering design process quality. Key goals of this meeting were to 1) obtain feedback from the ERP on the student work products, 2) obtain feedback from the ERP on the student work assessment rubric, and 3) set the precedence for the evaluation team's coding of work products by each member coding a sample of videos and talking through their rating process. The second meeting was in June 2015 to review the draft evaluation report due to NASA. The goals of this meeting included obtaining feedback from the ERP on the evaluation measures and methods as well as on implications of findings and recommendations for future implementations and evaluations of 21CCLC. Key implications from these meetings are presented in the discussion section of this report as they pertain to key findings and recommendations.

The final list of ERP members were:

[12] Four sites were unable to participate due to IRB issues within their school districts, three sites contacted the evaluation team after the evaluation deadline (4%), and four sites were non-responsive (5%).

1. Dr. Martha Cyr- Worchester Polytechnic Institute

Dr. Martha Cyr is Director of K-12 Outreach and an adjunct assistant professor with the Mechanical Engineering Department at Worcester Polytechnic Institute (WPI) in Worcester, Massachusetts. She serves on the State of Massachusetts Science and Mathematics Advisory Council and played an active role in the newly accepted engineering curriculum frameworks for the state. In her role as Director, she works with programs that emphasize the use of engineering principles, through hands-on projects, to excite and motivate students and teachers in the learning of mathematics and science in grades K-12. She has published education-based articles as well as being an invited speaker on engineering education at national forums.

2. Jessica Harlan, Southern Alabama University

Jessica M. Harlan is a PhD student in Instructional Design and Development at the University of South Alabama (USA). She is currently working with the USA evaluation team for the Engaging Youth through Engineering middle school engineering module program. Prior to her work at USA, Jessica was a training officer for the Office of Research at the University of California, Davis. She continues to work as an instructional design consultant for multiple UC campuses. Jessica also has a Master of Arts in Psychology with an emphasis in program evaluation from California State University, Stanislaus. She has taught undergraduate psychology online and in person for the Los Rios Community College District in Sacramento since 2008. Additionally, Jessica has provided program evaluation, program development, and instructional design services as a consultant for non-profit and local government agencies.

3. Ms. Mercedes McKay, Stevens Institute of Technology

Ms. McKay is the Deputy Director of The Center for Innovation in Engineering and Science Education. Ms. McKay leads several national and statewide K-12 STEM curriculum development and teacher professional development programs that involve multi-institutional partnerships and collaborations. McKay also oversees the development of curricula for K-12 STEM education that have been recognized by the White House Office of Science and Technology Policy and which reside on the National Science Digital Library. Ms. McKay has served on advisory boards of national K-12 engineering programs and as a reviewer for K-12 STEM curricula. She earned a B.S. in Mechanical Engineering from Carnegie-Mellon University and a graduate certificate in Technology Applications in Science Education from Stevens Institute of Technology. Before joining CIESE, Ms. McKay was a practicing engineer and also taught high school science and mathematics.

4. Dr. Louis Nadelson, Boise State University

Dr. Nadelson serves on the faculty of Boise State University as an Assistant Professor in the College of Education. Before coming to Boise, Dr. Nadelson taught at the college level at the University of Florida in Orlando, the University of Nevada, Las Vegas, and The Evergreen State College in Olympia, WA, and has experience as a secondary teacher in math, science, and Upward Bound. Dr. Nadelson's research interests include STEM Education, inquiry curriculum and instruction, conceptual change, teacher change and instructional practices, and cultural influences on learning. He is an active presenter at conferences at both the local and national levels.

5. Dr. Greg Pearson, National Academy of Engineering

Dr. Pearson is the Senior Program Officer with the National Academy of Engineering (NAE) in Washington, D.C. In that role, he develops and manages new areas of activity within the NAE

Program Office related to K-12 engineering education, technological literacy, and the public understanding of engineering. Dr. Pearson works collaboratively with colleagues within and outside the National Academies on a variety of projects involving K-12 science, mathematics, technology, and engineering education, and the public understanding of engineering and science. Greg has an undergraduate degree in biology from Swarthmore College and a graduate degree in journalism from The American University.

6. Dr. Christine Schnittka, Auburn University

Dr. Christine Schnittka is an assistant professor in the College of Education and the Department of Curriculum and Teaching with a joint appointment in the College of Engineering. Her current research involves developing and evaluating engineering design-based curriculum units that target key science concepts and environmental issues through the contextual lens of problem-based learning. Prior to receiving her Ph.D. in science education at the University of Virginia, Dr. Schnittka was a middle school teacher and administrator for 10 years, and prior to that, worked as a mechanical engineer.

FINDINGS

We present the findings for the implementation and summative studies in this section. First, the methods and analyses are reviewed as well as the sample(s) used in the analyses and then findings are presented by research question. In the following section, we present the conclusions and recommendations.

As stated earlier in the document, the implementation and formative evaluation was impacted by the removal of the (1) Instructor/Site Coordinator Feedback Form and (2) Student Feedback Form due to failure to obtain Paperwork Reduction Act clearance. Therefore, the implementation and formative analyses are based primarily on site visit/interview data and findings presented in the implementation and formative sections should be interpreted with caution as these findings were not obtained from a representative sample. However, the subsample of six sites was chosen based on several criteria listed on page 13 to obtain as diverse a sample as possible, including those sites with both several implementation challenges and those with few challenges in order to more fully understand findings related to implementation.

While key findings from in-person interviews are summarized in these sections, please refer to Appendix J for case studies from each of the six sites in this sub-study sample for a rich description of the formative research findings. Student Participation and SME logs, DoS scores, and evaluation communication with sites are also used as evidence for these sub-studies.

IMPLEMENTATION

Implementation data sources included student participation and SME logs maintained by site staff, Dimensions of Success scores from observations of after-school activities, interviews with site staff, and project documentation assembled by NASA staff. Evaluation communication with sites are also used as evidence for the findings that follow.

Interview and observation data was collected from a sample of six sites (representing four states) visited in person. Interviews took approximately two hours and included questions specifically targeted to facilitators and site coordinators. Interviews were completed with 13 individuals in total. Project roles of interviewees included site directors (2), site coordinators (5), and facilitators/instructors (6). Questions were asked based on site staff roles, and it should be noted that no more than 9 individuals ever responded to a single question, allowing these site visits to be exempt from the clearance requirements of the Paperwork Reduction Act.

Given the selection criteria for the sites visited by the evaluation team, it is believed to be a demonstrative sample of sites that experienced few challenges and sites that experienced some major challenges. The information presented in this section comes from 6 of 55 sites that completed the NASA STEM Challenge on time (11%) and should be interpreted with caution due to the small sample size. It is also important to note that though some sites that were visited experienced major barriers, these sites sought assistance and did not quit due to implementation issues. Alternatively, there were some sites that declined participation in the site visits and others that said they would prefer to not be visited as they knew they were not going to complete the Challenge or had no students that were still interested in the Challenge. This context should be kept in mind when interpreting these findings.

For the six sites visited, implementation began between the end of January and beginning of March. All sites had weather delays (e.g., delays due to school cancellations, etc.) and required utilization of the deadline extension of April 30th. Using the data primarily from the site visits, numerous variations were noted at the state and site levels. Note: When relevant, information from personal communications via email and phone between site staff and the evaluation team are also included in this section. These communications came from the larger sample of 77 sites, however, do not include every site.

As stated earlier in the document, the implementation and formative evaluation was impacted by the removal of the (1) Instructor/Site Coordinator Feedback Form and (2) Student Feedback Form due to failure to obtain Paperwork Reduction Act clearance. Therefore, some implementation and formative analyses are based primarily on site visit/interview data; this limitation due to the small sample size will be noted in the text that follows. While the sample size was small, the subsample of six sites was chosen based on several criteria listed on page 13 to obtain as diverse a sample as possible, including those sites with both several implementation challenges and those with few challenges in order to more fully understand findings related to implementation.

While key findings from in-person interviews are summarized in these sections, please refer to Appendix J for case studies from each of the six sites in this sub-study sample for a rich description of these implementation research findings.

Research Question 1

The data for Research Question one came from all 77 sites that began the challenge.

To what extent was the Phase 2 Pilot implemented as planned?

The external evaluator, in collaboration with the NASA project team, documented the implementation of the Engineering Design Challenges (EDCs) activities as outlined in the inter-agency agreement. Data sources included project implementation logs, records maintained by NASA staff, and site information form data collected from all sites, as well as interviews conducted with site staff from a subsample of six sites. Key findings are shared below.

Phase 2 began in January 2015. Throughout the implementation of Phase 2, support in a variety of forms was offered to 21CCLC facilitators and students including a blended approach for professional development (PD) comprised of: a face-to-face training within each state; webinars with each state; student connections with NASA scientists and engineers; and a help desk to assist site facilitators with content and technology questions. During implementation, many sites requested an extension of the challenge deadline date -- some due to late starts created by inclement weather, others because of the frequency of student meeting times. Table 1 summarizes the major implementation activities and original and revised dates.

Table 1. Implementation Timeline

Implementation Activity	Original Date (2015)	Revised Date (2015)
Face-to-face professional development training	January 5 to 30	January 5 to February 6
Professional development webinar training	February 2 to 13	February 2 to 13
Scientist and engineer connections	February 13 to April 15	February 13 to April 29
Challenge deadline date—video submissions due	April 16	April 30
Student showcase participants announcement	Week of April 27	Week of May 11
Virtual student showcase	May 8	May 28

Engineering Design Challenges: The EDCs developed by NASA and implemented through Phase 2 were designed to tap into students' innate curiosity through real-world situations and to challenge students to take ownership of tasks. In the process of designing solutions, students were encouraged to innovate, apply science concepts, and work collaboratively with other students. Table 2 briefly describes how each of the seven essential EDC features relates to the design process used by professional engineers. Each of the activities offered through the challenges incorporate these seven elements. The challenges had a limited number of materials and resources, a fixed amount of time, and specific parameters or guidelines to follow. Students were able to immerse themselves in engineering practices, learn why these practices are central to engineering, and understand and appreciate the skills of an engineer.

Table 2. Seven Essential Features of Engineering Design (adapted from Capobianco, Nyquist, & Tyrie, 2013)

Feature	Description
Goal-oriented	The goal is centered on client and/or end user needs. Can be a person, company, or organization.
Authentic content	The challenge addresses a real problem and provides a useful solution.
Constraints	The problem is framed by rules, conditions, or regulations such as cost, time, and materials.
Familiar materials	Engineers must be familiar with their tools, equipment, and materials to use them effectively.
Solution is a product	Engineering design-based problems yield prototypes of processes that can be replicated.
Multiple solutions	Many solutions balance available resources, time, safety, and cost constraints.
Teamwork	Modern engineering is complex and diverse. It usually requires more than one person's expertise.

Major Supports: To support implementation, NASA provided a variety of resources to participating sites, which were organized into planning, implementation, and recognition activities as shown in Table 1. In January 2015, over 170 representatives from 80 sites attended the state-based In-Person Professional Development designed to prepare instructional staff for engineering design challenge implementation. Webinars, on-demand video training, a facilitator guide, and help desk support also provided training and implementation support to sites. The implementation phase occurred between February and April 2015. Out of the 80 sites, 61 (71%) participated in scientist and engineer connections with NASA, and 61 sites submitted final student products. Sites submitted a total of 136 student videos in which teams of students explained their unique solution to a design challenge and the process that they used to develop a final recommendation. Of the 61 sites completing the challenge, 78% of sites submitted two or more videos. State-level data on training and implementation is provided in Table 3.

Table 3. Site Registration and Challenge Completion

State	Sites Attended F2F PD	Participants Attending F2F PD	Sites Participating in Scientist and Engineer Connection	Sites Providing Final Student Work Products (Video)
California	9	20	5	5
Colorado	6	9	5	4
Florida	8	21	7	6
Michigan	9	31	7	8
Montana	8	10	5	5
New Jersey	10	20	6	8
Oklahoma	8	24	8	6
Rhode Island	6	12	6	6
Virginia	7	12	6	7
Wisconsin	9	18	6	6
Total	**80**	**177**	**61**	**61**

Student connections with NASA scientists and engineers through various media was a popular feature of the challenges. To prepare scientists and engineers for connections, NASA scheduled multiple training opportunities covering a number of developmental appropriate presentation strategies. Connections were designed to introduce students to STEM careers, support instructional staff in discussing STEM content, and foster discussion around the engineering design process (i.e., brainstorm solutions, discussion of potential revisions, etc.). Scientist and engineer connections were scheduled originally to take place for 8 weeks; however, this service was extended to 10 weeks because of inclement weather that impacted the schedule of many participating states. During those 10 weeks, 119 connections were made. Audience sizes per connection were intentionally left small, with the average event engaging students from 1.4 sites to maintain high levels of collaboration and interactivity.

Table 4. Scientist and Engineer Connection Usage, by Month

Category*	February	March	April	Total
Virtual connection events	15	65	39	119
Students attending	165	547	409	1121
Educators attending	21	117	58	196
Parents attending	0	13	1	14

*Numbers include repeat participants as sites had students attend multiple connections.

Student Participation Logs from 51 sites showed that individual students spent an average of 5.22 documented hours (Median 2.75, SD 7.27) on their Challenge. However, according to information gathered from the six site visits, this average is far below the amount of time that sites actually spent on Challenges and is a byproduct of site staff incorrectly or inconsistently completing Logs. Specifically, when compared to the average amount of time reported during in-person interviews at the six sites (i.e., 32 hours on average, 16 hours at a minimum, and 55 hours maximum), the Logs show a drastically lower number of hours spent on task by students.

At the McNeel 21CCLC site – The McNeel site was one of several profiled in case studies conducted by the evaluator. The after-school curriculum was heavily focused on college and career exploration, and after-school instructors facilitated hands-on activities around this focus. The challenge was the first formal STEM activity conducted at this site, which was in its first year of implementation as a 21CCLC site.

McNeel facilitators and students were able to participate in multiple NASA Virtual SME sessions. Facilitators reported that students understood the "why" after talking with the SMEs -- that is, they understood why they were working on the challenge and recognized that there were careers where similar challenges or problems were worked on. Site staff observed that NASA scientists communicated with students on their level and used visual models or videos to help students understand difficult concepts. Overall, instructors felt that the Virtual SME Connections made an impact on the students and after attending those, the challenge became real to them.

Research Question 2

What variations in pilot implementation were found at the state and site levels?

The response to this research question was negatively impacted by the removal of the (1) Instructor/Site Coordinator Feedback Form and (2) Student Feedback Form due to failure to obtain Paperwork Reduction Act clearance. Therefore, the evaluator was unable to respond to this question as it was originally written. However, project documentation and data collected during interviews and site visits conducted with the six sites in four states (Florida, Michigan, New Jersey, and Virginia) provide some insight to the variations in pilot implementation across sites who reported either "few challenges" or "major challenges." Due to the small sample size from which these data came, these results should be interpreted with caution as they are not statistically representative of the entire sample.

Using the data from interviews at these six sites, three overarching themes were found for variations at the site level, including variations in: 1) perceptions and utilization of in-person training, 2) program implementation, and 3) virtual SME Connections. These variations as well as subthemes are described in detail below.

Variations in in-person training.

In-person trainings were offered at different times according to state, with some trainings delayed due to weather. One training was held in each of the 10 selected states at a variety of locations (e.g., science museum). Key sub-themes focused on variations in in-person training included: a) organization of training, b) trainer engagement, c) training content, and d) challenge information provided. Exhibit 3 provides example quotes from the interviews, demonstrating these variations.

Exhibit 3: Themes for variations in in-person training

Theme	Positive Feedback	Neutral/Negative Feedback/Suggestions for Improvement
Variation in Organization of Training	"We did the parachutes and then we went through [again] and did a test drop."	"We did 2 or 3. Might be too much. It's all the same steps." "Felt rushed, overwhelmed…wished there was more time and we had a finished product. Felt unfinished."
Variation in Trainer Engagement	"We chose the CEV Challenge because the trainer was so engaging. Others I couldn't follow because they weren't as entertaining."	"I watched [participants] playing on Facebook and liking pictures all day long."
Variation in Content	"The facilitators were set after the training." "We knew the expectations. It was a fun day."	"Challenge part was too long. Should have walked through the [evaluation/process] manual. They didn't talk about all the paperwork."
Variation in Challenge Information Provided		"We were given three options. Well our state was. We asked the [State Department of Education]. They didn't choose them either. We wanted to do [another option]. It would be better if they let you choose from all 6 next year."

In summary, some sites thought trainings were well organized, while others thought participants were rushed through Challenges and not able to finish. Additionally, some recalled working through multiple Challenges during the training.

Some sites would have liked the training to explain the implementation process and the paperwork more, while others believed they walked away understanding what was needed and required from sites. Some mentioned how engaging the trainers were, while others mentioned noting that participants were bored and not paying attention to the trainers. Additionally, all states had different Challenges that the trainings focused on, though none of the sites knew who chose the Challenges or why, and many mentioned wanting to do a Challenge that was not offered to their site/state.

Variations in program implementation

There was one overarching sub-theme for variations in program implementation: sites who felt they "started too early" also reported start-up issues. One site stated that they believed they started implementing "before NASA was ready for them" to begin. Three sites mentioned that they felt they were "trained early" and also noted experiencing issues with contact information and, consequently, start-up.

Two sites that began before the evaluation component was finalized felt frustrated that they were being told to implement elements after the fact, such as the STEM Attitudes Pre-test and Student Participation Logs. Other issues that were mentioned under this key theme included that the Y4Y website was not up and running when two sites began implementing and that the calendar and various elements of the website would not work for two of the six sites interviewed.

Variations in Virtual SME Connections

Three sub-themes emerged within variations in Virtual SME Connections including 1) student engagement, 2) participation/attendance, and 3) technology issues and cancellations.

Feedback regarding SME Connections was overwhelmingly positive for the five sites that were able to engage in the Connections.

Sites were probed about what could be done better in order to give substantive feedback regarding the pilot implementation of SME Connections and elements that could be refined in future implementations in order to further enhance successful implementation.

Student Engagement

When talking with the six sites visited, variations in implementation start dates impacted when students first interacted with SMEs, which, in turn, may have affected student engagement, based on feedback from site staff. One site, with a late start-up, had a Virtual SME Connection as one of their introductory implementation activities and, as a result, reported "immediate interest and buy-in" from students. Other sites stated not being well prepared for their initial Virtual SME Connections because they "jumped into Challenge specific Webinars" and "students did not have [exact] questions yet." Sites stated that these were "still helpful" but "less impact[ful]" than SME Connections that the students were prepared for.

Finally, three sites with very high praise of SMEs mentioned wanting to use SMEs as a way to "introduce" the program to their students in order to "hook them early" after participating in Virtual SME Connections later in their respective implementations.

Participation/Attendance

Five of the six visited sites mentioned scheduling and attending multiple SME Connections. When looking at all 77 sites, implementation tracking of scheduled Virtual SME Connections shows that most SME Connections were scheduled in March and April, even though the majority of sites began implementing in February.[13] This suggests that most sites made their first SME Connections weeks into implementation.

Over the course of the program, according to the implementation schedule, Virtual SME Connections were offered for 10 weeks, beginning February 19th and ending April 29th. Challenge-specific session options ended on March 27th, with all SME Connections between March 30th and April 29th focused on general Q&A and NASA Careers. Slots were available at 10am (28 options), 3pm (47 options), 4:30pm

[13] According to notes from the implementation team regarding SME scheduled attendance, in the month of February, 14 sites from 8 states were scheduled to attend (1 from CO; 3 from FL; 2 from MI; 1 from MT; 2 from NJ; 3 from OK; 1 from RI; 1 from VA). In March, 41 sites from 10 states scheduled to attend (1 from CA; 3 from CO; 5 from FL; 5 from MI; 4 from MT; 6 from NJ; 5 from OK; 6 from RI; 3 from VA; and 3 from WI). And in April, 34 sites from 10 states scheduled to attend (5 from CA; 2 from CO; 4 from FL; 4 from MI; 1 from MT; 1 from NJ; 5 from OK; 5 from RI; 4 from VA; 2 from WI).

(48 options), 6pm (46 options), and 7:30pm (13 options) EST over the 10 weeks, with 7:30pm timeslots beginning March 10th and being offered exclusively on Tuesdays and Thursdays. Later timeslots beginning in March could explain increased attendance for West Coast sites in the months of March and April.

Of note, 60 discrete sites scheduled to attend at least 1 Virtual SME Connection according to implementation tracking (5 sites from CA, 4 sites from CO, 7 from FL, 7 from MI, 5 from MT, 6 from NJ, 8 from OK, 7 from RI, 6 from VA, and 5 from WI), however, some of these connections were brief only to test future connections and other scheduled connections were cancelled due to reasons mentioned in detail below (see *Technology Issues and Cancellations*). Still, implementation tracking show higher attendance (78%) than SME Logs (52%), which were returned by 1 site in CA; 3 sites in CO; 6 sites in FL; 6 sites in MI; 2 sites in MT; 6 sites in NJ; 5 sites in OK; 5 sites in RI; 3 sites in VA; and 4 sites in WI.

Technology Issues and Cancellations

When talking with the 6 sites visited, 3 sites scheduled SME Connections and cancelled for weather or technology reasons. One site was not able to reschedule due to their timeline. Additional sites (beyond the 6 visited) communicated technology concerns with the evaluation team via email and phone communications. Some facilitators mentioned being "technologically challenged" and not being comfortable with the technology aspect of the program, and, in some cases, sites did not have consistently reliable technology or internet. SME Connection notes further recorded that technology issues or cancelations occurred in 8 of 10 states during tracked connections. In total, technology issues or cancellations were experienced for 38 of the 145 tracked Virtual SME Connections (26%). Many were mild issues, such as microphones needing to be muted to remove echoes. Some issues were cancellations due to weather or sites not showing for their SME Connection. A bulleted list of connection issues is included below according to prevalence:

- Cancelled (17 occurrences)
  - Due to school schedule change (6)
  - Due to weather (5)
  - No explanation (5)
  - Due to technology (1)
- Network issue (9 occurrences)
  - Included issues such as needing to connect via phone due to firewall, connectivity issues, school network issues, not having Google Hangout, not being allowed to use Google Hangout at school, losing connection during session
- Audio issues (7 occurrences)
  - Included issues such as needing to mute and unmute, audio echo, no audio (1 occurrence), mic not working and needing to use phone, mic muting/technical issue
- Webcam issue (5 occurrences)
  - Webcam did not work (5)

Research Question 3

To what degree were stakeholders satisfied with pilot implementation?

It is important to note that the reporting depth for this question was affected by the inability to receive OMB Clearance for the Instructor/Site Coordinator Feedback Form and the Student Feedback Form due to the lengthiness of the Paperwork Reduction Act clearance process and the tight timeline of the current study. While implementation feedback was limited, qualitative feedback documented during site visits provides insight on stakeholder satisfaction.

As a point of reference, as students are an important part of the stakeholders for this study, the reader should refer to Research Question 1 in the summative section which provides student feedback on their experiences with 21CLLC based on open-ended responses to satisfaction questions in the STEM Student Survey.

Because stakeholders were asked the degree to which they were satisfied with implementation, participants not only shared their level of satisfaction but also suggested refinements to the program and implementation which, if addressed in future implementations, may result in even greater satisfaction. However, because this information was obtained from only six sites, it will take the expertise of the implementation team to decide whether these suggested refinements are likely to positively impact all sites and whether they are feasible.

Overall, instructors and facilitators at these 6 sites were very satisfied with several aspects of the 21CCLC program, including (a) in-person training, (b) webinars and video training, (c) student and facilitator guides, (d) Virtual SME Connections, and (e) Challenge implementation.

All sites indicated that they wished to participate in future iterations of the program based on their experience and the growth they saw in their students.

Further detail about why stakeholders were satisfied with the 21CCLC program is provided below as well as suggested refinements based on their experiences.

Satisfaction with in-person training

Of the six sites visited, five stated that they were satisfied with the in-person training.

When asked for further detail about their satisfaction with the training, participants differed on their opinions about the length of training, and these opinions were associated with the science background or level of expertise of the participants. Specifically, site staff with a science background felt that the content was well explained. Some even felt that the training “could have taken half a day.” Alternatively, those less comfortable with the content stated that the training could be extended to “one and a half days” or “two days, to fully go through all the Challenges.”

Those participants who felt less comfortable with the content suggested potential refinements to the training that might help others without a strong science background in future implementations. These suggested refinements included adding content, changing the structure of the training, and changing some program logistics.

- Additional content:

  - Ensure training addresses how to use/navigate program resources. "[Trainings needed to] include more information about how to navigate the Y4Y website and the [support resources]."
  - Include a component on inquiry. "[Inquiry] gets easier as trust [with students] builds. But it was hard [at first]." "Instead of all the content, [trainings] could focus on [inquiry] methods."
  - Include a "training on teaching middle-school students." It was mentioned multiple times that "this is a tough age to teach." Students have "issues with recalling information," but middle school students are also "constantly changing," and "finding a personality/identity" due to adolescence, etc.
- Structure trainings based on those with and without a science background:
  - For those without a science background – "have a full day on each Challenge" in order to understand the level of detail required to implement with students. At minimum, allow participants to go through each Challenge in its entirety. Many wanted "final products."
  - Develop separate trainings for varying levels of scientific expertise.
  - Make the training "more concise" or "present information in smaller increments." Do not "overwhelm" the audience.
- Program Logistics:
  - "Require" facilitators to attend the in-person training
  - "Explain why" certain states have certain Challenges, and "allow sites to choose" their own Challenge.

Satisfaction with webinars and on-demand video trainings

Six sites participated in Webinar trainings and three sites watched On Demand Video Trainings.

Each of these sites reported satisfaction with these training components.

When probed for greater detail on their implementation and what might have enhanced their experience, participants suggested the following refinements:

- Allow participants time to "review materials covered in Webinars prior" to the session so they "can digest" information.
- Promote On Demand Videos and Discussion Boards. Only three of the six sites used On Demand Videos. One site was aware of them but could not get them to work. None of the six sites used the Discussion Boards. One site was aware of them, but was not interested in participating, while another site mentioned they "would have used them if they knew about them sooner" due to learning about the Discussion Boards shortly before students finished their Challenge.

Satisfaction with student and facilitator guides

All interviewees from the six sites reported being satisfied with the guides and believed they were helpful to successful implementation.

When probed for greater detail on what could enhance their experience with the Student Guide, the only refinement mentioned was that it would be helpful if the Student Guides "include important concepts, like 'scale' and 'model.'"

Similarly, participants were overall very satisfied with the Facilitator Guides, only suggesting that it would be helpful if the guide was "more concise." When asked if there was anything that could be added to enhance satisfaction, participants suggested that Guides be organized according to: Challenge difficulty, the number of hours required per Challenge, and the minimum requirements per Challenge.

Satisfaction with Virtual SME Connections

Five of six sites were able to participate in the Virtual SME Connections, and all of these sites reported significant satisfaction with them. Participants were highly satisfied overall and highly praised the SMEs and their abilities to relate to students.

Although participants interviewed were highly satisfied overall, the following refinements were offered by two of the sites: a) have SMEs prepared with leading questions to get the conversation started, b) change timing of Connections to ensure student attendance, and c) prepare staff and students on what to expect from Connections. However, it is unknown whether these two sites attended the SME Connection Webinar which was designed to inform facilitators of what to expect during connections and offer leading questions. Regardless, these findings seem to suggest the importance of the SME Connection Webinar to successful implementation.

Satisfaction with Challenge implementation

All six sites visited completed the Challenge with the help of a two-week deadline extension. However, all 6 sites believed they needed more time to complete the Challenge than was laid out in the initial training and in the training guides. Thinking through the timeline for implementation, participants suggested the following refinements for future implementation:

- Lengthening the timeline for Challenge implementation. Facilitators shared stress about pacing and deadlines and noted that it is less enjoyable for students. (e.g. Facilitators "need patience to let [students] fail but then we have a timeline." "We were constantly reminding [students] of the timeline. And when [do we have time to get] the paperwork done?" "[Students] needed off days. But we had to enforce the deadline.")
- Implementing "at the beginning of the year." This would help to avoid "[state] testing, science fairs, and spring sports," And implementing early in the year also "gets kids excited" about STEM and learning and "sets the tone" for a year of inquiry.
- Not limiting the program to afterschool only. "It can work during the [school] day. It fits perfectly with 8th grade state curriculum."

- Increasing the number of individuals that can be on a team to 8. (e.g. "We could have had more students participate if teams were larger, like 8 [per team]. But with two teachers, we couldn't have 5 or 6 teams.")
- Altering implementation and evaluation tracking and paperwork:
    - Providing confirmation that materials were successfully submitted and received.
    - Using a weekly tracking email for paperwork submission.
    - Providing teachers with the ability to save/print paperwork and progress.
    - Creating forms in Excel for entry of data/information so it could be tracked.
- Better communication. One site that was involved in the Pilot stated that last year, during the Pilot, there was "better communication between the administration and the State Coordinators, NASA, and ED." S/he felt this relationship was lacking this year, and it disappointed the site director and the state coordinator.

Research Question 4

What barriers or challenges were faced in pilot implementation?

Focusing again on the six sites that were visited, feedback from the subsample was overwhelmingly positive, with most of these sites experiencing few challenges.

Only one site experienced a moderate amount of challenges, and only one site experienced a significant number of challenges. When asked to explain any implementation barriers or challenges for the purpose of informing future implementation, the 13 participant responses from the six sites generated the following themes: (1) training, (2) timeline, (3) student recruitment, retention, and engagement, (4) technology/equipment, (5) communication, and 6) content. The following provides an in-depth explanation of these themes as well as supporting quotes from participants from the six sites.

Trainings

Because the one-day training was so helpful to attendees, a challenge that one site faced was that only the site director attended the in-person training. The instructors who did not attend felt they were missing key background knowledge about the process and the program, and, therefore, recommended that "the 1-day training be required." The other sites echoed the importance of instructors attending the one-day training, with one instructor stating that they "would not want to do [the STEM Challenge] without the 1-day training."

Timeline

Two sites mentioned that their timeline for implementation was delayed due to the fact that many students did not know anything about NASA and they had to take time during the recruitment and introduction to explain and give background information, which they were not expecting. “Our students didn’t know NASA. So that wasn’t a hook for them.” Two sites also mentioned that, due to the tight timeline, some facilitators had to force students to work on the Challenge on “off days” or when students clearly “needed a break.” In addition, the project was wrapping up during a time when the weather was getting nice and students wanted to be outside. One participants stated, “The weather gets nice after an awful winter. They want to go outside. If we wouldn’t have had weather delays, it would have been perfect. They would have finished while it was still nasty out.” One coordinator mentioned, “The last two weeks I’ve asked them how they were doing. They want to be done. They want to move on.” Having students work through being mentally and physically tired may have impacted the students’ experiences.

Instructors from all six sites mentioned that the timelines provided in the training and guides were inaccurate. Specifically, instructors felt that they needed more time to implement such difficult content with 5th graders, that the more complex challenges needed more time allotted for researching the need, and that the program needed to account for more time for repeating and reflecting on information that had already been covered, given that the students could not retain what they learned only working on the Challenge 1 or 2 hours per week. Quotes supporting this challenge include:

1. “We could not have done this in 10 or 20 hours.”
2. “We chose this [Challenge] because it was going to be hard, but we spent twice as much time researching than the kids did to save them time. Granted, we’re over the top, but this takes 50 hours.”
3. “I could have taught this for another 8 weeks. And they were still engaged.”
4. “You can go deeper into so many [topics] but you can’t because of the deadline. We might do this again without the timeline and focus on other parts.”
5. “It’s after school. They’re tired. They’re at [an] age where you have to repeat everything. They forget what they did last week. We spent a lot of time repeating.”
6. “5th graders, especially, had no scientific method [knowledge]. I haven’t had them [in science class] yet, they don’t know science yet. But they were the ones that were [most engaged] so we stuck with them.”

Student recruitment, retention, and engagement

As this was intended to be an afterschool program, participants from most sites in the subsample mentioned that they only recruited from students who had previously signed up to participate in afterschool activities and not from the entire school. However, some sites mentioned that they would have preferred being able to recruit from the entire school. For example, one participant said, “I think we would have had more success if we [targeted] the whole school – science students, kids that want to do science. Our [afterschool] kids don’t like science. They don’t have good experiences with science.” Another coordinator stated, “In order to participate in [any] afterschool activities, they had to sign up in October and make a year commitment. [We could only offer] NASA to [those students who signed up] and we didn’t know [about the Challenge] in October.” In other words, they could only recruit from a small pool of students and recruitment was not focused on those who might excel in the program such as those with good grades or interests in science.

According to three site coordinators, another factor that impacted recruitment was that students felt intimidated by the introduction to the program and the level of difficulty of the information presented. “I think I scared them talking about what a big deal it was.” “We emphasized how special the opportunity was – so students loved that, others were turned off.” Sites mentioned they would benefit from NASA’s help in introducing the program next year. “They loved the SMEs. They were so great. If that could happen earlier, if would get them [engaged]. Or if the SMEs could talk to the whole [school], we could increase our numbers.” “Our students didn’t know NASA before last year[‘s Pilot]. And we were so excited about SMEs this year that that is what we did first. We let them watch the teaching videos, too. So we were all on the same page. They bought in.”

There were other issues related to retention. One issue related to maintaining attendance was that Spanish speaking students dropped out at two sites due to the materials being only in English. We lost two [Spanish speaking] kids because I couldn’t take the time to explain things separately to them.” Another issue was that students were not aware of the Culminating Event. Some who were aware that exemplar videos would be selected thought the “winners” would be going to NASA. For example, one participant said “They want to win. They want to go to Dallas.” Another facilitator stated, “They believe they’ll win and get to go to DC.” Other students were unaware that it was a competition at all. “They want to know what is in it for them. Why are they doing this? They aren’t getting a grade.” Instructors thought that being aware of the competition aspect of the Challenge would have helped maintain student engagement. Many sites were nearby NASA centers, and some facilitators suggested taking students to space centers or NASA centers as part of the program. “[Inner city] students do not regularly see professionals, especially science professionals,” and teachers thought this would be great motivation for STEM activities and engagement.

Technology / equipment

Some sites mentioned issues with technology, including:

a. The Y4Y website did not work for weeks (2 sites),
b. The calendar did not work early in implementation (3 sites),
c. They did not receive eBlasts (spam filter (1 site) or contact information issue (3 sites)),
d. There were issues with the student videos (5 sites),
    i. Did not expect editing process to be so long/laborious/intense (5 sites)
    ii. Did not know how to use editing software/options at first (4 sites)
e. No access to iPads/iMovie throughout Challenge (1 site).

Another challenge mentioned by one site was that they did not have access to expensive required equipment for one of the Challenges; namely, the vacuum for the Pressure Suit Challenge. In addition, one site mentioned a few times that they were frustrated that they could not work directly with NASA as they did in the Pilot, stating that this year’s approach “seemed to be less effective than when NASA and ED were direct [contacts].”

Communication

Three of the six sites visited were missing email communications and evaluation contacts early in implementation due to the implementation and evaluation teams having the wrong contact information for the site staff. One site had the wrong person listed on original forms and it took weeks to get in contact with someone that could straighten out the issue, which caused them to be behind on implementation and evaluation.

Sites were also misinformed or uninformed about the student videos that were picked as exemplars. One site did not hear anything about the outcome of the student videos, two sites thought winning teams were travelling, and all sites seemed confused about what was happening at the end of the Challenge and next year.

Content

While the majority of comments from coordinators and instructors from all sites regarding content were positive, critiques primarily focused on the level of difficulty of the content. Instructors from two sites stated that "inquiry was too much" for some students at the beginning of the Challenge. "We had students leave that didn't want to do the required thinking." Instructors stated that there were some students who had difficulty with the material at first. They said that students who were not experienced with "that type of thinking/learning environment would get frustrated," in some cases "acting up" and "getting kicked out of the Challenge." In addition, inquiry was sometimes unfamiliar and challenging to facilitators. "It wasn't new to me but it did take some time to get comfortable." Some instructors felt that the EDP was "too advanced for [younger students]" (i.e. 5th graders) who were unfamiliar with even the scientific method. Additionally, one instructor believed the curriculum and vocabulary were complicated and could be "dumbed down a bit." Of note, instructors said that these issues were largely "resolved" throughout the Challenge as they became increasingly comfortable with the content. Inquiry became "easier as student trust [in facilitators] increased" and as relationships developed. And the instructors said that the students that were "interested" were the ones that "finished."

When asked why certain students dropped out of the Challenge, instructors reflected on the differences in the group that they started with and the group that completed the Challenge. At sites where students dropped out due to content, instructors noted that by the end of the Challenge, many students that might have found the content difficult had likely already dropped out, leaving the facilitators with smaller groups and more dedicated students, and making inquiry teaching easier. The feedback from the six sites seemed to suggest that if the program is interested in reaching and maintaining a student base with a variety of experience with science, then the program must be adapted to help instructors and students become comfortable with inquiry early in implementation. Sites with instructors that were "very comfortable" with inquiry also stated that their students were "very comfortable" with inquiry and did not mention students leaving the Challenge because it was "too hard."

Finally, sites thought that background information on NASA was needed to "hook students," as multiple sites had students who had never heard of NASA prior to the Challenge. To them, it appeared that "the NASA brand" was "supposed to be exciting" to students, but considering that these students were low income, ESL, and either inner city or rural students, instructors suggested that they and their students might need more background information and context to get students engaged early in the STEM Challenge.

Research Question 5

What effective practices were identified in pilot implementation?

Focusing again on the six sites that were visited, effective practices were asked in a variety of ways. Sites were asked to reflect on if and why their students were engaged in the NASA STEM Challenge; if and how the NASA STEM Challenge improved the site's and staff capacity to implement STEM programming; where site staff turned when they needed Challenge help; and what related to facilitation consistently worked for them. Based on these responses, a number of effective practices are suggested in this section. Below is a bulleted list of effective practices, credited by site staff from the six visited sites as increasing student engagement, site capacity, and/or program impact:

- Use of Virtual SME Connections
    - Using SMEs to introduce students to the Challenge was credited with "immediate buy-in" and "ownership" for students.
    - Having multiple sites on each Virtual SME Connection was credited with "giving students a chance to hear more questions answered," allowing them to gain more content experience.
    - Connections allowed students to see that they were "part of a much bigger Challenge."
    - SMEs were credited with "making STEM relevant" and linking STEM to "education and employment opportunities" and "college and career fields students never knew of."
    - SMEs were credited with always speaking to students "on their level," allowing students to ask any question, and, when necessary, "answering in multiple ways," "until students understood."
- Use of Inquiry
    - Teachers had varying levels of comfort/expertise with inquiry at the beginning of the Challenge, but all stated that they were confident with inquiry teaching by the end of implementation. "Inquiry got easier as relationships [grew]." Some facilitators believe that it helped to "discipline students" with regard to finding answers to questions and "strengthen relationships" between staff and students.
    - The nature of the Challenge and the use of inquiry was credited by some staff with increasing student confidence. In two cases, students that had learning disabilities were able to complete the Challenge and site staff noted that they "excelled" due to nature of inquiry learning.
- Allowing students to choose the Challenge
    - Site staff credited students choosing their Challenge with increased student interest and effort. "They chose [Spaced Out Sports] because they love video games. We weren't going to do that one, but they were really excited about that one."
- Use of student journals and student reflections
    - Student journals and reflections were credited with "keeping students on task."
    - One site encouraged students to keep "research notebooks" due to their students' interest in the research phase.
    - The journals and reflection were considered "essential to the video process."
- Access to the Help desk

    - The Help desk was credited with solving a number of minor and major issues related to implementation and facilitation. Site staff were grateful that the Help desk and SMEs were there to answer questions that they did not have the answer to. This allowed them to schedule Virtual SME Connections and answer student questions without derailing the implementation timeline.
- Enforcing the use of teams
    - Teamwork and "working together" was often mentioned as the "most beneficial and relevant" aspect of the NASA STEM Challenge as it related to students' lives. One facilitator noted, "These kids don't work things out with words. This is a violent area. I put them together. They worked it out. Every day I thought there would be an issue. I only had to step in once."
    - Teamwork was credited with developing communication skills.
    - The Challenge also was credited with relationship building between students and staff due to the "team environment" that the "intensity of the program" encouraged.
- Implementing a curriculum-based, hands-on, minds-on NASA STEM program
    - Implementing the NASA STEM Challenge was credited with increasing site capacity to implement similar programs; increasing staff capacity due to increases in content knowledge, experience with teaching STEM hands-on activities, and experience with teaching inquiry; increasing capacity of sites to train other school districts on STEM Challenges; and increasing capacity and confidence to implement more intensive hands-on STEM curriculums in school and after school.
    - Most sites said that the NASA Challenge was the "most intensive curriculum" they had ever used in their afterschool programs and now felt "comfortable" and "excited to use the curriculum with new students."
    - The use of research, the EDP, and video technology allowed students to be engaged in a variety of STEM activities. Though some students might not have been engaged in all aspects, with "such diversity," "students found [elements] they became immersed in."
    - One site was able to gain media attention and engagement due to students "winning" a NASA Challenge.
    - Participation in the NASA STEM program had students from multiple sites going home afterschool and engaging their parents in the required research and Challenge elements. Parents donate building supplies at multiple sites and would come watch on "test drop days." "[Students] knew what they were doing. They'd tell their parents. …Parents would come in and help." Parents were also asked to attend a Virtual SME Connection at one site and after attending, one parent asked, "When do we get to start?"

Research Question 6

To what extent did 21 CCLC activities, including SME interactions, meet program quality expectations for out of school STEM?

Quality of Challenge Implementation: To assess the degree to which facilitated STEM Challenge experiences met accepted quality standards for out of school STEM, the evaluation conducted implementation observations using the Dimensions of Success observation tool,[14] a nationally validated protocol that tracks the quality of STEM out of school learning opportunities and pinpoints strengths and weaknesses using 12 indicators across four domains as follows:

1. **Features of the Learning Environment** (Organization, Materials, Space Utilization)
2. **Activity Engagement** (Participation, Purposeful Activities, Engagement with STEM)
3. **STEM Knowledge and Practice** (STEM Content Learning, Inquiry, Reflection)
4. **Youth Development in STEM** (Relationships, Relevance, Youth Voice).

The twelve Dimensions of Success were rated using a four-level rubric to determine the range of quality associated with each dimension. The DoS observations were conducted at the same six sites that received site visits by two certified DoS observers. Four sites had scores of "3" (reasonable evidence present) and "4" (compelling evidence present) on all dimensions; one site had all 4's (compelling evidence); and one site had scores of "2" (inconsistent evidence present) and "3" (reasonable evidence present) across all dimensions. Table 5 displays individual scores below. Table 5 also shows the average scores by dimension. Of the six sites visited, sites scored lowest, on average, in the Youth Development in STEM Dimensions of Relevance and Youth Voice and highest on the Dimensions of Inquiry and Relationships.

Table 5. Dimensions of Success Site Scores, by Site and Overall

Dimensions	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Average
Organization	4	4	2	4	4	4	**3.7**
Materials	4	4	2	4	3	4	**3.5**
Space Utilization	4	3	3	4	3	4	**3.5**
Participation	4	4	2	4	4	3	**3.5**
Purposeful Activities	4	4	2	4	4	4	**3.7**
Engagement with STEM	4	4	2	4	3	4	**3.5**
STEM Content Learning	4	4	2	4	3	4	**3.5**
Inquiry	4	4	3	4	4	4	**3.8**
Reflection	4	4	2	4	3	4	**3.5**
Relationships	4	4	3	4	4	4	**3.8**
Relevance	4	3	2	4	3	4	**3.3**
Youth Voice	4	3	3	4	3	3	**3.3**

Site visits occurred after DoS observations at 5 of the 6 sites visited. This was structured so that the DoS scores could be presented and explained to facilitators during the site visits by a separate evaluator. Both facilitators and the evaluator agreed that DoS scores corresponded with what was experienced during evaluation site visits, and also corresponded with the barriers and challenges described by sites during the in-depth interviews. One site reported experiencing significant implementation challenges (site 3), and one site experienced moderate challenges (site 5). (See Appendix J Stringer site (site 3) and McNeel

[14] The DoS (Dimensions of Success) observation tool defines 12 indicators of STEM program quality in out-of-school time (e.g., afterschool, summer camps, etc.). It was developed and studied with funding from the NSF (National Science Foundation) by the PEAR (Program in Education, Afterschool and Resiliency), along with partners at ETS (Educational Testing Services) and Project Liftoff. For more information about DoS, please visit http://www.pearweb.org/tools/dos.html.

site (site 5) for specific detail on challenges that these sites experienced.) Facilitators also agreed with the DoS observation assessments of the learning environment, students' participation and engagement levels, staff understanding and use of inquiry, and staff's and students' relationships. Site staff also believed that their DoS observation scores and feedback, discussed with them during site visits, accurately represented what was going on in their classrooms at the time of the observation weeks previously.

DoS scores were also reflected in student video products that were scored by the evaluation team, with sites experiencing barriers and challenges scoring lower on average than sites experiencing fewer challenges with regard to the evaluation's video rubric. The case studies in Appendix J explore these comparisons further.

Virtual SME Connections

With regard to Virtual SME Connections, staff were consistently impressed with the scientists and engineers who spoke with the students. SMEs were "knowledgeable" while "still speaking to the students directly and on a level that they could understand." They were "prepared for any question" and if the students could not grasp their meaning, "[SMEs] would show videos or models to further explain" their responses. "SMEs made the Challenges relevant to the students' lives." They showed how "classroom science translates to the real world," and how important team work and problem solving is to "solving real world problems." This suggests that the training to prepare scientists and engineers for connections, which included multiple training opportunities, covering a number of developmental appropriate presentation strategies, were successful in preparing the SMEs. NASA SMEs also validated that the Challenges were "real problems" and "students believed they were helping to solve NASA's problems." SME Connections were noted as the times when site staff heard students ask the most "why" questions. Students were described as "mesmerized" and "always engaged, excited, and on their best behavior" when they were attending a SME Connection. Implementation Research Question 1 and Formative Research Questions 1 and 2 focus on satisfaction with SMEs, suggestions for improvement, and technology/access issues encountered in detail. In addition, Research Question 1 in the summative section also provides student feedback on SMEs from open-ended responses in the STEM Student Survey.

Summative Sub-study

The summative sub-study assessed the degree to which the STEM Challenges yielded student-level outcomes. Desirable student outcomes that NASA hoped to realize were an improvement in students' interest in STEM and a demonstrated understanding of the engineering design process.

Interest in STEM was assessed through a research-based scale on a pre-post survey instrument administered across all participating sites. Student understanding of the engineering design process was documented through an analysis of open-ended responses on the post-survey and also through an in-depth analysis of a subset of presentation videos created by students and facilitators using a scoring rubric that measures the engineering design process. Key findings are presented below.

The primary participants for the summative evaluation were 840 5th, 6th, 7th, and 8th grade students completing survey(s) fielded online across 54 sites. Of the 840 students providing data, 366 (or 44%)

provided data at both waves. Student work was assessed with the Student Work Assessment Rubric (see Appendix I) and student STEM attitudes were assessed with the STEM Attitudes Survey (Martinez, Linkow, Velez, & DeLisi, 2014) prior to (or pre-test) and after (or post-test) STEM Challenge activities. The specific attitudes assessed were Enthusiasm for Science, Interest in Design and Hands-On STEM Activities, Interest in Out-Of-School STEM Activities, and General Interest in Science. Additional survey items measured participation in science-related activities. Analyses examining STEM attitudes examined whether the change over time was statistically significant (or larger than what we would expect by chance alone) and whether this change over time was affected by student grade using hierarchical linear modeling. Coded video quality was examined with descriptive statistics (e.g., averages, percentages). A detailed description of the study sample, the survey and other measures used, and the specific analyses used can be found in Appendix K. Specific survey items comprising each subscale can be found in Appendix M and an item-by-item justification for these measures from the Summer of Innovation project can be found in Appendix N.

Research Question 1

Do students completing a NASA Challenge demonstrate increased positive attitudes toward STEM?
Analysis of these data suggested that students increased their participation in other STEM activities from 31% at pre-test to 48% at post-test, which is presumably a result of the STEM challenge. Additional subscales of STEM Attitudes were tested but did not yield positive results; however, it is important to note that STEM attitudes were already high at baseline. Please see Appendix L for more information on these findings.

Qualitative responses from STEM Attitudes Survey

Students' attitudes toward STEM was also determined by qualitatively assessing the open-ended responses from the STEM Attitudes Youth Survey. Students had unlimited space and time to provide their responses to: 1) what they liked best about the program, 2) what they would change about the program, 3) whether they would recommend that their friends participate in the program, and 4) why they would recommend their friends participate in the program. These responses were coded for key themes which are shared below by question. We also present some supporting quotes from the dataset.

Exhibit 6: Themes for what NASA students liked best about 21CCLC

Theme	Frequency	Percentage
Constructing a Prototype	228	47%
Working as a Team/ With Friends	77	16%
Researching the Need/ Talk with SMES	71	14%
Having Fun with Science	41	8%
Testing & Evaluating	40	8%
Designing/ Redesigning/ EDP	31	6%
Brainstorming a Solution	27	6%

Note: N = 488. Percentages will not equal 100%, as percentages have been rounded, some students did not respond, some students mentioned multiple themes in their response, and some responses did not fit a common theme.

Themes that derived from the question of what students liked best about the 21CCLC program focused mainly on steps of the EDP (see Exhibit 6). For example, nearly half of the responses involved describing the building process or constructing a prototype. This was by far the most common theme and may indicate what drives student interest in STEM. It is also noteworthy that constructing a prototype was what they liked best about 21CCLC, above working with their friends or having fun.

Other common themes included researching the need or talking with an SME, brainstorming solutions, testing and evaluating their prototypes, and redesigning. Although the percentages for these additional themes are lower, it is important to point out that themes derived from student responses focused on steps of the EDP, which suggests interest in the actual EDP process. Other themes not focused on the EDP included having fun with science and working as a team, which are also important to note as these were underlying objectives of the program.

Quotes that support these themes are below:

- Constructing a prototype: "I liked the building because it required determination and it was really fun."
- Working as a team/ with friends: "I liked that I got to work with a group of very intelligent kids and that there was no real leader and we all participated in the project equally."
- Researching the need: "My favorite part about this NASA activity was that I was offered the opportunity to work with real NASA scientist and engineers. I learned a lot working with them, and I also liked how there were women scientists. It was very cool because there are not that many women scientists in the science field. That was very inspiring because it lets me know that I can get into that field of work and have a shot. All in all I think that I took a lot from this activity but my favorite was getting to talk to real scientist and engineers while working alongside my friends"
- Having fun with science: "I got to put my love of engineering and hanging out with my friend together."
- Testing and evaluating: "I like how interesting the work is to do, and I like when we test our theory."
- Designing/ Redesigning/ EDP: "What I liked best about the NASA activity is the different steps that we had to do I liked it because it gave me more understanding about the whole thing."
- Brainstorming a Solution: "What was the best thing about this NASA activity is that I was able to contribute for my team by giving them some brief solutions and sketches that can be helpful with the establishment of a new radiation shield."

Exhibit 7: Themes for what NASA students would change about 21CCLC

Theme	Frequency	Percentage
Nothing	119	24%
Would have changed components of the program	84	17%
Would have changed the Challenge implementation	52	11%

Note: N = 488. Percentages will not equal 100%, as percentages have been rounded, some students did not respond, some students mentioned multiple themes in their response, and some responses did not fit a common theme.

As shown in Exhibit 7, when asked what they would change about the 21CCLC program, the most frequent response was "nothing" (24%), suggesting that the students would want to participate in 21CCLC again, exactly as it was implemented. Other students said they would have changed the components of the program such as making the program harder or easier, adding more activities, doing the program longer or more often. Some students did not like the packet whereas others found the packet useful for explaining things and giving them guidance. Another response given focused on changing the Challenge implementation and most of those responses focused on having more time to complete the challenge. Quotes that support these themes are below:

- Nothing: "If I were in charge I would not change anything in this program because it was really organized and it was really fun."
- Would have changed components of the program: "I would give the students more background information like take them to a space museum and show them more pressure suits."
- Would have changed the Challenge implementation: "I if I were in charge I would give the teams more time to complete the project. I feel like if we had more time we could have made better videos."

Exhibit 8: Would Students Recommend 21CCLC to their friends?

Response	Frequency	Percentage
Yes	417	88%
No	57	12%

Note: N = 474.

Exhibit 9: Themes for why students would recommend 21CCLC

Theme	Frequency	Percentage
It was fun	194	41%
Enjoyed working as a team / with friends	64	13%
Enjoyed learning about STEM/ Space/ NASA	57	12%
Enjoyed learning new things	51	11%
Good experience	32	7%

Note: N = 474. Percentages will not equal 100%, as percentages have been rounded, some students did not respond, some students mentioned multiple themes in their response, and some responses did not fit a common theme.

Importantly, 88% of students said they would recommend that their friends participate in the 21CCLC program (see Exhibit 8). The most frequent reason provided was because it was fun (see Exhibit 9). Other responses included because they enjoyed being a part of their team or working with friends, because they enjoyed learning about STEM, space and NASA, because it was a good experience, and because they learned new things. These findings suggest that students' attitudes toward STEM were favorable and that they were engaged and excited about STEM programming.

Quotes that support these themes are below:

- Fun. "I would because it was a fun learning experience and it was fun to build, redesign, and test."
- Enjoyed working as a team/ with friends. "I would recommend it because nothing is more fun than bonding with your friends while doing science."
- Enjoyed learning about STEM. "I think that it challenges kids with potential to use their minds and skills to create something. It's great for learning more and more about science and astronomy."
- Enjoyed learning new things. "It is a fun experience, and you learn a lot about space than you might not have already learned."
- Good experience. "Because you have an amazing experience while thinking hard about something that could help change the way we live tomorrow and benefit our exploration." And, "It helps a child have a better love for science."

Research Question 2

Do students describe a quality engineering design process in their final product (i.e., video)?

The evaluation rubric used to score student's final video products was based on the eight steps of NASA's engineering design process: (1) Identify the Need or Problem, (2) Research the Need or Problem, (3) Develop Possible Solutions, (4) Select the Best Possible Solution, (5) Construct a Prototype, (6) Test and Evaluate the Solutions, (7) Communicate Solutions/ Findings, and (8) Redesign. The rubric was also closely aligned with the implementation rubric and guidance given to sites for development of the student work products. The scoring rubric provided clear instructions to raters, describing expectations about each step of the engineering design process and the final student work product as defined by the NASA Challenge curriculum developers and implementation team (see Appendix I).

An important component of the evaluation was to solicit review and input from a panel of nationally recognized experts in STEM education. The external evaluator convened an ERP whose function was to advise the team and the Technical Monitor on the evaluation, including review of and feedback on the student work assessment and the evaluation report, including feedback on measures, methods, and implications of findings. The ERP was comprised of five individuals who are recognized experts in STEM education, research, and evaluation.

Categories for rubric ratings were as follows: 2 = All criteria are met; 1 = Some criteria are met; 0 = None of the criteria are met.

Members of the ERP (Expert Review Panel) convened to review the rubric and coding and analysis procedures and to help establish the coding and categories for ratings.

All 15 videos that were submitted from the subsample of six sites were included in these analyses. After scoring was completed, the following categories were developed for total scores:

- 0-5 = Poor Demonstration of Engineering Design Process
- 6-8 = Average Demonstration of Engineering Design Process
- 9-11 = Good Demonstration of Engineering Design Process
- 12-16 = Excellent Demonstration of Engineering Design Process

These categories were determined based on coders' perceptions of cut-offs for a clear demonstration of the EDP. Specifically, those scoring a total of 5 and under did not clearly demonstrate the EDP, those scoring between 6-8 understood certain elements or steps of the EDP but not the entire process, those scoring between 9-11 understood the EDP but didn't explain a few key concepts in depth, and those scoring between 12-16 really understood the EDP and could talk about it on a richer level than the others. All 15 videos that were submitted from the subsample of six sites were included in these analyses.

As demonstrated in the exhibits below, the analysis found that the majority (87%) of videos demonstrated a good or excellent demonstration of the engineering design process. Of the 15 student videos, two (13%) presented videos that were rated as a poor demonstration of the engineering design process (total scores between 0 and 5); seven (47%) presented videos that were rated as a good demonstration of the process (total scores between 9 and 11), and six (40%) presented videos that were rated as an excellent demonstration of the process (total scores between 12 and 16). Further analysis found that students' understanding of certain steps in the engineering design process was stronger than others. Student videos scores are highest on the Construct a Prototype step, followed by Identify Need, Select the Best Solution, Develop Solutions, Test and Evaluate and Communicate Solutions, and Redesign, Research Need.

In the videos, students discussed their understanding of the engineering design process in their own words. As seen in the exhibits below, on average, students scored with a "good demonstration of engineering design process" in the videos evaluated from the six sites visited. Further, in open-ended responses that looked at students' feedback from all sites, student responses about what they liked best about the program themed to match the EDP, pointing to a wider understanding of the EDP by students that completed the STEM post-test.

Exhibit 14. Distribution of quality Engineering Design Process scores by Step.

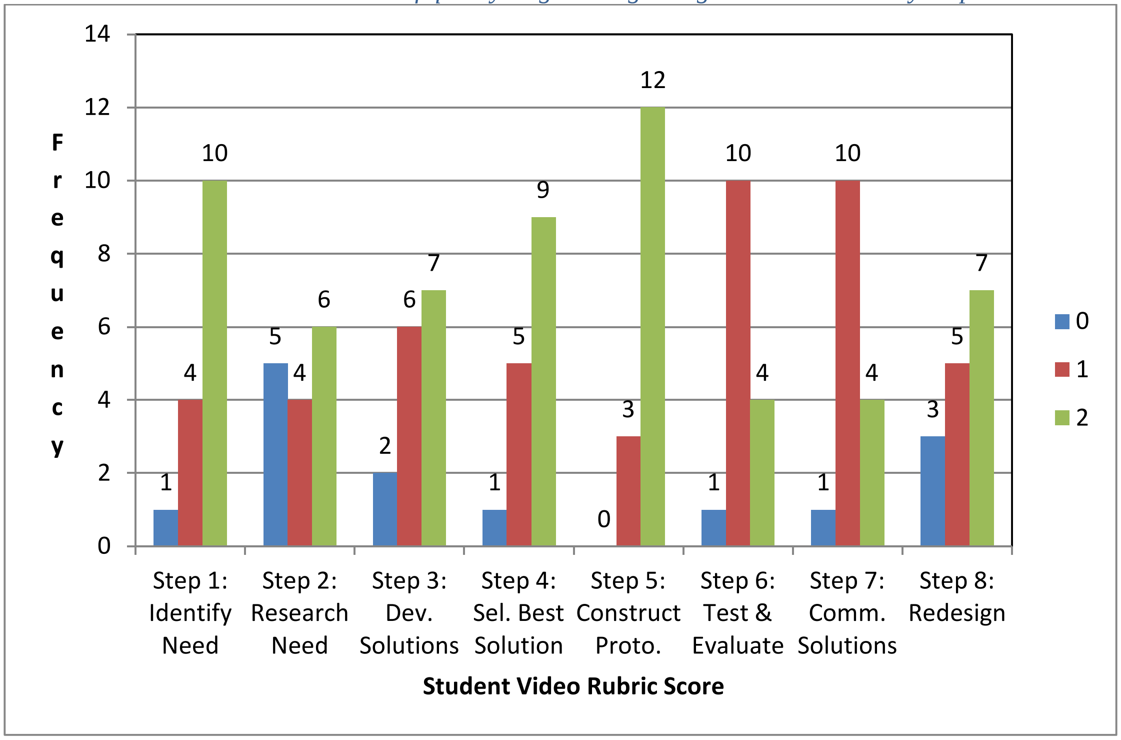
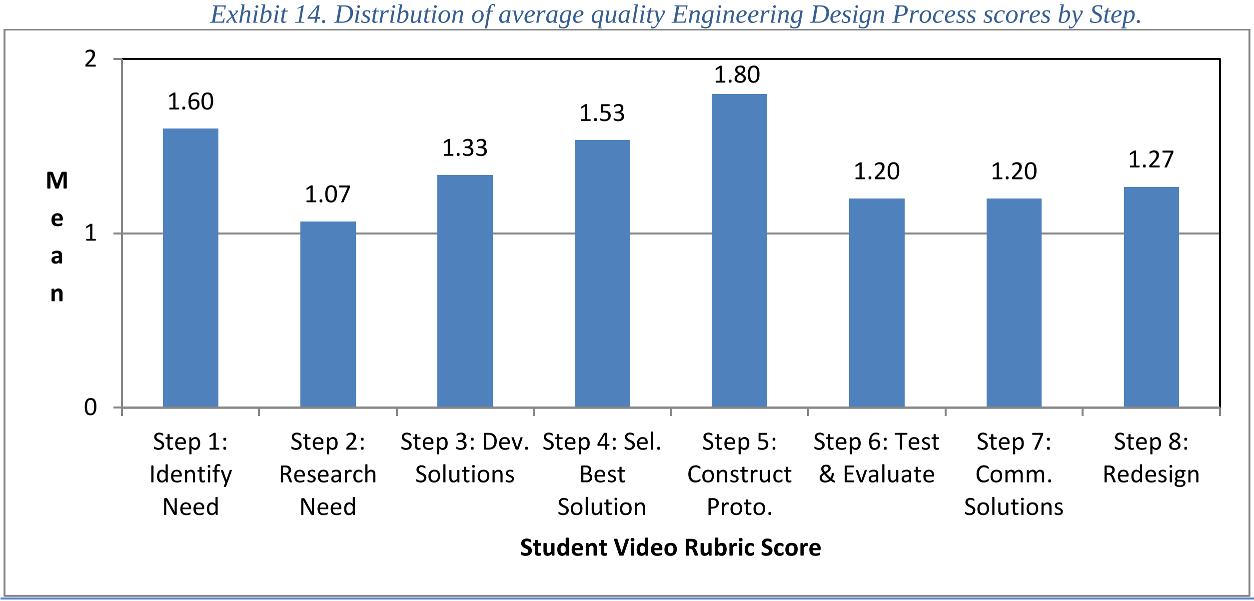


Exhibit 14. Distribution of average quality Engineering Design Process scores by Step.



CONCLUSIONS & RECOMMENDATIONS

This final section of the report presents an integration of the study findings from the three sub-study components as well as all data sources. It is organized around some of the key themes that have emerged from the study findings, including: STEM Attitudes, STEM Exposure, Student Work Assessment, Dimensions of Success, and STEM Implementation. Finally, additional recommendations for consideration are provided.

STEM Attitudes

Analysis of pre-post student responses demonstrated that students' self-reported participation in other STEM activities increased from 31% at pre-test to 48% at post-test, which is presumably a result of the STEM challenge. This finding was robust and statistically significant for students' participation in specific STEM activities: Students were likely to have increased their attendance of science clubs, science competitions, and science camps or after-school activities. This is an important objective of STEM engagement activities and likely speaks to their continued involvement in science that will help foster scientific skill development. Qualitative findings, which were based on open-ended responses students gave on the post-survey about the program, further documented favorable attitudes among the students toward STEM. Specifically, students overwhelmingly had favorable responses toward the program. Eighty-eight percent of students said that they would recommend this program to their friends, and 41% said they would recommend it because "it was fun," suggesting that their attitudes toward STEM were favorable and that they were engaged and excited about STEM programming.

> **Recommendation 1. It is possible that students participating in a STEM program in any capacity might demonstrate improved STEM outcomes when compared to students who have not participated in a STEM program. For this reason, NASA should consider having a comparison group in future studies in order to assess differences in students exposed to STEM programming and those not exposed to STEM, rather than assessing variations in STEM exposure among STEM program participants.**

Student Work Assessment

The majority of student work products (87%) were coded as "good" or "excellent" demonstration of the engineering design process (EDP), meaning that most of the criteria from the rubric were met. Student work products scored highest on the "construct a prototype", suggesting that the building step may heavily influence interest and engagement in science. The qualitative findings also showed that students most favored the building aspect of the Challenge.

Overall, the evaluation team believed they were able to objectively assess the EDP through the student videos. The evaluation team met with the Expert Review Panel (ERP) after each panel member had coded two videos using the draft rubric, and the evaluation team felt that with the ERP's assistance they were able to come to a consensus on when criteria were fully met, partially met, or not met at all. The evaluation team agreed that students demonstrated a quality EDP when they could confidently talk about the EDP in their own words, touching on criteria listed for each step that came from the Educator Guides disseminated to sites. The evaluation team recommends adding a fourth rating on the scoring rubric scale that would allow coders to distinguish between groups who met the criteria versus those who met criteria *and* demonstrated an in-depth understanding of the EDP. The evaluation team did not believe that elements such as teacher guidance, advanced editing techniques, and more advanced models translated into higher scores, as the process was focused on meeting criteria of the EDP steps and not on video quality.

The ERP members expressed some concerns about the student work assessment, including: 1) the quality of the video/ video editing skills or communication skills were being assessed and not the actual process, 2) it did not seem fair to assess what occurred during 10-20 hours of work in a 3-5 minute video because students might not have remembered everything or might have been limited by time constraints, 3) it was difficult to code videos using a rubric because the EDP is not linear and there were multiple steps taking place or being communicated at same time; and 4) some videos showed photos to demonstrate the EDP instead of talking about it so it was not clear what the students understood. ERP members suggested the following alternatives to measurement which might allow for more in-depth assessment of the EDP: 1) allowing students to video short segments throughout the program activities rather than in one video at the end, 2) having student keep track of daily activities (e.g., storyboard, journal, log, portfolio, apps such as LiveAssess, systems such as Lead the Way Innovation Portal).

> **Recommendation 2. An advantage to the review of student videos was that students felt comfortable talking about the EDP steps in their own words, which could be argued as an objective assessment of what they learned. NASA should consider adapting the current student work product criteria as well as the rubric and pairing it with alternative methods for assessment of student work products, including journaling and logs of daily activities as well as available apps and data systems.**

<u>Dimensions of Success</u>

Dimensions of Success (DoS) observations, overall, showed that most sites demonstrated reasonable or compelling evidence of STEM. DoS scores confirmed what was experienced during evaluation site visits and the barriers and challenges described by sites during the in-depth interviews. One site experienced significant challenges (scoring 2s and 3s), and one site experienced moderate challenges (scoring mainly 3s). DoS scores were also reflected in student video products that were scored by the evaluation team, with sites experiencing barriers and challenges scoring lower on the evaluation's video rubric. Facilitators agreed with the DoS observation assessments of the learning environment, students' participation and engagement levels, staff understanding and use of inquiry, and staff and students' relationships. They also believed that their DoS observation scores and feedback, which were discussed with them during site visits, accurately represented what was going on in their classrooms at the time of the observation.

> **Recommendation 3. Due to its successful implementation in the current study, NASA should continue to use the DoS observation instrument as a measure of STEM success, but supplement that measure with others, including in-depth interviews and regular feedback. Additionally, as many of the facilitators are teachers, they are comfortable with being observed but have a high interest in knowing upon what criteria they are being evaluated. The DoS observation dimensions and criteria should be made available to sites prior to site observations.**

STEM Implementation

Of the original 93 21 CCLC sites identified for potential participation in the NASA STEM Challenge, 77 sites began the Challenge and 55 sites (or 71%) completed the Challenge on time. An additional 6 sites submitted student videos after the deadline, for a completion rate of 79 percent (61 of 77). It is not clear from the current evaluation why 16 sites began the Challenge but did not submit final work products. However, barriers existed at the six sites visited for in-depth interviews, and these barriers may have been relevant for other sites as well. It should be noted, however, that the sites visited completed the Challenge, which suggested these barriers were not highly consequential. Implementation challenges included: a) absent, infrequent, or ill-timed communication with the implementation team, b) not being fully aware of the evaluation requirements, c) experiencing technology issues related to implementation resources (e.g., Y4Y Website), and d) feeling the timeline was rushed. Of all barriers mentioned, the rushed timeline was mentioned most often and also discussed as the largest barrier to maintaining student engagement and meeting program requirements. Specific challenges to the timeline included early implementation issues; implementing at a time that conflicted with science fairs, spring sports, and state testing; needing more time to recruit students; needing more time to implement difficult content; and needing more time to account for repeating and reflecting on information that had already been covered because students could not retain what they learned only working on the Challenge 1 or 2 hours per week.

> **Recommendation 4. NASA should consider lengthening the timeline of the Challenge to include more time for start-up and preparation as well as for time for Challenge implementation. More time in the beginning phase of the project would also likely enhance communication between sites and the implementation and evaluation teams. Many sites also suggested implementing in the Fall rather than the Spring would be preferable.**

The in-person training was well attended and perceived as helpful in obtaining needed context and knowledge related to STEM, in general, and the Challenge specifically. There were variations in use of related resources. Findings from the in-depth interviews suggest that better communication about available resources in the training and immediately following could likely enhance access to training resources as well as working out technological issues before implementation began. Instructors were satisfied with the training materials and the guides were perceived as helpful. One challenge related to the manuals was that facilitators felt they were too detailed and contained too much information. Some suggestions for manual improvement included listing challenges according to difficulty, detailing minimum requirements, and listing what adaptations can be made based on age of students.

> **Recommendation 5. NASA should consider the suggestions made by instructors in this evaluation in order to enhance training materials and manuals. Specifically, it would be beneficial to have more frequent communication about available resources, more streamlined information, less complex language, and ways to adapt content based on grade.**

Our in-depth interviews suggested that coordinators and instructors would have benefited from assistance with recruitment. Some thought the program would be more successful if 1) they could have recruited from the entire school rather than just those who previously signed up for afterschool programming, 2) they had more material to help them provide context about NASA, 3) SMEs could talk to the whole school to get them excited about joining the Challenge, and 4) students were aware of and reminded about the competition aspect of the Challenge.

Recommendation 6. NASA should consider providing additional recruiting materials and recruitment methods for sites in order to help get students properly introduced to NASA and the Challenge and engaged early in the Challenge.

Virtual SME Connections were perceived as highly effective and were reported as most beneficial when students were prepared to ask questions. There were noted complications due to timing of SME Connections, weather and school cancellations, and some technological difficulties.

Recommendation 7. In order to maximize SME Connections and student engagement, the program should make sure times and dates are offered early so that sites can choose relevant Virtual SME Connections early in implementation, make sure sites and staff are prepared prior to their first connection so that technology issues do not cause disengagement, and make sure site staff and students are prepared for SME Connections by having questions ready to ensure rich discussion.

Additional Recommendations

Recommendation 8. The data obtained from the six site visits was rich and helped greatly in understanding the implementation process as well as in interpreting our quantitative results. NASA should consider including a larger sample for site visits in future evaluations to strengthen study findings.

Recommendation 9. Future evaluations should consider effective ways to track program exposure in order to more adequately assess the impact of program exposure on outcomes. Student and Instructor/Coordinator Feedback Forms would have provided the needed additional data. However, since there were issues in the current study with accurate weekly data entry, perhaps future implementations could include an incentive for completing the logs and/ or make the logs part of an activity journal that the student teams complete weekly.

Recommendation 10. As recommended by the ERP, NASA should consider including measures of "level of comfort or familiarity" with STEM for instructors leading the programming in order to assess how varying levels of comfort or expertise among instructors might impact outcomes. The current evaluation originally included such measures in the feedback forms but was unable to implement those due to a lack of Paperwork Reduction Act clearance. Along the same lines, NASA should also consider adding measures of student understanding, capability, and comfort with STEM.

Recommendation 11. As recommended by the ERP, NASA should ensure that all programming, including manuals and training materials, include an operational definition of STEM upfront so instructors, coordinators, and students are clear on what the program is about. In addition, surveys and guides for interviews should provide participants with a definition for STEM prior to asking them to respond to questions.

Recommendation 12. As described in this report, there were challenges due to the brevity of the project timeline that impacted several aspects of the implementation and evaluation. In order to avoid these issues in future implementations, there needs to be: (a) more lead time to consult with an Expert Review Panel on the emerging area of K-12 engineering evaluation to refine instruments and methods and increase the rigor of the evaluation; (b) more time to allow for OMB clearance of new instruments or feedback forms, ensuring the alignment of the Challenges and instruments as well as the opportunity to seek implementation/ process data through feedback forms from a representative sample of sites; and (c) adequate time to address feedback from NASA and ED on all aspects of the evaluation. NASA should allow for long-term planning for such projects in order to allow for the desired rigor for evaluation and implementation.

APPENDIX A – ENGINEERING DESIGN CHALLENGE OPTIONS

APPENDIX B SITE INFORMATION FORM

National Aeronautics and Space Administration

SITE INFORMATION FORM

Site Coordinators should complete this form for each instructor of a NASA STEM Challenge Class at their site, and multiple forms should be completed for classes with multiple instructors.

Site Coordinator Name/ID: ____

Site Name: ____

Instructor Name/ID: ____

State: __________

NASA Challenge Implemented: ______________________________________

What type of site is this?

a) School implements STEM programs
b) STEM focused-school
c) Other, please describe: ____

Qualifications of Instructor (i.e., person who taught NASA Challenge)
Please check all that apply to describe the instructor

- ☐ The instructor is a teacher
- ☐ The instructor is a math teacher (for example, being certified math teacher, have license to teach math)
- ☐ The instructor is a science teacher
- ☐ The instructor does not currently teach math class, but has math background (for example, majored in math, taught or tutored math before,
- ☐ The instructor does not currently teach science class, but has science or engineering background (for example, majored in science or engineering, taught or tutored science or supported engineering projects, works in engineering)
- ☐ The instructor does not have math, science or engineering background.
- ☐ The instructor is a parent volunteer

How long has instructor taught STEM afterschool programs?

- ☐ Prior to this NASA Challenge, the instructor did not have any experience of implementing similar programs
- ☐ _________ year(s)

How long has instructor taught *any* afterschool program?

- ☐ _________ year(s)

Did the instructor attend the in-person training? ❑ Yes ❑ No

APPENDIX C STUDENT PARTICIPATION LOG

National Aeronautics and Space Administration

STUDENT PARTICIPATION LOG

Instructions: This form should be completed by the instructor or site coordinator for each student participating in the NASA STEM Challenge program, including what was covered in each class and how long the student participated.

The purpose of this Log is to track attendance and student participation on a weekly basis.

Instructor/Site Coordinator Name or ID:___________________________________

School: ____

Date of NASA STEM Challenge Activity/ Class (Week of Challenge): ______________

Student Name/ ID	How long did student attend? (minutes/ hours)	What was covered while student was in attendance?

APPENDIX D STUDENT SME INTERACTION LOG

National Aeronautics and Space Administration

STUDENT SUBJECT MATTER EXPERT INTERACTION LOG

Instructions: This form should be completed by the instructor or site coordinator for each student participating in the NASA STEM Challenge program after each interaction with the NASA engineer or scientist (sometimes called subject matter experts or SMEs). The Log will document what topics were covered and how long the student participated.

The purpose of this Log is to track attendance and student participation in the SME interactions.

Instructor/Site Coordinator Name/ID:___________________________________

School: ____

Date of NASA STEM Challenge SME Interaction (Week of Challenge): ______________

Student Name/ ID	How long did the conversation last? (minutes/ hours)	What was covered while student was in attendance?

APPENDIX E STEM ATTITUDES SURVEY PRETEST

STEM Attitudes Survey (PRETEST)

National Aeronautics and Space Administration

Congratulations on taking part in a NASA educational activity! To improve this program for the future, all students who participate in this activity are being asked to complete a survey. There are no "right" or "wrong" answers to any of the questions. We want your honest opinions. It should take about 10-15 minutes to complete the questions. Thank you very much for your help!

NASA and its research team follow strict rules to make sure that only they will see your answers to this and future surveys for this activity, except as required by law. No report will use your name or describe you in any way that could identify you.

If you wish to participate in this survey, please continue. Return your completed survey to your instructor.

Tell NASA about yourself.

Your first name: ______________________________ Your last name: ______________________________

1. What is your birthday (MM/DD/YYYY)? [ ]

2. What grade did you enter last fall 2014?

5th	6th	7th	8th
○	○	○	○

3. As things stand now, how far in school do you think you will get?

- ○ Less than high school
- ○ Earn a high school diploma or GED
- ○ Complete an Associate's degree
- ○ Complete a Bachelor's degree
- ○ Complete a Master's degree
- ○ Complete a Ph.D., M.D., law degree, or other high level professional degree
- ○ I don't know

4. Why did you sign up for this NASA educational activity? *(Check all that apply.)*

- ○ To have fun
- ○ To learn more about NASA and space
- ○ To have something to do
- ○ To learn more about different majors in college (e.g., engineering, science)
- ○ To learn more about science
- ○ To learn about what scientists and engineers do
- ○ To make my parents/guardians happy
- ○ To meet others with interests similar to mine
- ○ To help me to do well in school
- ○ None of these

5. **Have you ever participated in a NASA educational activity?**
   - ○ Yes
   - ○ No
   - ○ I don't know

Tell NASA about your science activities in and outside of school.

6. **What science class did you most recently take? This might be the class you are currently taking.**
   - ○ Science or General Science
   - ○ Life Science
   - ○ Earth Science
   - ○ Physical Science
   - ○ Integrated or Coordinated Science
   - ○ Other science course
   - ○ I don't know

7. How much do you agree or disagree with the following statements about your most recent science class?	Never	Rarely	Sometimes	Often
7.1 I enjoyed this class very much	○	○	○	○
7.2 I thought this class was a waste of my time	○	○	○	○
7.3 I thought this class was boring	○	○	○	○

8. **Which of the following activities did you participate in during your most recent school year? This might be the current school year. *(Check all that apply.)***
   - ○ Science club
   - ○ Science competition
   - ○ Science camp or after-school activity, not including a NASA activity
   - ○ Science study groups or a program where you were tutored in science
   - ○ None of these

9. During the most recent school year, how often have you done the following science activities? This might be the current school year.	Never	Rarely	Sometimes	Often
9.1 Read science books and magazines	○	○	○	○
9.2 Access web sites for computer technology information	○	○	○	○
9.3 Visit a science museum, planetarium, or environmental center	○	○	○	○
9.4 Play games or use kits or materials to do experiments or build things at home	○	○	○	○
9.5 Watch programs on TV about nature and discoveries	○	○	○	○

Tell NASA your opinions about science.

The next series of items contain a number of statements about science. You will be asked what you think about these statements. There are no "right" or "wrong" answers. We just want your opinions. For this survey, the word "science" covers a broad range of topics, including space and planets, animals and plants, medicine, computer programming, and designing things like machines.

10. Please indicate the extent to which you agree or disagree with each of the following statements. ***Select ONE in each row.***	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
10.1 Science is something I get excited about.	○	○	○	○
10.2 I like to take things apart to learn more about them.	○	○	○	○
10.3 I like to participate in science projects.	○	○	○	○
10.4 I'd like to get a science kit as a gift (for example, a microscope, magnifying glass, a robot, etc.).	○	○	○	○
10.5 I like to see how things are made (for example, ice-cream, a TV, an iPhone, energy, etc.).	○	○	○	○
10.6 I like to watch programs on TV about nature and discoveries.	○	○	○	○
10.7 I am curious to learn more about science, computers or technology.	○	○	○	○
10.8 I like to work on science activities.	○	○	○	○
10.9 If I have kids when I grow up, I will take them to a science museum.	○	○	○	○
10.10 I would like to have a science or computer job in the future.	○	○	○	○
10.11 I want to understand science (for example, to know how computers work, how rain forms, or how airplanes fly).	○	○	○	○
10.12 I enjoy visiting science museums or zoos.	○	○	○	○
10.13 I get excited about learning about new discoveries or inventions.	○	○	○	○
10.14 I like reading science magazines.	○	○	○	○
10.15 I pay attention when people talk about recycling to protect our environment.	○	○	○	○
10.16 I am curious to learn more about cars that run on electricity.	○	○	○	○
10.17 I get excited to find out that I will be doing a science activity.	○	○	○	○
10.18 I enjoy reading science fiction books.	○	○	○	○
10.19 I like learning about science on the internet.	○	○	○	○
10.20 I like online games or computer programs that teach me about science.	○	○	○	○

Please continue…

Almost done!

10. Please indicate the extent to which you agree or disagree with each of the following statements. (CONTINUED) ***Select ONE in each row.***	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
10.21 Science is boring.	○	○	○	○
10.22 I do science-related activities that are not for schoolwork.	○	○	○	○
10.23 I like science.	○	○	○	○
10.24 Science is one of my favorite subjects.	○	○	○	○
10.25 I take science only because I have to.	○	○	○	○
10.26 I take science only because it will help me in the future.	○	○	○	○
10.27 Before joining this program, I was interested in science and science-related things.	○	○	○	○
10.28 Before joining this program, I participated in science activities outside of school.	○	○	○	○
10.29 I like to design a solution to a problem.	○	○	○	○
10.30 I like to be part of a team that designs and builds a hands-on project.	○	○	○	○
10.31 I'm curious to learn how to program a computer game.	○	○	○	○
10.32 I like to design and build something mechanical that works.	○	○	○	○

Thanks for taking the time to complete this survey!

Return your completed survey to your instructor.

Paperwork Reduction Act Statement - This information collection meets the requirements of 44 U.S.C. § 3507, as amended by section 2 of the Paperwork Reduction Act of 1995. You do not need to answer these questions unless we display a valid Office of Management and Budget control number. The OMB control number for this collection is 2700-0150, expiration 8/31/2015. Return your completed survey in the self-addressed stamped envelope. We estimate that it will take about 5 minutes to read the instructions, gather the facts, and answer the questions. *You may send comments on our time estimate above to*: by email to HQ-OEIDAdmin1@mail.nasa.gov or by mail to NASA Office of Education, 4U18, 300 E Street SW, Washington, DC, 20546-0001.

NASA Privacy Policy - This notice provides NASA's policy regarding the nature, purpose, use and sharing of any information collected via this form. The information you provide on a NASA-issued form will be used only for its intended purpose, which is to improve NASA's Summer of Innovation program based on participant feedback. Your responses will be made anonymous and aggregated for review by the Summer of Innovation program management. NASA will protect your information consistent with the principles of the Privacy Act, the e-Government act of 2002, the Federal Records Act, and as applicable, the Freedom of Information Act. Submitting information is strictly voluntary. By doing so, you are giving NASA (and its designated representatives**)** your permission to use the information for the intended purpose. If you do not want to give NASA permission to use your information, simply do not provide it. However, not providing certain information may result in NASA's inability to provide you with the information or services you desire. For additional information please visit NASA Privacy Policy and Important Notices at http://www.nasa.gov/about/highlights/HP_Privacy.html.

APPENDIX F STEM ATTITUDES SURVEY POSTTEST

STEM Attitudes Survey (POSTTEST)

National Aeronautics and Space Administration

You recently participated in a NASA educational activity. To improve this activity for the future, all youth who participated are being asked to complete a survey. There are no "right" or "wrong" answers to any of the questions. We want your honest opinions. It should take about 6 minutes to complete the questions. Thank you very much for your help!

NASA and its research team follow strict rules to make sure that only they will see your answers to this and future surveys for this activity, except as required by law. No report will use your name or describe you in any way that could identify you.

If you wish to participate in this survey, please continue. Return your completed survey to your instructor.

Tell NASA about yourself.

1. Your first name: ______________________ Your last name: ______________________

2. What is your birthday (MM/DD/YYYY)? [ ]

3. What grade did you enter last fall 2014?

   ○ 5th ○ 6th ○ 7th ○ 8th

Tell NASA about your experience.

For questions 4 through 6, please respond in whole sentences.

4. What did you like best about this NASA activity?

5. If you were in charge, how would you change your NASA experience?

6. Would you recommend that your friends participate in this NASA activity? ○ Yes ○ No
   Please explain why or why not.

7. How much did participating in this NASA activity impact you?	**Not At All**	**Slightly**	**Moderately**	**A Great Deal**
7.1 Increased my knowledge of NASA and space.	○	○	○	○
7.2 Increased my interest in studying science or engineering in college.	○	○	○	○
7.3 Helped me understand science better.	○	○	○	○
7.4 Led me to a better understanding of my own career goals.	○	○	○	○
7.5 Made me decide to take different classes in school (including college) than I had planned.	○	○	○	○
7.6 Made me more confident in my ability to succeed in science.	○	○	○	○
7.7 Increased my confidence in my ability to participate in science projects or activities.	○	○	○	○
7.8 Helped me connect with others who have similar interests.	○	○	○	○

Tell NASA about your science activities in and outside of school.

8. What science class did you most recently take? This might be the class you are currently taking.

○ Science or General Science
○ Life Science
○ Earth Science
○ Physical Science
○ Integrated or Coordinated Science
○ Other science course
○ I don't know
○ None → ***(If None, skip to #10.)***

9. How much do you agree or disagree with the following statements about your most recent science class?	**Never**	**Rarely**	**Sometimes**	**Often**
9.1 I enjoyed this class very much.	○	○	○	○
9.2 I thought this class was a waste of my time.	○	○	○	○
9.3 I thought this class was boring.	○	○	○	○

10. Which of the following activities did you participate in during your most recent school year? This might be the current school year. *(Mark all that apply.)*

○ Science club
○ Science competition
○ Science camp or after-school activity, not including a NASA activity
○ Science study groups or a program where you were tutored in science
○ None of these

11. Since you began participating in the NASA activity, how often have you done the following science activities?	**Never**	**Rarely**	**Sometimes**	**Often**
11.1 Read science books and magazines.	○	○	○	○
11.2 Access websites for computer technology information.	○	○	○	○
11.3 Visit a science museum, planetarium, or environmental center.	○	○	○	○
11.4 Play games or use kits or materials to do experiments or build things at home.	○	○	○	○
11.5 Watch programs on TV about nature and discoveries.	○	○	○	○

Tell NASA your opinions about science.

The next series of questions contain a number of statements about science. You will be asked what you think about these statements. There are no "right" or "wrong" answers. We just want your opinions. For this survey, the word "science" covers a broad range of topics, including space and planets, animals and plants, medicine, computer programming, and designing things like machines.

12. Please indicate the extent to which you agree or disagree with each of the following statements. ***Select ONE response in each row.***	**Strongly Disagree**	**Disagree**	**Agree**	**Strongly Agree**
12.1 Science is something I get excited about.	○	○	○	○
12.2 I like to take things apart to learn more about them.	○	○	○	○
12.3 I like to participate in science projects.	○	○	○	○
12.4 I'd like to get a science kit as a gift (for example, a microscope, magnifying glass, a robot, etc.).	○	○	○	○
12.5 I like to see how things are made (for example, ice-cream, a TV, an iPhone, energy, etc.).	○	○	○	○
12.6 I like to watch programs on TV about nature and discoveries.	○	○	○	○
12.7 I am curious to learn more about science, computers or technology.	○	○	○	○
12.8 I like to work on science activities.	○	○	○	○
12.9 If I have kids when I grow up, I will take them to a science museum.	○	○	○	○
12.10 I would like to have a science or computer job in the future.	○	○	○	○
12.11 I want to understand science (for example, to know how computers work, how rain forms, or how airplanes fly).	○	○	○	○
12.12 I enjoy visiting science museums or zoos.	○	○	○	○
12.13 I get excited about learning about new discoveries or inventions.	○	○	○	○

Please continue…

Almost done!

12. Please indicate the extent to which you agree or disagree with each of the following statements. (CONTINUED) *Select ONE in each row.*	Strongly Disagree	Disagree	Agree	Strongly Agree
12.14 I like reading science magazines.	○	○	○	○
12.15 I pay attention when people talk about recycling to protec our environment.	○	○	○	○
12.16 I am curious to learn more about cars that run on electricity.	○	○	○	○
12.17 I get excited to find out that I will be doing a science activity.	○	○	○	○
12.18 I enjoy reading science fiction books.	○	○	○	○
12.19 I like learning about science on the internet.	○	○	○	○
12.20 I like online games or computer programs that teach me about science.	○	○	○	○
12.21 Science is boring.	○	○	○	○
12.22 I do science-related activities that are not for schoolwork	○	○	○	○
12.23 I like science.	○	○	○	○
12.24 Science is one of my favorite subjects.	○	○	○	○
12.25 I take science only because I have to.	○	○	○	○
12.26 I take science only because it will help me in the future.	○	○	○	○
12.27 Before joining this program, I was interested in science and science-related things.	○	○	○	○
12.28 Before joining this program, I participated in science activities outside of school.	○	○	○	○
12.29 I like to design a solution to a problem.	○	○	○	○
12.30 I like to be part of a team that designs and builds a hands on project.	○	○	○	○
12.31 I'm curious to learn how to program a computer game.	○	○	○	○
12.32 I like to design and build something mechanical that works.	○	○	○	○

Thanks for taking the time to complete this survey!
Return your completed survey to your instructor.

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APPENDIX G DOS RUBRIC AND GUIDE

Dimensions of Success (DoS) Observation and Scoring Rubric

DIMENSIONS

Features of the Learning Environment:

- Organization
- Materials
- Space Utilization

Activity Engagement:

- Participation
- Purposeful Activities
- Engagement with STEM

STEM Knowledge and Practices:

- STEM Content Learning
- Inquiry
- Reflection

Youth Development in STEM:

- Relationships
- Relevance
- Youth Voice

SCORING

All dimensions are scored on a scale of 1 to 4.

- 1 = Evidence is absent
- 2 = Inconsistent evidence
- 3 = Reasonable evidence
- 4 = Compelling evidence

RUBRIC

Features of the Learning Environment	
• Organization……………………………………	
• Materials……………………………………	
• Space Utilization……………………………………	
Activity Engagement	
• Participation……………………………………	
• Purposeful Activities……………………………………	
• Engagement with STEM……………………………………	
STEM Knowledge and Practices	
• STEM Content Learning……………………………………	
• Inquiry……………………………………	
• Reflection……………………………………	
Youth Development in STEM	
• Relationships……………………………………	
• Relevance……………………………………	
• Youth Voice……………………………………	

Dimensions of Success (DoS) Observation and Scoring – Examples of Compelling Evidence (Scores of 4)

Organization

- All necessary materials are available
- Transitions are smooth
- Time used effectively, with minimal time loss
- Flexibility IF need arises

Materials

- Materials used are APPROPRIATE and APPEALING
    - Appropriate: culturally sensitive, developmentally appropriate, supportive of STEM learning goals, safe
    - Appealing: interesting and/or varied
- Materials *may* offer multiple ways of interacting with STEM content – physical models, diagrams, computer simulations, and video

Space Utilization

- The space is used in a way that is conducive to STEM learning in an out-of-school time (OST) environment (i.e., different from a formal, teacher-directed set-up).
- The space is appropriate for all aspects of the STEM activity being enacted (e.g., there is enough room to move around, there are appropriate areas/conditions to work with particular materials, etc.)
- Distractions are minimal, and do not divert students' attention or detract from their overall experience during the STEM activity

Participation

- Focuses on the extent to which students are participating in the activities
- Refers to explicit participation ONLY and not to engagement in STEM thinking or reasoning or inquiry practices
- Are all students participating or just a subset of students?
- Students are following directions and completing the activities as guided by the facilitator
- Students are not participating if they are zoning out, walking around the room, talking/distracting other students, etc.
- Does the facilitator have to prompt students to participate or does the design and implementation secure participation throughout?

Purposeful Activities

- The activities are structured so students understand the purpose and goals of the activity
- The activity goals are structured to support a cohesive focus on a concept or set of related topics in STEM
- The facilitator uses time productively to support STEM learning goals
- It matters what is SEEN, not what is PLANNED
- Are all parts of the activity purposeful?
- Purpose doesn't have to be explicitly stated

Dimensions of Success (DoS) Observation and Scoring – Examples of Compelling Evidence (Scores of 4)

Engagement with STEM

- Students have opportunities to engage in hands-on activities
- Students take an active role in their learning – they are doing the cognitive work instead of letting the facilitator do all the exploring/thinking about STEM content
- The hands-on activities must help students understand particular STEM content instead of just providing them with superficial experiences to disconnected facts or "STEM-like" topics (hands-on, minds-off)
- Are the students' minds on STEM or a side activity/goal?

STEM Content Learning

- The facilitator presents STEM content accurately
- Facilitator makes connections across content ideas to deepen students' understanding of concepts
- Students comments and questions indicate that the activities support their understanding of the content
- Students have opportunities to apply their knowledge beyond superficial memorization/repetition
- Is the facilitator correction student misconception / leading them in the correct direction or letting them go on without having correct information?
- When students leave the room, do they know what they just did?

Inquiry

- The activities provide opportunities for students to engage in STEM practices – such as making observations, modeling, asking questions, conducting investigations, analyzing data, and constructing explanations
- Students participate in STEM practices in authentic ways to pursue scientific questions, address a design problem, collect data, etc.
  - Students are not just superficially going through the motions of inquiry
  - Students are not simply following direction or a step-by-step lab
- Are students behaving like STEM professionals?
- Are STEM experiences AUTHENTIC?
  - Authenticity is based on age appropriate standards
  - Students are using inquiry not being given step-by-step instruction

Reflection

- Activities support explicit reflection on the STEM concepts in which students have engaged
- Refers to the degree to which the quality of student reflections are superficial or meaningful, and connection-building
- Is the facilitator asking questions merely to get the right answer or is there sustained reflective activity?
- Is there depth of reflection?
  - Facilitator provides purposeful prompts and questions to encourage students to make sense of what they are doing
  - Students make meaningful connections between activities they participate in and larger STEM concepts

Dimensions of Success (DoS) Observation and Scoring – Examples of Compelling Evidence (Scores of 4)

Relationships

- Facilitator has positive relationships with the students (and other facilitators, if applicable)
    - Facilitator is not cold/procedural, with a flat affect and no interpersonal connections
    - Facilitator is not just there to instruct
- Students have positive relationships with each other.
    - Students are cooperative and share materials and ideas
    - Facilitator makes eye contact when speaking to students
    - Respectful interactions
    - Students listen to each other and take turns
    - Facilitator makes an effort to address students by their names
    - No criticism or judgments/disrespectful sarcasm

Relevance

- Activities make connections with students' lives, personal experiences, other subject areas, or larger STEM issues
- Activities help students link STEM concepts to careers and community concerns
- The rubric considers the extent to which both the facilitator and students make these "real world" connections

Youth Voice

- The activities encourage students to voice their ideas, concerns, and opinions to each other and/or the community
- Students can make important and meaningful choices within acceptable facilitator-defined limits
    - Students have the opportunity to share their ideas outside of the program to school/community members. (Reminder: this is an example of compelling evidence/ a score of 4.)

APPENDIX H IN DEPTH INTERVIEW MODERATOR GUIDE

Introduction

Paragon TEC was contracted by NASA and the Department of Education to conduct an evaluation of NASA STEM Challenges in 21 CCLC classrooms. Part of the evaluation will assess how NASA can improve training and support materials for 21CCLC sites to implement NASA Challenges. So, our interview questions today focus on how your site utilized NASA training and materials and your suggestions for improving NASA's training and support. This aspect of the evaluation is not an assessment of your site or your instruction, or of the overall program impact. In addition, this interview is voluntary. You can skip any questions you do not want to answer.

At the end of this evaluation study in July, we will be writing a report for NASA. We will be summarizing all of the interview responses from our site visits in this report; however, we will not disclose any names or connect your responses to your specific site. Today, we will be taking notes during our conversation. To ensure accuracy, we would like to record this conversation. The recording will be deleted after we have summarized your responses. Are you okay with us recording the interview? Do you have any questions?

About 21CCLC Site and involvement with 21CCLC

1. What are your site's objectives around STEM programming?

2. Tell me a little bit about your involvement with 21 CCLC and the NASA STEM Challenge:
   a. How long have you worked with 21 CCLC and in what capacity?
   b. How were you involved in the NASA STEM Challenge?
      i. Did you work on a NASA Challenge with your students?
      ii. If yes, was this the first time you worked with students on STEM?
         1. Were you comfortable with your role?

3. What types of math, science, and technology programs did this site provide in the past two years besides the NASA STEM Challenge program?
   a. Who provided the programming / funding / instruction for these other STEM programs?
   b. What did students do in these other programs? Were there hands-on activities? Was it in the format of in-school instruction or more formatted for afterschool instruction?

4. How does the NASA STEM Challenge program differ from past STEM programming implemented at your site?

Utilization of NASA Training

5. Now I'd like to ask about who attended the NASA in-person training from your site.
   a. Did you attend the NASA in-person 1-day training?
      i. Did you participate in any Live Webinar trainings?
      ii. Did you access any On Demand Video Trainings?

b. Did someone else from the site attend the in-person training? If yes, who?
    i. Do you know if other members from your site attended Webinars or accessed On Demand Video trainings?

[If "NO"to 5a, skip to #11.]

6. What knowledge or skills did you gain from the training? (e.g., engineering design; design process; content information; how to use a Klew Chart; how to debrief and encourage students to reflect on learning; instructional techniques that you will use going forward? Access to resources or how to use any resources?)

7. In what ways, if any, did the training(s) make you feel more comfortable and confident with:
    i. the materials and resources provided?
    ii. the implementation of the Challenge?
    iii. supporting other instructional staff to implement the project?

8. What was missing from your training(s) (e.g., instructional practices; student issues that you didn't expect)?

9. What do you wish was done differently?

10. Did everyone who worked on the NASA STEM Challenge receive in-person training?
    a. If not, what percentage of those who worked on the Challenge received the in-person training?
    b. If everyone did not receive in person training, did everyone who worked on the Challenge receive training from someone who attended the in-person training? Or did they attend Webinars or access On Demand Video trainings?

--- ----------------------------- ---------------------------

11. Did you provide training to anyone?
    a. If yes, who did you provide training to?
    b. Please describe the training you provided. How many instructors were trained? How long was their training? Where were instructors trained? How many times was the training offered?
    c. What percentage of instructional staff received this training?

12. Do you feel that not having everyone attend the in-person training altered the impact of the Challenge implementation?

13. What were the challenges to having instructors participate in the in-person training or Webinar trainings?

----------------------- ---------------------------------- --

[*14-17 only for those who did not attend in-person training.*]

14. Since you did not attend the in-person training, did you receive training from a person at your site that DID attend the in-person training?
    a. If yes, please describe what you learned.

15. In what ways, if any, did this training make you feel more comfortable and confident with:
    a. the materials and resources provided?
    b. the implementation of the Challenge?
    c. supporting other instructional staff to implement the project?

16. What did you feel was missing from your training (e.g., instructional practices)?

17. What do you wish was done differently?

Utilization of NASA support materials and NASA Subject Matter Experts

18. How did your site use NASA's support materials? (e.g. the Help Desk, the Manuals, the Y4L website, step-by-step instructional guides; professional development opportunities; webinars, Discussion Board; eBlasts)
    a. What are your perceptions of the accessibility of these materials?
    b. What did you think about the content (Was it easy to understand? clear? inclusive? Useful? … In what ways?)

19. How did your site use NASA scientists and/or engineers, also known as subject matter experts or SMEs?
    a. What value did you see in having access to NASA SMEs?
    b. How did interactions with NASA SMEs help students or instructors working on the NASA Challenge?
    c. What would have made the SMEs more helpful?

Implementation of NASA Challenge

20. Describe how you implemented NASA Challenge.

    a. When did you start implementation?
    b. How many classrooms implemented the NASA Challenge?
    c. Who are the students who worked on the NASA Challenge? (e.g., Did they volunteer? Were they selected? (If so, what were the criteria?) Were they pulled from other afterschool programs?
    d. Did you have a different number of students start the program versus the number of students ending the program?
        i. If yes, do you know why students stopped attending the program? Why?
    e. How many total hours did the students work on the NASA Challenges?
    f. Can you give an overview of what the students did?
        i. Which Challenge did they work on? (Parachuting onto Mars; Spaced out Sports; Radiation Exploration Challenge; Why Pressure Suits?; Packing up for the Moon; Crew Exploration Vehicle (CEV) Design)
        ii. How was the Challenge chosen?
    g. What about the instructors? What were they typically doing?

21. How would you describe students' engagement with NASA Challenge?

   a. Were there a subset of students that were usually participating or were all students participating?
   b. Were students following instructions from the facilitator or often leading themselves or helping one another?
   c. Did the facilitator often prompt students to get back on task or were students usually interested in the task?
   d. Was there frequent use of hands-on opportunities?
   e. Did you see the students in a hands-on, minds-on frame of mind?
   f. When the students left the room for the day, could they have connected what they were doing to STEM or were they focused on the activities they were completing? (e.g., "we cut out cardboard squares and measured," or "we're cutting out materials so that we can make a weather vane to go outside and look at wind speed.")
   g. Were students behaving like STEM professionals? [i.e., making observations, modeling, asking questions, conducting investigations, analyzing data, constructing explanations, etc.]

22. Now, I'd like to share your DoS observation with you. This is the information that was collected from your classroom session earlier in April. *[Share Dimensions of Success observation notes]*.
    a. How does this compare with your curriculum and lesson plans and your experiences with the students?

23. What would you say are the main reasons for student engagement or lack of engagement?

    a. How was the NASA Challenge relevant for students?
    b. Does your site practice inquiry-based learning regularly? (i.e. less step by step teacher instruction; more focused on student's ideas and allowing students to take direction and lead where a lesson will go.) What knowledge did you or your facilitators already have about how to facilitate inquiry based learning?

24. Now, I am going to list some of the instructional suggestions the NASA materials suggested to incorporate in your instruction. Please tell me if each of these suggestions was helpful in implementing the NASA STEM Challenge.
    a. Choose an open ended question. [extremely helpful? Not at all helpful to the Challenge goals? Why did you say ____? Was this difficult to use with your students?]
    b. Take students out of their comfort zone, and provide process to work on problem solving. [PROBE]
    c. Providing safe environment where students can make mistakes. [PROBE]
    d. Choose reasonable challenge. [PROBE]
    e. Keep journal of student questions. [PROBE]
    f. Model problem solving process. [PROBE]
    g. Ask what they learned, what they might change. [PROBE]

25. How do the qualifications and experiences of instructional staff affect the implementation of the Challenge?
    a. What <u>qualifications</u> do you think are most important in an effective facilitator?
    b. What <u>characteristics/experiences</u> do you think are most important in an effective facilitator?

Alignment with 21CCLC objectives and needs

26. How did the NASA STEM Challenge support your 21CCLC center's STEM programming objectives?
    a. How did participating in the Challenge improve the capacity of your center to implement STEM programming?

27. When you were asked to implement the NASA STEM Challenge, what needs did your center have? (i.e. technology concerns, staffing concerns, content experts)

    a. Did NASA training, support materials, and access to NASA SMEs satisfy these needs?

Improvement suggestions

28. How can NASA's training be improved?

29. How can NASA's materials be improved?

30. How can the access to NASA SMEs be improved?

APPENDIX I STUDENT WORK ASSESSMENT RUBRIC

Student Work Assessment Rubric

The categories below represent the 8 steps of the Engineering Design Process. Scores for each category will be based on the scale below and will reflect the extent to which the listed criteria are met.

Instructions: Read the scoring guidelines and criteria for each category prior to watching the student videos. Once you are familiar with the coding system, watch the video and rate each category based on what is presented. Then, watch the video one more time to ensure that you did not miss anything. Adjust ratings as needed. Send ratings via e-mail to Dr. Melissa Abadi at mabadi@pire.org.

Rubric Scoring Guidelines
2 = All criteria are met.
1 = Some criteria are met.
0 = None of the criteria are met.

Rubric Categories & Criteria **Score**

Identify the Need or Problem (Step 1) _____
• The problem is identified and explained in detail in the students' own words.
• All criteria and constraints are listed/discussed and clarified.

Research the Need or Problem (Step 2) _____
• Resources were identified that help examine the need or problem.
• Conversations with SMEs were had to examine the need or problem.

Develop Possible Solutions *(Step 3)* _____
• Possible solutions are listed / discussed.
• Most promising solutions are selected.
• Most promising solutions are refined by 2-3 sketches in 2-3 dimensions.

Select the Best Possible Solution (Step 4) _____
• Strengths and weaknesses of each possible solution are discussed.
• One solution is selected, possibly including features from various designs.
• A description of why this solution was chosen is discussed.

Construct a Prototype (Step 5) _____
• List of materials and tools is prepared.
• Procedures are prepared and followed.
• A full-size or model is constructed in 2-3 dimensions.

Test & Evaluate the Solutions (Step 6) _____
• Models are tested for effectiveness in solving the problem. (talked about angles tested)
• Data is collected as evidence for success or for need of improvement.
• Results are repeated in additional trials.

Communicate Solutions/ Findings (Step 7) _____
• Presentation is very well-organized.
• Presentation is clearly communicated (verbally or visually) with appropriate data, sketches, or graphs.
• Presentation highlights all team members' contributions.

Redesign (Step 8) _____
• Modifications to the presented solutions are considered based on what was learned.
• Students review the original need to make sure suggested future modifications meet criteria.

TOTAL (out of 16 pts possible) _____

1

APPENDIX J CASE STUDY SUMMARIES

FORMATIVE EVALUATION CASE STUDIES

This document contains summaries of the six qualitative case studies conducted at each of the site visits for the NASA 21CCLC Study. Please note that the names of these sites have been replaced with pseudonyms and identifying information has been removed to preserve anonymity.

SITE: JEFFERSON

The Site and Facilitators

As a 21CCLC, the site has few afterschool opportunities (about 60-70 students participate) because students cannot stay after school due to a dangerous neighborhood and religious restrictions of some students. The STEM objective for the site is to provide opportunities and hands on activities to students to engage in learning in mathematics, technology, engineering and science in order to improve student achievement. The site follows state academic guidelines and Common Core in teaching mathematics and science. STEM has just recently been introduced to the school. LEGO robotics was also introduced during the 2014-15 school year and is taught afterschool to a small group of students by the NASA STEM Challenge facilitator. Funding for previous programs has come from 21 CCLC, at-risk funds, and the general budget.

The Jefferson NASA STEM Challenge staff was comprised primarily of two individuals – with one taking on the role of site coordinator and facilitator and the other working as site director. Both were comfortable with their roles on the NASA project. The facilitator had been teaching science for more than 15 years and teaching at the site for two years. The facilitator did not have a role with the site as a 21 CCLC. The site was encouraged to participate even though they could not complete the NASA STEM Challenge as an afterschool program due to the structure of the school and a lack of a qualified afterschool facilitator.

Regarding capacity, the site is technologically advanced when compared with most schools. However, the director believes that the NASA STEM Challenge has opened doors for more intensive in-school and afterschool STEM programming given how well the students responded to the Challenge.

NASA Training

The facilitator and site director attended the 1-day, in-person, NASA training. The facilitator believed the training was too long and the second half was unnecessary. With his science and education background, he believed there was no need to walk through multiple Challenges; the description and explanation involved in walking through one Challenge was enough. Instead, he believes the time should have been used to walk through the paperwork requirements of the site coordinators and the facilitators and the video requirement for the students. In addition, the facilitator believed the training should have focused on the facilitator implementation manual and the evaluation manual rather than going through the student manual three times. It seemed to him like the evaluation component was added on to what teachers originally agreed to participate in. He was also turned off due to other participants' lack of engagement in the training. Many adults seemed bored and some were searching the internet and not paying attention.

The facilitator is extremely comfortable with inquiry, the Engineering Design Process (EDP), and hands on science activities. He has also included this type of instruction in his classroom since teaching at Jefferson and believes his students are comfortable with being given an open-ended lesson plan where they problem solve on their own. He also has interest in using the curriculum going forward.

The Packing up for the Moon Challenge was selected by the facilitator because it was easy to incorporate into 8th grade state Earth science curriculum, and he believed it would be the most challenging for his students. He wanted his students to struggle and achieve. There were times that he thought it was too hard, but the students got through it, and "it was serious science and problem solving."

Apart from the training, the facilitator joined approximately four Live Webinar trainings related to Packing up for the Moon. It was his first experience with Webinars and he was excited to have that as part of the training. The facilitator also accessed On Demand Video trainings, and thought the Y4Y website was phenomenal. The calendar was slightly challenging and weather forced the site to cancel their scheduled Virtual SME Connection. Due to the Challenge being facilitated during the day, students were never able to complete a later Virtual SME Connection, and this was the largest disappointment for the facilitator. Additionally, the timeline forced the facilitator to have the students continue working on their Challenge rather than participating in follow-up Webinars. The facilitator did show the On Demand Videos to students when there were relevant questions that videos could answer. NASA Technical staff was excellent to work with, and the facilitator hoped that he would be able to have some kind of feedback for his students, congratulating them on finishing or doing a brief Q&A so that his students would be able to participate in the Webinar element of the Challenge. The facilitator was comfortable with technology and rarely utilized the Help Desk. Students did use the Y4Y website often. He did not use project Discussion Boards. He thought there were too many eBlasts and weekly emails. Emails looked unorganized and were frequently stating or restating details. Additionally, sites did not have a detailed calendar of all available SME dates, etc., which would have been very helpful. All responses were quick, if the facilitator asked a question, someone would respond on both the implementation and evaluation teams.

The facilitator did not revisit the instruction manual after learning the material himself. He did not follow the suggested instruction apart from the Introduction. He taught the material according to his methods of inquiry teaching.

NASA Challenge Implementation

In terms of the NASA STEM Challenge, the program was introduced to students during a two-day introduction. Because the site implemented the Challenge during the school day, all students participated. The 46 students, primarily 7th and 8th graders, were divided into 15 teams of four or five and completed the Challenge at their own pace. Five of the teams were able to submit their videos by the April 30th deadline. The socio-economic status (SES) of the participants ranges from lower to middle income. Students' science grades ranged from low to high, also.

The challenge began in February after the two-day introduction. Once the challenge started, students spent roughly 5 hours per week working in their groups, which the facilitator randomly generated using a computer program. The facilitator estimates they spent 27 hours working on the Challenge. He felt he could have taught the curriculum for another month if he wanted to go into detail with all the concepts. He does not believe the suggested timeline in the manual is reasonable for the Packing for the Moon Challenge. The timeline played a role in causing the facilitator to skip Virtual SME Connections and caused him to rush the student video production process. He also assigned homework to students so they would be ready to answer the next day's problems. Additionally, the video process took longer than anticipated. While the students used daily journals due to facilitator request, it was hard for students to complete paperwork at the right time. For example, they might redesign the prototype before they sketched possible solutions. The facilitator would follow their thought process and ask questions but not always make them complete all of the EDP steps on paper. In addition, some students could talk about what they did to each other but it was hard for them to describe what steps of the EDP were completed with each decision they made. Additionally, the facilitator had most of the students for two years and students understood inquiry. The 6th grade students were more likely to get frustrated with the Challenge process due to inexperience with the inquiry process.

The facilitator did not follow the suggested instruction of the implementation manual, but had students complete journals and engage in reflection in order for the students to track their progress. In addition, students had regular access to tablets during class and were accustomed to asking questions and using the internet to help find answers to their questions and the teacher's questions. The facilitator also regularly taught students how to sort through information to find facts. Facilitators and students were unable to participate in a SME (subject matter expert) session, therefore, rather than ask the SMEs, he had his students write down questions and find the answers themselves.

Students were described as highly engaged and completely engulfed. Many of them were excited to start class and waited outside of the classroom door daily to continue their work from the day before. Moreover, students were engaged throughout the entire Challenge, according to the facilitator. He was surprised how engaged they were but has high expectations for this students. The facilitator generally talked and taught early in the process, however, he was rarely talking for more than 10 minutes after the Challenge was a few weeks in. Overall, he felt that the skills (e.g., teamwork, problem solving, critical thinking, reflection, management, ability to make mistakes) obtained during the NASA STEM Challenge are valuable for kids living in the area. According to the facilitator:

> The Challenge makes students think. There is no right and wrong answer. No two teams had the same problem, and they had to work in groups and learn how to work together. This age group normally does not talk through problems – they choose to use violence – and this program encourages teamwork and problem solving, it is very relevant to their lives.

It worked very well in the classroom environment and the facilitator would like to do it again with his 8th graders next year. He believes engagement was not driven by grades, but students were interested in the competition aspect of the Challenge. The facilitator did not grade final products but did spot checks and assigned homework. He cannot fully explain why they were so excited and engaged the entire time.

Suggested Improvements

The site had a number of suggested improvements for the NASA STEM Challenge going forward. At the training and in the facilitator manuals, Challenges should be listed according to difficulty and according to the number of hours required to complete each Challenge. Requirements bare minimum and also added topics that could go into teaching the Challenges would also help facilitators make decisions about how to choose which Challenge they should implement with their students. For example, with regard to the Packing for the Moon Challenge, lessons for teaching about water, teaching about soil science, and teaching about meteors could be added to required content. Also, a list of adaptations that could be added or removed for making the Challenge appropriate for 6th versus 8th grade students, for example, could be added to the manuals.

The content that was missing from the student manual was the concept and importance of "scale." The Packing for the Moon manual did not enforce the importance of the concept, in his opinion. The site staff also believe that the program should be implemented at the beginning of the year so that it does not run into state testing in May. Implementing at this time would get kids excited at the beginning of the year about school and learning, and excited about STEM. The tone would be set at the beginning of the year for "self-learning" and inquiry. The facilitator also believes this could easily be implemented during class rather than afterschool in schools like Jefferson, where afterschool activities are not an option and where students need STEM experiences. He thinks teaching this afterschool would be difficult due to time requirements, while it fit perfectly with state curriculum, and allowed for months of class time to be used, and covered a variety of science concepts.

The site would also like a better introduction to the program and Challenge. The facilitator suggested a field trip that could introduce the Challenge. Inner-city students do not get the chance to see science professionals. Alternatively, an initial session where students meet the engineers, through a Virtual SME Connection, could introduce the NASA Challenge to students...

Related to paperwork, the facilitator believes that the students should complete daily logs and tell NASA what they are actually doing. Since students are all at different stages when working on the Challenge, it is more beneficial to hear from them rather than the instructor. In addition, the daily log would prepare them to talk through the EDP, explaining where they are in the Challenge and what they have done so far, preparing them for the video process.

With regard to experienced facilitation – content should be easy for science teachers. However, the facilitator believed that in order to effectively facilitate this type of lesson, the teacher has to understand how to teach this method. “If you can’t think this way, you’re going to have a hard time convincing somebody else to think this way.” A training on this type of instruction might be very helpful – one that trains on the process and the way of thinking. For example, during the initial training, the training can be focused on inquiry, not on step-by-step instruction, and Challenges can be introduced to facilitators in that way.

DoS Observation

During the Dimensions of Success Observation that occurred at Jefferson, there were 19 8th grade students and one facilitator present. There was reasonable evidence or compelling evidence (scores of 3 and 4) in all 12 of the dimensions. In Features of the Learning Environment, (1) Organization and (2) Materials were highly appropriate, and (3) Space Utilization was scored a 3 due to distractions in the hallway while students were recording videos. When looking at Activity Engagement, (4) Participation, (5) Purposeful Activities, and (6) Engagement with STEM were scored high, with compelling evidence to support each dimension. When looking at STEM Knowledge and Practices, (7) STEM Content Learning, (8) Inquiry, and (9) Reflection were all scored a 4, denoting high levels of STEM Knowledge and Practices during the observation session. Finally, Youth Development in STEM includes (10) Relationships, (11) Relevance, and (12) Youth Voice. Relationships scored a 4 and Relevance and Youth Voice were scored as a 3 since there was not substantial discussion around or demonstration of relevance to students’ personal lives, and the Challenge was chosen for the students based on state curriculum.

Video Evaluation Rubric Scores

Five videos were submitted for the Jefferson site. Out of 16 possible points, the videos scored a 9, 9, 5, and 13. One video was unable to be scored due to issues with the visual element of the recording. The audio on this video followed the EDP process, but still could not be scored. These scores reflect a mixed engagement in the NASA STEM Challenge activities but also a mixed adherence to the steps outlined in the Challenge EDP. A point was also deducted for each video since there was no mention of Virtual SME Connection attendance.

- The video that scored a 9 displayed a strong design. The points that were deducted were due to students not following the video rubric/guidelines and not incorporating a few elements such as SME conversations, sketches/data/graphs, and potential redesign modifications.
- The video that scored a 9 displayed a strong prototype with solid conclusions but the process was not well explained. And the presentation was hard to follow. The problem was not identified and the EDP was not discussed.
- The video that scored a 5 displayed one prototype but no solutions were discussed. There was no mention of testing, evaluation, or redesign.
- The video that scored a 13 had a complete explanation of the EDP, along with sketches. Points were deducted for a lack of discussion of solutions and testing.

SITE: KENNEDY

The Site and Facilitators

The site objectives surrounding STEM programming at Kennedy included implementation of student-directed, project-based learning (PBL), exposing students to opportunities like NASA, and helping prepare students academically for secondary education. Instructors emphasized that students were exposed to material during the NASA STEM Challenge that was no longer part of their school-based curriculum, including engineering and technology. Prior to the NASA STEM Challenge, they implemented hands-on mathematics, science, and technology programs, including boat building, gardening, and studying Monarch butterflies. Apart from the NASA STEM Challenge, Kennedy has not implemented a STEM-based program with a structured curriculum. They normally design their own curriculums for the afterschool programs.

The Kennedy NASA STEM Challenge was comprised of persons with various professional roles, including the site director, site coordinator, a certified teacher, and a student worker (local high school valedictorian planning to study engineering in college), all of who were comfortable with their role in working with their 21 CCLC site and in their roles on the NASA project. The site coordinator and facilitator of the Challenge had been with the sites since the Fall of 2014.

Participation in the NASA STEM Challenge expanded the site's capacity. It got the attention of local high schools and local media. Parents were engaged in what their students were doing academically, and kids were energized and excited at the end of the day. Additionally, site staff feel comfortable and confident in teaching similar programs, having gained access to the NASA STEM materials and research references. They plan to implement a Lego Challenge in the summer, which they would not have included without the NASA Challenge experience.

NASA Training

One team member attended the 1-day, in-person, NASA training, and two members attended two Live Webinar trainings. The site director who attended the training shared information and materials from the in-person training with the site coordinator and facilitator. The relaying of information (e.g., manuals, hand-outs) from the site director who attended the in-person training and those who attended the webinars were the primary means through which members at the Kennedy site were trained on the NASA STEM Challenge. By attending webinars, facilitators reported that they learned the parameters and timeline of the NASA STEM objectives as well as proper documentation and tracking. Facilitators also accessed the Y4Y website videos and referred back to their manuals to get further understanding of the EDP. They did not access On Demand Video trainings specifically for facilitators and were not aware of Discussion Boards. Additionally, the director forwarded information from the eBlasts to the coordinator and facilitator; they were never contacted directly. Finally, the facilitator mentioned doing some professional development activities on the Y4Y website on the topic of generic STEM knowledge.

The site was trained on three Challenges, including the CEV, Packing Up for the Moon, and Exploration Design/Radiation Shield. All individuals felt the trainings made them feel more comfortable and confident with the materials/resources. Members communicated that although the information obtained from the training was useful, they were already familiar with the instructional techniques (e.g., Klew charts, rubric, inquiry-based learning). Facilitators and students were familiar with inquiry-based learning, though facilitators acknowledged that younger students may not be as familiar. Furthermore, it was reported that student frustrations primarily occurred due to a lack of teamwork skills rather than inquiry-based learning issues. Teams included students from multiple grades, and this made working together difficult at time. More specifically, students wanted facilitators to provide specific ideas and examples to guide their experiences. Facilitators were happy that they did not have an example product to show students because they felt that it would have influenced the students' decision making processes. In terms of educational background, one facilitator indicated that although she does not possess a degree in science, she is not uncomfortable or unfamiliar with scientific concepts; however, she reported that she did not feel comfortable or have a solid knowledge base for engineering.

Ultimately, facilitators wished that the training they received was more concise. It would have helped to have chosen a Challenge and focused solely on that manual. It would have also helped to have received the manuals first, read through the materials, and then received the in-person training or the training from the site director. Receiving the manual and the training at the same time was "a lot to digest." The facilitator was highly complementary of the manual. Since she did not attend the in-person training, she heavily relied on the manual and read it in its entirety.

NASA Challenge Implementation

In terms of the NASA STEM Challenge, the program was introduced to 30 after school students. Those interested in learning more, voluntarily signed up to participate. They started with 15 students, and the final group was comprised of four boys and four girls. There were three groups; two groups of three students and one group of two students. Two students were enrolled in 7th grade, one was in 6th, and five were in 5th. Participants were from lower income families, with some kids living in "extreme poverty." Facilitators described the students' science grades as "very mixed," but did not think any student "had a strong science background."

The challenge began on February 17th. Facilitators and students were most excited about the CEV Challenge and chose to focus on that. Students spent between 25 to 30 hours working in their groups over the span of eight weeks. Typically, students spent their time separated into groups working on their builds. Facilitators believed that they probably needed 1 ½ hours per day, two days per week or needed to add an additional day each week to spend on the Challenge since the video process took much longer than anticipated. While the students initially used their journals at the facilitator's request, the students eventually relied on their journals as a resource to breakdown each group's broader goals into a more structured, step-by-step process, which helped clarify their EDP goals. They found that the reflection process was most helpful when the students and facilitators had to decide what needed to go into the final video product, although during this process students struggled to answer "why" questions and explain their builds.

Facilitators and students were able to participate in three subject matter expert (SME) sessions. Students were able to ask questions, and facilitators believed that the SMEs left a valuable impression on the students. With regard to engagement, out of the eight students who completed the Challenge, two were identified as being present at meetings "only to participate, not to think." Overall, facilitators believed that 75-85% of the students were engaged, even more so when it came time for the students to design, test, and build their CEVs. Facilitators generally floated from one group to the next if the students were all working well with one another. During these times, facilitators also completed paperwork regarding previous meetings. Facilitators were always available and students would come to them whenever they needed to buy materials or needed to measure or weigh their CEVs. When the students needed more direction, facilitators generally spent more time with the groups. However, facilitators made efforts to maintain balance among the groups (e.g., student-led vs. more instructor interaction).

Overall, instructors felt that the skills (e.g., teamwork, application, budgeting, thinking) obtained during the NASA STEM Challenge were relevant to the students' lives, benefiting them academically, socially, and emotionally. The students learned to use a scale, determine various volumes, "learned without ever thinking about it," and became more confident than before the Challenge started. For the students who were engaged, facilitators believed they were excited to meet NASA scientists and were taking part in something creative and fun. It meant something to them. In addition, facilitators felt that it was a very different environment, learning approach, and topic than they are normally exposed to. This site is located in a fishing community and it was reiterated that most kids stay and become fishermen. This was something that expanded their worlds.

Lastly, facilitators believed that students were engaged due to a sense of accomplishment, the video final product, and feelings of pride as a result of working together as a team. They also believed that the winner of the Challenge would get a trip to Washington, DC. In addition, the facilitators and the site were planning a trip to space camp in Tallahassee for all the students that completed videos, regardless of winners. It was communicated that group dynamics changed several times during the research phase; however, at least one person within each group was focused and willing to encourage other group members to complete the project. Instructors were certain that students would be interested in future NASA STEM Challenges and expect that more students will participate who initially dropped out the first time due to "self-doubt," including those that did not originally think they had an interest in the program but were wishing they had participated by the end of the Challenge. Students also stopped participating for a number of reasons. Early on, students decided to quit during the research phase because they had not gotten to the "fun part" yet. Some students also discontinued because they disliked other students participating in the program or were involved in school related projects that took them out of eligibility for the Challenge. Volleyball and baseball also started during the Challenge. Finally, one student was forced to drop out by his parents due to his grades and he completed the Challenge on his own at home.

Suggested Improvements

The site had a number of suggested improvements for the NASA STEM Challenge going forward. In terms of training, the facilitators believe that the training could have been more concise. More specifically, they felt they received a lot of information at one time and would have been able to understand the material more easily had it been presented in smaller increments. In addition, having the opportunity to review information prior to the first Live Webinar Training would have made more sense, as facilitators did not have a lot of prior information or time to formulate questions. They also felt that the evaluation guidebook could have been more concise. Furthermore, facilitators wished that everyone involved with implementation could have attended the in-person training in Orlando, FL. Facilitators believed that they would have felt more comfortable and led to greater improvements in implementing the program had they received the in-person training. In addition, they believed the timeline was tight. It left facilitators concerned with pacing and deadlines at the beginning of the Challenge.

With regard to the Virtual SME Connections, site staff suggest giving sites a heads up on format – what should sites expect and what should sites do to prepare for SMEs. It was helpful when other sites were on the webinars, too, in cases where their students did not have many questions. This is another reason that it might have been helpful if all site staff were receiving eBlasts rather than the director forwarding information that she thought was pertinent to the facilitators.

When asked about successful attributes of high quality STEM educators, the facilitators at Kennedy emphasized that afterschool instructors must be organized and provide guidance while remaining hands off, be supportive, and be willing to question students but not suggest answers. Moreover, they must implement the curriculum in a structured manner and possess a degree in education or at least an understanding of effective classroom management, rubrics, and inquiry/reflection. “The students are supposed to figure out the process on their own so it makes it okay if the teachers are doing the same. I had feelings of “am I doing this right, should I do more?” But everyone, us, the site director, was so excited that the kids got it.”

Finally, there was a clear misunderstand about what winners of the Challenge received, how many winners there were going to be, and what was going to happen next year. The site would like better communication about all of these elements.

DoS Observation

During the Dimensions of Success Observation that occurred at Kennedy, there were three teams of 8 students and two facilitators present. There was reasonable evidence or compelling evidence (scores of 3 and 4) in all 12 of the dimensions. In Features of the Learning Environment, (1) Organization, (2) Materials, and (3) Space Utilization were all highly appropriate for STEM afterschool activities. Activity Engagement dimensions of (4) Participation, (5) Purposeful Activities and (6) Engagement with STEM were scored 4, with compelling evidence to support Activity Engagement. When looking at STEM Knowledge and Practices, (7) STEM Content Learning, (8) Inquiry, and (9) Reflection were all scored a 4, denoting high levels of STEM Knowledge and Practices during the observation session. Finally, Youth Development in STEM includes (10) Relationships, (11) Relevance, and (12) Youth Voice. Relationships and Relevance were both scored as 4 and Youth Voice was scored as a 3 since the CEV Challenge was chosen for the students.

Video Evaluation Rubric Scores

Three videos were submitted for the Kennedy site. Out of 16 possible points, the videos scored a 16, an 11, and a 14. These scores reflect a good to excellent engagement in the NASA STEM Challenge activities and understanding of the EDP.

- The video that scored a 16 displayed a strong prototype and an excellent understanding of STEM and the engineering design process. The video rubric/guidelines were followed and the presentation was well organized.
- The video that scored an 11 displayed a strong interest in the video process. They displayed an understanding of the EDP and the research process, but did not follow the video rubric or show their prototype. There were gaps when discussing solutions and data/testing.
- The video that scored a 14 had an excellent understanding of the design and redesign processes. Points were deducted based on missing detail about the build process.

SITE: MCNEEL

The Site and Facilitators

This is the site’s first year as a 21CCLC site. They are heavily focused on college and career exploration and do afterschool hands on activities around this focus. Afterschool activities are taught by teachers from the school district. The NASA STEM Challenge is the first afterschool STEM activity that is curriculum based. Prior to this year, there was no afterschool program and students were getting STEM education through the classroom only. This year they have done afterschool STEM "themes" like forensics, engineering, and space. A forensic theme, for example, would have some teachers focused on the science element, others on mathematics, and even language would focus on forensic stories.

The McNeel NASA STEM Challenge staff was comprised of three individuals with various professional roles, including a site coordinator, a facilitator, and a site director, all of who were comfortable with their role in working with their 21 CCLC site and in their roles on the NASA project. The facilitator was the only individual that had a background in science education. The other staff involved were interested in science, but did not have a solid understanding of space science. They felt comfortable with their supporting roles but would not have felt comfortable teaching STEM curriculum.

Though the site did not officially have STEM programming objectives, regarding capacity, site staff believe that the NASA STEM Challenge gave them a solid background and support structure to point to when discussing how mathematics and science relates to educational and career requirements. The Challenge also lit a spark in the students. They would be eager to participate next year, and staff feel that they could implement this curriculum or something similar with ease in the future.

NASA Training

Three individuals attended the 1-day, in-person, NASA training. The site coordinator believed the training was fun and the hands-on opportunities were great. She was not familiar with the content and with the training alone, did not grasp the content. The training allowed her to understand the process and she was happy that they had a science teacher lined up to facilitate the Challenge with the students. She walked away with a better understanding of the implementation process and the expectations. Everything was clearly laid out and she felt comfortable with the expectations for the site, the staff, and the students. She did not feel anything was lacking from the training, however, she stated that science does not easily make sense to her and the science in the training was not graspable for her. The facilitator, on the other hand, was comfortable with the content offered during the 1-day training.

Challenges offered to the site included Parachuting, Pressure Suits, and Spaced out Sports. Originally, the facilitator chose Parachuting and Pressure Suits, however, they decided on Pressure Suits and Spaced out Sports because that is what the students wanted. The facilitator was concerned because Spaced out Sports was not the Challenge that she knew much about, but she followed the enthusiasm of the students.

Apart from the training, the site coordinator and facilitator joined one Live Webinar training together, which reiterated the NASA STEM Challenge. The facilitator also accessed On Demand Video trainings, eBlasts, the Y4Y website, and referred back to the facilitator manual and materials. The facilitator was unable to utilize project Discussion Boards due to issues with the Y4Y Website. There was an issue with access to Y4Y in the beginning, but the Help Desk solved that issue. eBlasts were also not getting to the facilitator in the beginning of implementation but within a few weeks, they were being sent to all NASA site staff. While space science was not the facilitator's strongest subject, the materials gave her a solid base and the research materials, apart from the Y4Y Website, were easy to use and answer her questions.

Challenge staff and students were somewhat familiar with inquiry-based learning, though the facilitator acknowledged that students sometimes did not want to do the thinking on their own, especially after having been in school all day. Teachers in the school district are trying to increasingly incorporate inquiry style learning, but this is a recent push. However, in the opinion of the site coordinator, the NASA STEM Challenge facilitator is very comfortable with the inquiry style of teaching and incorporates it in everything she teaches.

NASA Challenge Implementation

In terms of the NASA STEM Challenge, the program was introduced to students already taking part in afterschool science activities. The socio-economic status (SES) of the participants was fairly low income. Science grades ranged from high to low, however, all of the students that persisted had a large interest in the Challenge and space science. All students are bi-lingual.

The challenge began end of January and was delayed until the beginning of February. The facilitator was focused on online trainings for facilitators when she began implementation with the students. She introduced students to the Challenge early in January and continued to remind students that the Challenge was going to begin soon. Five afterschool groups were set up prior to the Challenge implementation. 6th graders were working on the Challenge but do not attend the afterschool program on a regular basis, so they did not complete the Challenge. In addition, the facilitator mentioned that the 6th graders were frustrated with inquiry and were "not used to thinking." The 5th graders who regularly attend were the ones that the facilitator focused on, and they completed the Challenge. Since the focus was on 5th grade groups who had had less exposure to science, the facilitator was forced to take a step back and teach the scientific method.

Once the challenge started, students spent roughly 2 hours per week working in their groups. The site implemented for the full eight weeks. The facilitator would have liked more time for implementation. She felt that to implement properly, she needed more time to teach the scientific method and the inquiry process. Two technology issues arose during the Challenge. For the Pressure Suit Challenge, the site did not have a vacuum to test their designs. After multiple conversations with NASA and ED (suggested solutions: finding a physics teacher with a vacuum, a local college, checking online for a cheap option), the site still did not have a vacuum and began reaching out to site staff and parents. A parent had a food saver, which the afterschool program was able to use to test the student's pressure suits. If not for that parent, they are unsure what they would have resorted to. Additionally, the video process took much longer than anticipated. The facilitator recorded throughout the Challenge and needed to edit a lot of video. Site staff discussed video editing issues with NASA and ED and ultimately asked for assistance from a friend. The friend was able to help students edit the videos that were submitted prior to the April 30th deadline. The deadline extension was very helpful as the school was on Spring Break at the time of the original deadline.

Facilitators and students were able to participate in multiple SME (subject matter expert) sessions including a Why Pressure Suits session, a Spaced out Sports session, and a follow-up Q&A session. Students understood the "why" after talking to the SMEs. They understood why they were working on the Challenge. They understood that there were careers where similar things were worked on and problems were worked through. The Virtual SME Connections made the Challenge relevant to the students. Site staff thought the sessions were great, and the scientists talked to the students on their level without talking down to them. SMEs would get a model or show a video to clarify when the students did not understand a concept. There was only one issue with technology during an initial SME session that forced the site to miss that Webinar. They were able to reschedule and attend another one though.

The site coordinator believes the students participated fully and were leading themselves for the most part. She saw them engage with their teams and work to solve their own individual problems around their own designs. Students used a budget and focused on their builds. Instructors generally were walking the classroom and asking questions or answering questions throughout the NASA Challenge sessions. The facilitator, when asked about engagement, described her 5th graders as "all about it" while her 6th graders "didn't want to do the thinking." Overall, instructors felt that the Virtual SME Connections made an impact on the students and after attending those, the Challenge became real to them. They believed that NASA could use their designs in space by using different materials and making their models bigger. According to the facilitator, this age group loves space science but many schools no longer teach it. This Challenge brought that curriculum back and sparked or reignited that interest in her students. It gave the students new opportunities and they rose to the occasion. “It encourages intensive thinking, which these kids need.”

For the students that were engaged, the site coordinator believes that the facilitator’s enthusiasm was invaluable. The students were excited because she was excited to teach the material and always talked about the impact of this opportunity. Staff anticipate that students’ interest with future NASA STEM Challenges will be high, but timing of implementation is very important. At the McNeel site, students stopped participating for a number of reasons. Though students are supposed to commit to the afterschool program from October to June, some stop attending. In winter, it is too dark at 6:15pm, when the program ends, for many students to walk home. In addition, students stopped regularly attending the afterschool program due to snow and cold. In addition, in the spring, 6th to 8th grade students began tryouts for soccer and baseball teams. For this reason, the NASA STEM Challenge was implemented to completion with 5th graders only.

Suggested Improvements

The site had a number of suggested improvements for the NASA STEM Challenge going forward. With regard to the training, it was suggested that those without a science background would need a full day on each Challenge in order to understand the level of detail required to implement with students. For those lacking a science background, there was not enough content in the training. The site coordinator also suggested that different trainings be provided for facilitators with different levels of science experience. Still, she did not think that this program can be taught by a person without a natural inclination toward science as it is too daunting to not know all the possible questions that students could ask about. For the facilitator, it would have been helpful if there was a training on how to navigate the Y4Y website. She did not use the Discussion Board because the site was overwhelming for her.

For implementation, it would help if there was a list of recommended sites where facilitators could get Challenge-specific materials (e.g. a vacuum for the Why Pressure Suits Challenge). These materials are critical to the Challenge, but they are expensive and not easily accessible. When focusing on students, younger students needed more background, more exposure to the scientific method, and the EDP. Due to the timeline, the inquiry process was rushed, and the facilitator believes she needed more time to implement properly with 5th graders. Additionally, if NASA and ED want to be truly inclusive, materials for students need to be in Spanish. The site lost multiple students that were very interested because materials were in English only.

When looking for effective facilitators, site staff believe the individuals need to have background knowledge or have quick access to acquire background information. “You don’t know what you don’t know, and if you don’t understand the science behind it, you can’t help the kids.” In addition, patience, allowing students to fail and succeed on their own, and high enthusiasm are seen as critical characteristics.

DoS Observation

During the Dimensions of Success Observation that occurred at McNeel, there were 10 students and one facilitator present. There was reasonable evidence or compelling evidence (scores of 3 and 4) in all 12 of the dimensions. In Features of the Learning Environment, (1) Organization scored a 4 and (2) Materials and (3) Space Utilization scored a 3 – rating as appropriate for STEM afterschool activities. When looking at Activity Engagement, (4) Participation and (5) Purposeful Activities scored a 4. (6)

Engagement with STEM scored a 3 due to some elements of the activities being "minds off." When looking at STEM Knowledge and Practices, (7) STEM Content Learning, (8) Inquiry, and (9) Reflection scored 3, 4, and 3, respectively denoting moderate to high levels of STEM Knowledge and Practices during the observation session. Finally, Youth Development in STEM includes (10) Relationships, (11) Relevance, and (12) Youth Voice. Relationships scored a 4 while Relevance and Youth Voice scored as a 3 since the Challenge was related to careers but never related to student lives and since youth voice never went beyond the classroom and the Challenge.

Video Evaluation Rubric Scores

Two videos were submitted for the McNeel site. Out of 16 possible points, the videos scored a 9 and an 11. These scores reflect engagement in the NASA STEM Challenge activities but an incomplete understanding of the EDP.

- The video that scored a 9 met a number of the criteria on the video rubric due to the teacher asking questions and the students responding. There was not a strong demonstration of the EDP. However, it was clear that the students had worked on their prototype as a team.
- The video that scored an 11 displayed a strong prototype. Again, the teacher was asking questions and the students were responding. There was evidence of testing, data collection, and redesign. One team member spoke the majority of the time.

SITE: MIDDLETON

The Site and Facilitators

The site objectives surrounding STEM programming at Middleton included the administration of STEM Attitudes pre-posttest surveys, teaching stem-based curriculum, and maintaining state and local standards for mathematics and science. As a 21 CCLC, they focused on mandatory mathematics requirements and incorporated project-based learning (PBL) whenever possible, including a Robotics program and a Bridge building program. They are heavily activity based and rarely do paper or pencil activities. They had previously implemented design squad challenges to their afterschool students and were comfortable with STEM hands-on activities. 21st Century had provided prior funding for these programs, and they were instructed by other teachers and various subject matter experts.

The Middleton NASA STEM Challenge was comprised of persons with various professional roles, including the school program director, project director, and certified teachers, all of who were comfortable with their role in working with their 21 CCLC site and in their roles on the NASA project. With regard to educational background, all persons involved in the NASA project possessed or were working towards a degree in education. Despite the fact that no one had a science background, all were interested in science. Regarding capacity, facilitators believe that the NASA STEM Challenge gave them additional experience and knowledge going forward and would like to reuse the curriculum in the future.

NASA Training

Four team members attended the 1-day, in-person, NASA training. Although initial impressions of the training centered on apprehension and a lack of clarity regarding the subject matter due to feeling rushed/lack of time, once members received materials, they felt they were better able to grasp the concepts and felt the training was helpful. One team member had previously attended a 5-day NASA training and believed the one-day training would have felt more polished as a two-day training with additional hands on time. As it was arranged, it felt rushed and unfinished to her and she would have liked to have had time to complete their product. The challenges described during the training included the Radiation Challenge, Packing Up for the Moon, and CEV, all of which were pre-selected or decided for their state/site. Facilitators were unsure of why they were only allotted those three Challenges and were disappointed that they could not choose from the six options. The engaging trainers are the ones that excited the facilitators and that is largely why they chose the CEV challenge. It was the Challenge that they enjoyed the most and retained the most knowledge of. Apart from the training, the site coordinator and facilitators joined one Live Webinar training. Facilitators also accessed On Demand Video trainings, eBlasts, the Y4Y website, and referred back to their materials. They were unaware of project Discussion Boards.

All individuals felt the trainings made them feel more comfortable and confident in taking what they learned and sharing it with the students, in addition to challenging the students' thinking once the content was taught (e.g., critical thinking, requesting students to elaborate/explain their thinking, reflect, etc.). Members communicated that although the information obtained from the training (s) was useful, many were already familiar with the instructional techniques and STEM-based programs simply due to previous stem programming implemented at Middleton in the past. NASA Videos also answered questions regarding the design process and use of a Klew Chart that one facilitator had. Facilitators and students were familiar with inquiry-based learning, though facilitators acknowledged that students sometimes just want the answer and need to have something tangible before they can think or "wonder" about a larger concept.

NASA Challenge Implementation

In terms of the NASA STEM Challenge, the program was introduced to students, and those interested in learning more voluntarily signed up to participate. They started with 17 and the final group was comprised of six boys and eight girls from a mix of grades with many interests. The socio-economic status (SES) of the participants ranges from lower income to higher income. Facilitators described the SES of the participants as being "a good mix." Science grades also ranged from good to not so great, however, all of the students that persisted have a large interest in science. The challenge began the first week of February, however, a warm-up session was included to get the students to begin thinking about design processes before the actual challenge started. Once the challenge started, students spent roughly one hour per day, five days per week, for 11 weeks working in their groups. Typically, students spent their time on a stage, with their groups and materials, working on specific objectives each day. They had time to work with their group to generate ideas, in addition to seeing what other groups were doing, and asking questions. Facilitators believed that it was a good amount of time spent on the Challenge, but emphasized that they were working on it 5 hours a week. Additionally, the video process took much longer than anticipated. While the students used their journals due to facilitator request, it was hard for students and facilitators to decide what needed to go into the 3-to-5 minute video. The students could talk about what they did to each other but it was hard for them to script a video presentation. They find that they are still in the reflection process as the Challenge is concluding and the last few days will be primarily reflection.

Facilitators and students were able to participate in three SME (subject matter expert) sessions including a general session, a CEV session, and a follow-up career questions session. Students were mesmerized and NASA support staff was patient and great with all questions. Students were also encouraged to ask the SMEs questions outside of the webinars and many students took advantage of this. Of the four groups who participated in the challenge, two groups tended to be more engaged, while the other two groups required more direction to get them to participate more fully. Instructors generally floated from one group to the next depending on what activity was going on each day. Overall, instructors felt that the skills (e.g., critical thinking, reflection, leadership, ability to make mistakes) obtained during the NASA STEM Challenge are valuable, relevant, and ones that can be utilized in various settings (e.g., home, school). The teams really learned how to work together and developed a level of confidence and camaraderie that they did not have before. Additionally, the facilitators felt that they now had a much stronger relationship with the group of kids that took part in the NASA Challenge. For the students that were engaged, facilitators believe they were excited about the prize at the end. They believed they were going to win and go on a trip and be recognized. Other students were just natural leaders and were going to finish a task that they started. Instructors anticipate that students' interest with future NASA STEM Challenges will depend on a number of things, including how the program is introduced to students and whether other STEM clubs or sports are going on at the same time. Students also stopped participating for a number of reasons. Early on, students decided that it was not for them and they were attracted initially to it because it was something different. Additional students were forced to leave because the Science Fair was occurring at the same time, as were some sports. Facilitators believe that a group size of 14 was perfect for two instructors.

Suggested Improvements

The site had a number of suggested improvements for the NASA STEM Challenge going forward. In addition to extending the in-person training to two days, one area that facilitators wish was covered in their training was how to get students to better retain information in the afterschool environment. There was often a gap with knowledge retention (due to middle school aged children and also after school environment) and time was spent going back and repeating and reflecting on what had already been covered. Additionally, facilitators mentioned that some vocabulary in the training manual was not explained well enough, believing the curriculum and vocabulary should be "dumbed down a bit."

When introducing the NASA Challenge to the students, the director believes she intimidated some students by saying NASA needed their help and acknowledging this was a special opportunity. She would like to show future participants the example videos so that they can understand the final product. She thinks that would peak student interest. She also thinks that sites and students should choose their Challenge.

When asked about successful attributes of high quality STEM educators, the facilitators at Middleton pointed to passion, organization, excitement, determinedness/diligence, resourcefulness, and creativity. They believe that STEM afterschool instructors must have an interest in science but they do not need a background in science for the NASA materials. The key is to get kids excited about science.

Related to implementation and evaluation paperwork, the site coordinator would like to keep track of attendance and other project tasks in a spreadsheet rather than on a log or online.

DoS Observation

During the Dimensions of Success Observation that occurred at Middleton, there were 10 students and two facilitators present. There was reasonable evidence or compelling evidence (scores of 3 and 4) in all 12 of the dimensions. In Features of the Learning Environment, (1) Organization, (2) Materials, and (3) Space Utilization were all highly appropriate for STEM afterschool activities. When looking at Activity Engagement, (4) Participation wavered during the end of the session and was scored a 3. (5) Purposeful Activities and (6) Engagement with STEM were scored high, with compelling evidence to support Activity Engagement. When looking at STEM Knowledge and Practices, (7) STEM Content Learning, (8) Inquiry, and (9) Reflection were all scored a 4, denoting high levels of STEM Knowledge and Practices during the observation session. Finally, Youth Development in STEM includes (10) Relationships, (11) Relevance, and (12) Youth Voice. Relationships and Relevance were both scored as 4 and Youth Voice was scored as a 3 since the Challenge was chosen for the students.

Video Evaluation Rubric Scores

Two videos were submitted for the Middleton site. Out of 16 possible points, the videos scored a 12 and an 11. These scores reflect an engagement in the NASA STEM Challenge activities.

- The video that scored a 12 displayed a strong understanding of STEM and the engineering design process. The points that were deducted were due to students not following the video rubric/guidelines and not incorporating a few elements such as SME conversations, sketches/data/graphs, and potential redesign modifications.
- The video that scored an 11 displayed a strong interest and understanding of the research process with an average understanding of the engineering design process of selecting the best solution, testing and evaluating solutions, and redesign.

SITE: MYERS

The Site and Facilitators

In the 6th year as a 21 CCLC site, STEM programming at Myers serves as an enrichment program for students in an effort to expose them to mathematics, science, engineering, and technology. The site had previously implemented mathematics and reading programs for their afterschool students, which were heavily activity-based and hands-on, however, the “STEM functions just weren’t there” for those programs. The instructional format of the afterschool programs included games and creative activities. It was a data-driven process so that educators could “target where remediation was needed” in the areas of mathematics and reading to improve test scores. 21 CCLC had provided prior funding for these programs, and they were instructed by the same facilitators who implemented the NASA STEM Challenge this year. When compared to the NASA STEM Challenge, the past materials were as different as “night to day and grade school to college.”

The Myers NASA STEM Challenge staff was comprised of the site director and a certified teacher; both acted as program facilitators and were even more comfortable with their role in working with their 21 CCLC site and in their roles on the NASA project this year in comparison to last year’s NASA pilot program. They have both been with the site for between 3 to 4 years. With regard to educational background, one facilitator was a certified science teacher and the other was not.

Regarding capacity, facilitators believe that the NASA STEM Challenge gave them additional experience and knowledge pertaining to specific Challenges. However, they reported that the majority of the helpful information they received occurred in last year’s training for the pilot program. They are actively looking for opportunities to share their NASA experiences and have offered to train and assist other afterschool programs.

NASA Training

Both team members attended the 1-day, in-person, NASA training. Although initial impressions of the training in the previous year included feelings of being overwhelmed, facilitators felt more comfortable this year due to obtaining most of the foundational knowledge during the pilot. Facilitators believed that "the growing curve was larger the first time around, being introduced to the whole package and getting familiar with terminology. This year, it was more specific [in terms of] horticultural issues, moon issues, and water." Facilitators did emphasize, however, that there was still a lot of information presented in the training this year that was new, due to new Challenges. The training is difficult to comprehend if you start feeling overwhelmed, but it is invaluable and should be required for participation. It was also communicated that the pilot training was much more hands-on, and there was time to go through each Challenge since there were only three Challenges in the pilot. This year, facilitators felt there were less hands-on activities but attributed that to the fact that there were six Challenges. Both facilitators believed that it would have been better for the phase 2 Challenge if the training was spread out over the course of 1 ½ days, which would provide ample time to go through each Challenge in its entirety.

The Challenges described during the training included the Radiation Shield, Packing up for the Moon, and CEV, all of which they believed were pre-selected or decided for their state/site. Facilitators were under the impression that each state had the choice to pick three Challenges; however, they communicated that their Department of Education did not have input in selecting Challenges for the state but did inform the site that they were not able to select the Challenge that they had participated in the year before. The facilitators chose Packing up for the Moon due to its reputation as being the "most difficult Challenge" (e.g., more involvement, time requirement, difficult vocabulary). For the phase 2 Challenge, the facilitators also made the decision to do only one Challenge with all students, rather than two Challenges as they had done the year prior. Apart from in-person training, both facilitators joined five Live Webinars, which included trainings and Virtual SME Connections. They even utilized one of the Virtual SME Connections as a "family night" where parents were invited to attend. Parents loved it and immediately wanted to join! Facilitators also accessed the Y4Y website, the Helpdesk, and referred back to their manuals when they had questions. They were unaware of project Discussion Boards, Blogs, or On Demand Video trainings, but would have participated if they had known about these earlier.

Both facilitators communicated that the information obtained from the training was useful. In addition, manuals was described as helpful "because everything was black and white." The training and implementation team were very good about having everything in order and presenting the material in a clear and concise manner. In terms of Inquiry-based learning, one facilitator indicated that he generally teaches in this manner; however, he did not elaborate on whether the students were familiar with this style of learning. The facilitators have been asked to provide training to a neighboring school district and they will be using materials from the pilot and some materials from phase 2 to share the NASA Challenges with them.

NASA Challenge Implementation

In terms of the NASA STEM Challenge, the program was introduced to students in a school-wide announcement in order to grow the 21 CCLC afterschool program, and those interested in learning more voluntarily signed up to participate. To participate, students were required to have one teacher reference, which included details about character, behavior, and ability to work with others. They started with 12 students, and the final group was comprised of six boys and two girls from a mix of grades (e.g., two 8th graders; three 7th graders; three 6th graders) with many interests. Students were primarily from lower income families, with 85% of the school at poverty-level. The school is an ELL hub (English Language Learners) and has students from 30 countries, and the NASA teams reflected this diversity. Science grades varied, some students were just finishing up their science fair project, and those not as interested in science had lower science grades. The Challenge began in the beginning of March. Once the Challenge started, students spent roughly two hours per day, four days per week for six weeks working in their groups (i.e. approximately 48 hours). Typically, the students spent their time divided into two teams working on the Challenges, depending on where they were within the design process (e.g., research phase, building prototypes, etc.). In general, facilitators helped keep students focused and ensured they were on track in terms of the project timeline. Facilitators also spent the time directing and overseeing the students work. Much of the time facilitators simply re-read the problem to students and asked the problem in a variety of ways to get the students to break the larger concepts into manageable pieces. Facilitators believed that they spent a good amount of time on the Challenge, but also emphasized that they were thankful the video deadline was extended to April 30th due to the many weather interruptions they experienced.

Facilitators also reported how impressed they were with all the subject matter experts (SMEs). For example, one facilitator liked the timing of the webinars and how the SMEs presented “heavy on the knowledge at first and then presented the science behind the Challenges later on.” It also provided the opportunity for facilitators and students to interact with different SMEs and ask the same questions in an effort to get exposure to different expert perspectives. Moreover, one facilitator stated, “I can’t think of a single way they let us down” and emphasized how openly and easily the SMEs communicated with the students. Days after introducing the Challenge, the site participated in their first Virtual SME Connection, giving students’ ownership of the Challenge from the beginning. Facilitators thought this early SME interaction was invaluable.

Facilitators reported that all students were engaged in the Challenge for a variety of reasons. Last year, the site took the NASA students to the nearest NASA Center, so that helped spark interest. In addition, the site encouraged competition and one of the site’s teams had been very successful with their Challenge during the pilot year. Students believed this year that the winning teams would be flown to the culminating event. Beyond the competition, facilitators believed that students were engaged simply because of the name “NASA,” even though many were unaware of what NASA was prior to the pilot NASA Challenge. It was now a well-known name around the school. In addition, students felt that they could make a difference and experienced feelings of pride based on the fact that NASA thought to solicit input from them. Moreover, the facilitators felt that they worked well as a team and the relationships that they share with the students contributed to their overall engagement level. Lastly, the facilitators believed that the recognition (e.g., on local T.V. stations, people knew the winners at the school) that students achieved from last year’s pilot program and the weather station webinar that the school offered to 6th grade students last year was enough to make the students want to participate. Overall, facilitators felt that the skills (e.g., teamwork, knowledge gained, life lessons) obtained during the NASA STEM Challenge are valuable and can be applied in their everyday life. “These kids think they can solve NASA’s problems. And they’ll tell you that.”

Of the 12 students that initially started the program, four of them quit due to spring sports. Facilitators believed if they had not had staffing shortages this year, they would have had more students participate in the Challenge. Last year, there were 30 students but they did not have the staff capacity to match that during phase 2.

Suggested Improvements

The site had a number of suggested improvements for the NASA STEM Challenge going forward. The facilitators preferred that the training get extended to 1 ½ days so they could have time to go through each Challenge in its entirety and understand it well enough as to incorporate supporting activities leading up to the Challenge with the students. In addition, facilitators would have liked to have input in what Challenges they were offered to select from. Facilitators would have also liked to know about the Discussion Boards and On Demand Video trainings earlier so they could have participated. They believed the suggested time of 20 hours was unreasonable for the Packing for the Moon Challenge and would have not met the deadline if the submission date was not extended. More time for research needs to be added to this Challenge.

For implementation, this site would prefer to implement in the Fall without the competition from Science Fairs and spring sports. In addition, they have fewer staff working afterschool and would have liked to have teams of 8 students. This would have allowed them to have more students in the program. Since there were only two staff available, they had to cap enrollment. Additionally, the site suggested having the students watch the facilitator videos. They did this during phase 2, and it let the students be on the same page as the facilitator and built trust and ownership for the students. They loved the addition of SMEs this year and would not want to go back to the time without them.

There was also confusion about the competition and the prize for phase 2. The site was under the impression that the winning team would travel to the culminating event. They had 8 students, five of which had parental consent to make this trip. They planned on winning and the students were excited about this detail. During the pilot it was stated that these kids were in a competition, there would be a winner, there would be an announcement of who the winner was, and there would be a prize. This year there was misinformation and the site was left wondering.

When asked about successful attributes of high quality STEM educators, the facilitators at Myers pointed to the importance of having a science degree/major, someone who works well with children and can have meaningful relationships, commitment to the program, desire to do the best you can do, and various “human qualities” (e.g., coaching, enthusiasm, let students think/fail/solve on their own, maintaining fun/positive experience). The facilitators greatly appreciate that NASA is looking at students as the future and giving credit to them for their ideas and validating their thoughtful work.

DoS Observation

During the Dimensions of Success Observation that occurred at Myers, there were 8 students and two facilitators present. There was compelling evidence (scores of 4) for all 12 of the dimensions. In Features of the Learning Environment, (1) Organization, (2) Materials, and (3) Space Utilization were all highly appropriate for STEM afterschool activities. When looking at Activity Engagement, (4) Participation, (5) Purposeful Activities, and (6) Engagement with STEM were scored high, with compelling evidence to support Activity Engagement. When looking at STEM Knowledge and Practices, (7) STEM Content Learning, (8) Inquiry, and (9) Reflection were all scored a 4, denoting high levels of STEM Knowledge and Practices during the observation session. Finally, Youth Development in STEM includes (10) Relationships, (11) Relevance, and (12) Youth Voice. All dimensions were a 4 with evidence of a very strong student-led environment.

Video Evaluation Rubric Scores

Two videos were submitted for the Myers site. Out of 16 possible points, both videos scored a 15. These scores reflect an engagement in the NASA STEM Challenge activities and excellent demonstration of the EDP.

- The first video that scored a 15 displayed an excellent understanding of STEM and the engineering design process. The video showed the entire team and their contributions. It should be noted that it was 6 ½ minutes long. A point was deducted from Step 7 (Communicating the Solution) because the video was too long.
- The other video that scored a 15 also displayed an excellent understanding of STEM and the engineering design process. A point was deducted because the team never discussed advice they would give to NASA.

SITE: STRINGER

The Site and Facilitators

The site objectives surrounding STEM programming at Stringer focus on getting students engaged in STEM activities. Monday thru Thursday, for one hour, there is a STEM activity. As a 21 CCLC, in the past year they focused on weekly STEM Challenges. The past STEM activities have included smaller experiments and a CSI activity. There is also a voluntary Robotics class. The director and development leader have been with the site for less than a year but knew that students struggled with science and science grades. It is their opinion that it takes a lot to get students to participate in afterschool science activities due to low interest levels. While the state's goal is to improve mathematics and language scores, the Stringer site has their own goal of improving science scores, leveling the playing field, and introducing their students to technology. They focus on students exploring fields they don't have experience with and giving them access to things they could be interested in.

The NASA STEM Challenge was geared more toward space, engineering, and building than any prior activities. The students had experience with hands-on science activities prior to this Challenge. However, students were able to choose if they wanted to participate in the NASA STEM Challenge where previous STEM activities all students were divided into groups.

The Stringer NASA STEM Challenge primarily included a site coordinator and a facilitator that was also the site's development leader. All were comfortable with their role in working with their 21 CCLC site and were comfortable working with the kids during the NASA Challenge. However, the facilitator felt lost with the materials at times. Two additional facilitators worked with the kids one day a week. With regard to educational background, the primary facilitator did not have a science background, but was highly interested in science. The other two facilitators were science teachers.

Regarding capacity, site staff believe that the NASA STEM Challenge gave them skills in engineering and design, but also video technology, and student access to new curriculum. The site also learned how to implement a project like this and how to interact with outside experts. Everyone feels that they had the right people lined up to participate but there were unexpected issues. They feel like they have learned a number of critical implementation gaps that they could avoid in the future.

NASA Training

Five STEM Challenge staff attended the 1-day, in-person, NASA training, including two site coordinators, two day-time school staff, and 1 facilitator. All believed it was helpful to have hands-on time and build what the kids were going to be building. It gave the staff an opportunity to see where kids would ask questions. It also helped clarify the hands-on aspect and was very useful in that regard. However, it did not explain the process, the requirements, and the resources accurately, in their experience. They were told in the training that there would be support staff to answer questions and NASA or ED would be available to them, but that was not this site's experience. They did have a positive experience reaching out to NASA support staff from the webinars for answers. Dave was always responsive. However, students could not find a contact to reach out to in order to get questions answered. Afterschool staff had issues accessing the calendar and had a very difficult time with the Y4Y Website. For a while the Website did not work at all for them. They were later told it was not up and running until their 3rd week of program implementation.

Apart from the training, the site coordinator and facilitators joined Live Webinar trainings that acted as refresher trainings, not giving them any additional information. Facilitators were unaware of On Demand Video trainings and did not know they were available, and suggested video clips from manuals were not pertinent to questions that students had. In addition, the facilitator stated that the Y4Y Website was difficult to navigate and it was a challenge to find the support and resources that site staff required. Any questions that were not answered by the instructor manual were difficult to get answered. As such, the site felt lost with the materials at times. In addition, staff did not know what was expected from them on a day-to-day basis. They felt it was not clearly stated during the training what was required from them and reminders were not given on a timely basis to allow them to complete tasks on time. Reminders were sent after the fact that something was due. Stringer had not received eBlasts until late into program implementation due to the wrong contact person receiving all communications regarding the Challenge. They were also unaware of project Discussion Boards and professional development opportunities.

The training and the manual helped staff feel comfortable with the materials and gave facilitators a starting point. During the planning process, facilitators wanted the Y4Y Website to answer their questions and that did not occur. It would have been more useful if the Y4Y Website was available when they started to plan rather than 3 weeks into Challenge implementation. They felt they were trained before NASA was ready to start implementing, believing that NASA/ED were not ready in January for them to start.

NASA Challenge Implementation

In terms of the NASA STEM Challenge, the program started with 12 participants and the final group was comprised of six boys from a mix of grades. Students came from a low SES (socio-economic status) household. Science and mathematics grades of the students in the afterschool program are primarily less than satisfactory. Science was not a strong point and interest in science was not high. Facilitators noted that this age group is also questioning who they are and what they are interested and confident in.

Students from Stringer participated in two challenges: Spaced out Sports and CEV. Challenges were chosen by the students. Facilitators went through each manual with the students and the students chose what they wanted to participate in. The challenge began but there were weather issues that caused delays. Stringer began mid-February after introducing the NASA STEM Challenge and implementing a

STEM activity with all afterschool students. It was difficult to get kids interested after the snow delays. Their students needed an introduction to what NASA was and what NASA was about. Not having that background information, many students questioned why they "had to do this." There were multiple students that did not participate that wished they would have after hearing about the program and the activities in greater detail. However, it was too far into implementation to include additional students. At Stringer, the coordinator believes that kids would need to be hand-picked for this activity, believing that based on grades, it was clear why many students chose to not participate.

Once the challenge started, students spent roughly three hours a week for seven weeks. One team chose to work on Spaced out Sports due to a mutual interest in video games. Additionally, at the start, two teams were working on the CEV Challenge but they ultimately combined their designs, using pieces from each that worked best, and finished with one product. One student chose to build by himself, despite being encouraged to work with other team members. That student did not complete the Challenge due to poor attendance in the afterschool program. Facilitators believed that it was a good amount of time spent on the Challenge, but added one day a week for the last few weeks of implementation in order to make up for snow days. Their students were in the video process before they learned of the implantation deadline extension.

Facilitators based their instruction on what they were taught, allowing students to figure out the problems for themselves. Facilitators were not previously fully comfortable with teaching inquiry and not giving students step-by-step instruction. Students expected the facilitators to give them the answer and have the answer. An agenda shaped the day toward research or hands-on days. Questions were not explicitly stated but facilitators gave general structure to keep students on track. Students and staff were focused on the deadline and students would occasionally get burned out. Staff would redirect the day so that students did not lose interest but due to snow days and time lost, this was not always an option. It was also difficult for students to articulate what they had worked on. Inquiry got easier as the relationship between students and facilitators developed. The training, however, did not help the facilitator feel comfortable with inquiry.

Facilitators and students were able to participate in three SME (subject matter expert) sessions including CEV, Spaced out Sports, and general Q&A sessions, which the students chose on their own preparing questions in advance. All students working on the Challenge attended the Virtual SME Connections and loved them. They liked interacting with other schools and hearing how other schools were doing with their builds, along with the questions other schools asked. The SME interactions were very helpful and Dave answered questions on the students' level through whiteboard and video explanations. It was a highly productive level of conversation. While students were hesitant during the first minutes of the first Webinar, they were quickly excited to participate and looked forward to each additional webinar. Some minor suggestions for improvement are listed below.

Of the six who completed the challenge, five were described as highly engaged, for the most part. Instructors generally were there to answer and direct/re-direct students, but students were working on their build and games in teams. Everyone knew who the "NASA kids" were. They were always answering questions on what they did during the day and they knew how to answer the questions. The site coordinator ranked them as a 9 out of 10 for his expectations of Stringer students. Overall, instructors felt that the skills (e.g., critical thinking, ability to make mistakes) obtained during the NASA STEM Challenge are valuable, and relevant to students' lives. Lack of student engagement is believed to be based on lack of understanding in the beginning. Many students also wondered why they were doing school work and not getting a grade. The site was unaware that videos were viewed by NASA and ED and winners were selected for a culmination event. It was believed that some incentive would have kept students going. Additionally, due to snow days they had to hurry to complete the Challenge and could not allow students to have "fun days" or off days. Still, toward the end, they were highly engaged in the build and in the video process. Students struggled with being out of their comfort zone but once comfortable were highly reflective and responsive.

Students also stopped participating for a number of reasons. Some were on the fence and lost interest. Those that were not interested were acting out and taking away from those that were engaged, so the facilitator gave them the choice to leave the NASA project. Additionally, attendance in the afterschool program is not enforced, and only one of the students that completed the Challenge participated in every session. Instructors anticipate that students' interest with future NASA STEM Challenges will depend on a number of things, including how the program is introduced to students and whether non afterschool students can be recruited.

Regarding paperwork, the site coordinator worked to make sure that paperwork was submitted on time, however, it was a challenge at first due to the wrong contact person receiving information at Stringer. The technical support was not set up correctly because the main contact for the program was listed as the school district's technology person. Additionally, there were two site coordinators and the high school coordinator was listed as a primary contact while the middle school 21 CCLC site coordinator should have been the primary contact for the NASA STEM Challenge. The high school site coordinator reached out to the evaluation team contact and was able to get the contact information straightened out about three to four weeks into the Challenge implementation.

Suggested Improvements

The site had a number of suggested improvements for the NASA STEM Challenge going forward. Focusing on implementation, there were major issues with the Y4Y Website, including issues this year that did not exist last year. The site's director had participated in the Pilot, and his opinion was that this year involved ED coordinators and it was more smoothly implemented when it was direct involvement of NASA and US Department of Education and more involvement of the State Coordinators last year. The added layer was what the site felt was the source of confusion and frustration. In addition, he stated that during the Pilot there was a better connection built with the administration and the inclusion of State Coordinators that was lacking this year. During training, Stringer would like to see more coordination, where the training showed the Y4Y Website and how to navigate the support resources. To engage the students, the culminating event from the Pilot where winning videos were selected from video submissions was used. Stringer was unaware that this was occurring for Phase 2 as well. This needed to be more clearly communicated with all sites to give the students something to get excited about. Technologically, the site had issues regarding the final student video product. The site had iPads but did not have video capabilities. iMovie was problematic for them so iPads were brought to the school and tutorials were given, but at first they did not have any idea how to complete the video process. If they would have had access to this in advance they could have videoed throughout the build and design process rather than only at the end with final products. Many of the implementation problems that Stringer experienced were related to the wrong contact person receiving NASA communications. Due to this issue, they did not receive eBlasts until midway through implementation. In addition, they mentioned eBlasts going to SPAM folders.

With regard to paperwork, staff would like confirmation that materials were successfully submitted and received. In addition, they would like a weekly tracking email that let them know what their site was responsible for completing in the near future. They would also like the ability to save and/or print paperwork that they were in the process of completing.

They believe that student interest could be increased by recruiting via the daytime school program, rather than just with afterschool students and that SMEs should be used as early as possible to pique the interest of students. SMEs, even through video, could explain what the students would be taking part in better than the facilitators that were at that point unfamiliar with the entire experience. Additionally, their students did not know what NASA was and what it was about so background information was required. Also related to Virtual SME Connections, it might be more helpful to students to have a few leading questions, such as, "how are you guys doing with your build? Are you running into this issue?" to start the conversation. Finally, timing of webinars were an issue for Stringer. They had to end early for students to eat supper and get on the bus to go home.

When recruiting successful facilitators, Stringer staff believe that facilitators need to be patient, interested, resourceful, and supportive of collaboration and teamwork, and understanding of this age group. A teaching background is not necessary but being able to get along with students and being excited about science is a requirement. It is also important to understand the afterschool environment. Students have highly qualified expert teachers during their school day and the Stringer director believes it is the part of the afterschool facilitators to support, reinforce, and explore those lessons taught during the day. It is also important to ask tough questions and wait for the answer. Additionally, students sometimes have issues with their daytime teachers and those might not be the best individuals to get them to experiment and learn afterschool as daytime issues can carry over into the afterschool environment if the wrong teacher is participating.

DoS Observation

During the Dimensions of Success Observation that occurred at Stringer, there were 5 students and four adults present. There was inconsistent evidence or reasonable evidence (scores of 2 and 3) in all 12 of the dimensions. Scores are on a scale of 1 to 4. In Features of the Learning Environment, (1) Organization and (2) Materials scored a 2, and (3) Space Utilization scored a 3 with regard to being appropriate for STEM afterschool activities. When looking at Activity Engagement, (4) Participation wavered throughout the session and was scored a 2. (5) Purposeful Activities and (6) Engagement with STEM were also scored 2, with inconsistent evidence to support Activity Engagement. When looking at STEM Knowledge and Practices, (7) STEM Content Learning scored a 2, (8) Inquiry scored a 3, and (9) Reflection scored a 2, denoting low to moderate levels of STEM Knowledge and Practices during the observation session. Finally, Youth Development in STEM includes (10) Relationships, (11) Relevance, and (12) Youth Voice. Relationships and Youth Voice were both scored as 3 and Relevance was scored as a 2 since the Challenge was never related back to students' lives.

Video Evaluation Rubric Scores

Two videos were submitted for the Stringer site. One video was from the Spaced Out Sports team and the other was from the combined CEV team. Out of 16 possible points, the videos scored a 4 and 11. These scores reflect the engagement level in the NASA STEM Challenge activities that was observed during the DoS observation and that was discussed by the facilitator during the site visit.

- The video that scored a 4 displayed a strong interest in the game. There was less focus on the team or the engineering design process, evaluation trials, and problem solving, however. It does not seem that the team followed the video rubric guidelines.
- The video that scored an 11 displayed a strong prototype. The points that were deducted were due to students not following the video rubric/guidelines and not discussing the design process.

APPENDIX K: SUMMATIVE STUDY SAMPLE, MEASURES, AND ANALYSIS

Participants and Implementation

The summative sub-study was conducted with 840 5th, 6th, 7th, and 8th grade students completing survey(s) fielded online. Only data from the 54 sites that (1) completed the STEM challenge (operationally defined as submitting a video) and (2) completed a pre or post-test were included in this analysis. It should be noted than when including both completing and non-completing sites, the conclusions were nearly identical. Therefore, analyses were conducted with program completers only, as it is a better representation of those who completed the prescribed program dosage. Of these 54 sites, 53 (or 98%) had valid data at pre-test and 48 (or 91%) had valid data at post-test. Some process measures were only available for 35 of these 54 sites (or 65%), so analyses examining process data are restricted to this subset of the data.

Exhibit. Characteristics of student and site samples.

	Pre		**Post**	
	n	**%**	**n**	**%**
	Students			
Total	840			
Data At Both Waves	366	44%	366	44%
Data One Wave Only	352	42%	122	15%
Grade				
5	172	24%	135	28%
6	207	29%	139	28%
7	174	24%	100	20%
8	165	23%	114	23%
	N		**%**	
	Sites			
Total	**54**			
Crew Exploration Vehicle	22		41%	
Radiation Shield	6		11%	
Packing Up For Moon	5		9%	
Parachuting Onto Mars	14		26%	
Spaced Out Sports	8		15%	
Why Pressure Suits	9		17%	
School Type				
STEM Focused	2		6%	
STEM Implemented	12		34%	
Instructor:				
Is a Teacher	30		86%	
Is a Math Teacher	6		17%	
Is a Science Teacher	18		51%	
Not Teach Mathematics/Has Background	8		23%	
Not Teach Science / Has Background	8		23%	
Has No Background	6		17%	
Attended The In Person Training	30		86%	
Had Subject Matter Expert	36		67%	

Note: No one indicated that they were a parent volunteer. All site data based on N=35, except for challenge implemented and having a SME, which is based on N=54.

As can be seen in Exhibit, of the 840 students providing data, 366 (or 44%) provided data at both waves. Also, of the 840 students, 352 (or 42%) provided data only at pre-test and 122 (or 15%) only provided data at post-test. The students were relatively well balanced on grade at pre-test and post-test, as close to a third were in 5th (pre: 24%, post: 28%), 6th (pre: 29%, post: 28%), 7th (pre: 24%, post: 20%), and 8th (pre: 23%, post: 23%) grades. As can be seen in Exhibit 7, the challenges implemented in decreasing order of implementation frequency were Crew Exploration Vehicle (41%), Parachuting Onto Mars (26%), Why Pressure Suits (17%), Spaced Out Sports (15%), Radiation Shield (11%), and Packing up for the Moon (9%). Of all of the sites implementing the program, 6% were STEM-focused programs and 34% were schools implementing STEM. Almost all of the respondents were teachers (86%). Areas of focus for these teachers in decreasing order of occurrence were as follows: science teacher (51%), not a mathematics teacher but has background (23%), not a science teacher but has background (23%), mathematics teacher (17%), and has no science/mathematics background (17%). None of the teachers were parent volunteers. Almost all of the teachers attended the in-person training (86%) and about two-thirds (67%) of sites had a Subject Matter Expert (SME) speak to students.

Measures

Student Work Assessment was measured through a coding process using the Student Work Assessment Rubric (Appendix I), which was developed based on the eight steps of the Engineering Design Process as well as the implementation guidance provided to the sites in the Educator Guides. Prior to the coding process, the evaluation team invited members of the Expert Review Panel (ERP) to participate in coding six videos from the subset of sites used in the implementation evaluation. Two separate ERP members coded each video. During the ERP meeting, coders explained their rationale for coding and came to a consensus when ratings differed. This process helped the evaluation team's coding by setting precedents for objective review of the criteria. For the evaluation, coding was conducted independently after watching each video at least two times. Immediately after the independent coding was conducted, coders met to discuss their ratings and come to a consensus on a rating for each step in the rubric. To examine internal consistency in coding, the interclass correlation coefficient was calculated using a one-way random (products examined as random) single measure model. There was a high level of internal consistency between the raters (r_{ICC}=.98). The final measure examined reflects the agreed upon score, based on discussion.

STEM Attitudes were assessed through a pre-post survey instrument that was developed and piloted with fourth graders through NASA's Summer of Innovation project in order to measure interest and enthusiasm for science and engineering (Martinez, Linkow, Velez, & DeLisi, 2014). The question items and answer options were adapted from the High School Longitudinal Study of 2009 Student Baseline Survey, with two additional answer options adopted from the Noyce Enthusiasm for Science scale and the Assessing Women and Men in Engineering Rating Scale for Sense of Community. Answer options included extracurricular science and technology activities, such as science competitions and using kits or materials to do experiments or build things at home.

Martinez and colleagues report on four scales that were developed through factor analysis of the initial item pool and through creating scales with adequate internal consistencies. All internal consistencies were acceptable at baseline in the report detailing the development of these scales (α>.76; Martinez et. al., 2014). Considering the psychometric properties of these subscales in the current study at baseline, "Enthusiasm for Science" (α = .93, 19 items), "Interest in Design and Hands-On STEM Activities" (α = .79, 4 items), "Interest in Out-Of-School STEM Activities" (α = .78, 9 items), and "General Interest in

Science" (α = .69, three items), all had reasonable internal consistency reliabilities. All scale scores were created by taking the average of items comparison the scale.

The STEM Attitudes Survey contains a total of 36 items where participants respond on four-point Likert-type scales with higher numbers representing more favorable responses. The inventory contains four scales measuring *Enthusiasm for Science* (20 items, e.g., “I like to take things apart to learn more about them.”), *Interest in Design and Hands-on STEM Activities* (4 items, e.g., “I like to design and build something mechanical that works.”), *Interest in Out of School STEM* Activities (9 items, e.g., “Visit a science museum, planetarium, or environmental center.”), and *General Interest in Science* (3 items, e.g., “Science is one of my favorite subjects.”). Cronbach’s alpha was used as an index of the degree to with which all items were measuring the same underlying dimension. Alpha was acceptable (i.e., ≥ .70) at baseline for *Enthusiasm for Science* (.93), *Interest in Design and Hands-on STEM Activities* (.79), and *Interest in Out of School STEM Activities* (.78), and marginally acceptable for *General Interest in Science* (.69). Please see Appendix K for specific survey items comprising each scale and Appendix L for an item-by-item justification for these measures from the Summer of Innovation project.

We also constructed an index measuring *Participation in Other Science Activities*, by coding yes responses to any of the following items as 1 (0 otherwise):

- “Participated in a science club in the most recent school year.”
- “Participated in a science competition in the most recent school year.”
- “Participated in a science camp or after-school activity, not including a NASA in the most recent school year.”
- “Participated in a science study groups or a program where you were tutored in during the most recent school year.”

The student pre-post survey, administered across all 21CCLC participating sites, included two multiple-selection question items that inquired about students’ participation in other STEM activities. The question items and answer options were adapted from the High School Longitudinal Study of 2009 Student Baseline Survey, with two additional answer options adopted from the Noyce Enthusiasm for Science scale and the Assessing Women and Men in Engineering Rating Scale for Sense of Community. Answer options included extracurricular science and technology activities, such as science competitions and using kits or materials to do experiments or build things at home. This instrument was successfully implemented with fourth through eighth graders in the Summer of Innovation project.

Planned Analysis

Random intercept mixed model regression (sometimes referred to as hierarchical linear modeling) was used to examine change over time in *STEM Attitudes* and *Participating in Other Science Activities*. This analysis technique was chosen as it allows us to (a) include all cases even if they do not have both pre-test and post-test and (b) conservatively adjust estimates for variability among sites on the outcomes of interest. Thus, models adjusted outcomes for variability at the individual level (i.e., repeated measurements between pre- and post-test) and at the site level (i.e., variability among sites). These models regressed *STEM Attitudes* and *Participation In Other Science Activities* on grade (5^{th}, 6^{th}, 7^{th}, 8^{th}), wave (pre vs. post), and their orthogonal interaction. Thus, these effects let us know whether there were (a) differences in *STEM Attitudes* with increasing grade, (b) changes over time as a result of the

STEM program, and (c) whether there were differential changes over time as a function of grade. The model examining *Participation In Other Science Activities* used generalized linear mixed modeling, assuming a binomial distribution and a logit link function, due to this outcome being dichotomous.
Coded video quality was examined descriptively.

APPENDIX L: SUMMATIVE STUDY ADDITIONAL FINDINGS

This section provides a more detailed description of the quantitative analyses used to address Research Question 1, "Do students completing a NASA Challenge demonstrate increased positive attitudes toward STEM?" These analyses examined whether (a) there was a change over time on STEM attitudes and participation in other science activities and (b) whether these changes were more pronounced for particular grades.

Exhibit 1 presents the statistical tests for this research question and Exhibit 2 displays the cell means for the grade by time (pre-post) comparisons. Analyses examined whether changes were statistically significant (i.e., larger what we would expect than by chance along), which is indicated in the time row in Exhibit 1 and whether level of change differed as a function of grade, which is indicated in the grade X time row in Exhibit 1. Statistical significance is indicated by a "*" in Exhibit 1. Statistical significance is based on the test statistic value listed (i.e., either a t or z statistic), which can be safely ignored by the lay reader. We have also provided effect sizes (r and OR) for the interested reader, where these numbers speak to the magnitude of effects. This is less clear for OR (or the odds ratio), but it is clearer for r, where effects can be interpreted as small (r=.10), medium (r=.30), and large (r=.50) in magnitude. Odds ratios can be interpreted for time effects, for instance, as the odds participation in an activity was *OR* times more likely as a result of participation in the STEM challenge.

Exhibit 1. Statistical changes between pre-test and post-test in STEM attitudes and science activity grade.

		Enthusiasm For Science	Interest In Design And Hands On STEM Activities	Interest In Out Of School STEM Activities	General Interest In Science		Participated In Some Other Science Activity
ICC		.15	.13	.09	.20		.24
Intercept	**b**	3.19	3.38	2.78	3.18	**b**	-1.06
	t(753-772)	60.89*	53.87*	51.57*	44.51*	**z**	-4.21*
	r	.91	.89	.88	.85	**OR**	.35
Grade	**b**	-.07	-.09	-.07	-.07	**b**	-.04
	t(753-772)	-3.02*	-3.23*	-2.93*	-2.36*	**z**	-.39
	r	-.11	-.12	-.10	-.09	**OR**	.96
Time (pre-post)	**b**	-.05	-.10	-.03	-.09	**b**	.86
	t(351-359)	-1.90+	-3.04*	-.92	-2.99*	**z**	5.75*
	r	-.10	-.16	-.05	-.16	**OR**	2.36
Grade X Time	**b**	-.01	-.02	-.02	-.02	**b**	-.01
	t(351-359)	-.78	-1.46	-1.37	-1.13	**z**	-.09
	r	-.04	-.08	-.07	-.06	**OR**	.99

** p < .05, + p < .10*

Exhibit 2. Means (1-4) for STEM attitudes and science activity as a function of program exposure and grade.

	N	Enthusiasm For Science	Interest In Design And Hands On STEM Activities	Interest In Out Of School STEM Activities	General Interest In Science	Participated In Some Other Science Activity
Pre	718	3.07	3.20	2.63	3.04	31%
Post	488	3.07	3.15	2.65	2.98	48%
Grade 5	307	3.12	3.24	2.70	2.96	42%
Grade 6	346	3.10	3.23	2.69	3.05	36%
Grade 7	274	3.07	3.19	2.61	3.06	33%

Grade 8	279	2.98	3.04	2.54	2.98	42%
Grade 5 Pre	172	3.16	3.27	2.73	3.01	34%
Grade 5 Post	135	3.07	3.21	2.66	2.90	52%
Grade 6 Pre	207	3.06	3.23	2.63	3.05	30%
Grade 6 Post	139	3.16	3.22	2.78	3.04	44%
Grade 7 Pre	174	3.05	3.19	2.59	3.04	26%
Grade 7 Post	100	3.11	3.19	2.64	3.10	46%
Grade 8 Pre	165	3.01	3.10	2.59	3.04	36%
Grade 8 Post	114	2.94	2.96	2.46	2.90	51%

Analysis of pre-post student responses demonstrated that students' self-reported participation in other STEM activities increased from 31% at pre-test to 48% at post-test, which is presumably a result of the STEM challenge. This finding was robust and statistically significant for students' participation in specific STEM activities: Students were likely to have increased their attendance of science clubs (13% to 20%, z=1.97, p=.049, OR=1.51), science competitions (12% to 19%, z=3.36, p<.001, OR=2.03), and science camps or after-school activities (13% to 22%, z=4.12, p<.0001, OR=2.10). The change was in the same direction but only marginally significant for attending a science study group or a program where they were tutored (6% to 10%, z=1.71, p=.087, OR=2.18). Further, this finding of an increase in students' participation in other STEM activities was fairly uniform across participating grade levels (see Fig. 1). This important finding suggests that students were more likely to engage in science activities, presumably as a result of the program. This is an important objective of STEM engagement activities and likely speaks to their continued involvement in science that will help foster scientific skill development.

As can be seen in Exhibit 7, there was a general trend for those in higher grades to have slightly less favorable *STEM Attitudes*, independent of whether measures were collected at pre- or post-test. This mirrors findings from the National Assessment of Educational Progress for science proficiency, which suggests science proficiency declines from fourth grade (34%) to eighth grade (30%) and from eighth grade to twelfth grade (21%; NCES, 2011).[15] This effect was statistically significant for all four STEM Attitudes. There was a decrease from pre- to post-test mean for *Interest in Design and Hands-on STEM Activities* and *General Interest in Science*; however, this may be due to what is called a "ceiling effect", suggesting that means were so high at baseline that there was no room for improvement.

APPENDIX M: STEM ATTITUDE SUBSCALES

Measures of STEM interest and enthusiasm came from the Summer of Innovation Youth Survey (Martinez, Linkow, Velez, & DeLisi, 2014). These four scales were developed through factor analysis of the initial item pool and through creating scales with adequate internal consistencies. All internal consistencies were acceptable at baseline in the report detailing the development of these scales (α>.76; Martinez et. al., 2014). The items contain scales with 19 items measuring Enthusiasm for Science, four items measuring Interest in Design and Hands-On STEM Activity, nine items measuring Interest in Out-Of-School STEM Activities, and three items measuring General Interest in Science. All items used a 1-4 response scale, where 4 indicates stronger agreement or greater frequency. All scale scores are created by taking the average of items comparison the scale. The specific items comprising each scale are as follows.

Enthusiasm for Science Scale (baseline α=.92)

- Science is something I get excited about
- I like to take things apart to learn more about them
- I like to participate in science projects
- I'd like to get a science kit as a gift (for example, a microscope, magnifying glass, a robot, etc.)
- I like to see how things are made (for example, ice-cream, a TV, an iPhone, energy, etc.)
- I like to watch programs on TV about nature and discoveries
- I am curious to learn more about science, computers or technology
- I like to work on science activities
- If I have kids when I grow up, I will take them to a science museum
- I want to understand science (for example, to know how computers work, how rain forms, or how airplanes fly)
- I enjoy visiting science museums or zoos
- I get excited learning about new discoveries or inventions
- I like reading science magazines
- I pay attention when people talk about recycling to protect our environment
- I am curious to learn more about cars that run on electricity
- I get excited to find out that I will be doing a science activity
- I enjoy reading science fiction books
- Science is boring (reverse coded)
- I like science

Interest in Design and Hands-On STEM Activities Scale (baseline α=.78)

- I like to design a solution to a problem
- I like to be part of a team that designs and builds a hands-on project
- I'm curious to learn how to program a computer game
- I like to design and build something mechanical that works

Interest in Out-Of-School STEM Activities Scale (baseline α=.78)

- Since [reference period] how often have you done the following science activities:
    - Read science books and magazines
    - Access web sites for computer technology information
    - Visit a science museum, planetarium, or environmental enter
    - Play games or use kits or materials to do experiments or build things at home
    - Watch programs on TV about nature and discoveries
- I like learning about science on the internet
- I like online games or computer programs that teach me about science
- I do science-related activities that are not for schoolwork
- Before joining this program, I participated in science activities outside of school

General Interest in Science Scale (baseline α=.78)

- Before joining this program, I was interested in science and science-related things
- Science is one of my favorite subjects
- I take science only because I have to (reverse coded)

APPENDIX N: ITEM BY ITEM JUSTIFICATION OF YOUTH BASELINE SURVEY ITEMS FROM SUMMER OF INNOVATION PROJECT

Question	Source	Answer Options	Scale	Justification Notes
Your first name and last name	SoI student survey 2011	First name, Last name	N/A	Information is used to confirm match in dataset
What is your birthday?	SoI student survey 2011	Month Day Year	N/A	Information is used to generate a unique identifier in dataset for matching purposes
What grade did you enter last fall?	SoI student survey 2011	4th 5th 6th 7th 8th 9th Other	N/A	Information is used to confirm match in dataset, to establish youth eligibility for sample and provide capability to disaggregate findings by grade level and to remove students outside of the grade range from the sample

Question	Source	Answer Options	Scale	Justification Notes
As things stand now, how far in school do you think you will get?	Adapted from HSLS of 2009, Baseline Parent Survey	Less than high school Earn a high school diploma or GED Complete an Associate's degree Complete a Bachelor's degree Complete a Master's degree Complete a Ph.D., M.D., law degree, or other high level professional degree I don't know	N/A	This data element identifies the youth's educational expectations, which may serve as a correlate to student interest in academically focused activities

Question	Source	Answer Options	Scale	Justification Notes
Why did you sign up for this NASA educational activity? Check all that apply.	Adapted from the AWE Middle School Students Pre-Activity Survey	To have fun To learn more about NASA and space To have something to do To learn more about different majors in college (e.g., engineering, science) To learn more about science To learn about what scientists and engineers do To make my parents/guardians happy To meet others with interests similar to mine To help me to do well in school None of these	N/A	This question is intended to identify youth's motivation for enrollment.
Have you ever been in a NASA educational activity?	Adapted from 4-H Science Youth Survey (2012)	Yes; No; I don't know	N/A	Whether a youth has previously participated in a NASA educational activity will serve as a control variable.

Question	Source	Answer Options	Scale	Justification Notes
What science class did you most recently take? This might be the class you are currently taking.	Adapted from HSLS of 2009, Student Baseline Survey; science class titles drawn from CCSSO, State Indicators of Science and Mathematics Education 2007, Table 1.6 (http://programs.ccsso.org/content/pdfs/SM%2007%20report%20part%201.pdf)	Science or General Science Life Science Earth Science Physical Science, Integrated or Coordinated Science Other science course I don't know	N/A	This question is one of two questions intended to identify student interest in past science class at school. Class subject is identified in order to control for this variable in the analysis of change in student interest.
How much do you agree or disagree with the following statements about your most recent science class?	Adapted from HSLS of 2009, Student Baseline Survey	I enjoyed this class very much I thought this class was a waste of my time I thought this class was boring	Never Rarely Sometimes Often	This question is intended to identify student engagement in past science class at school, which is a dependent variable for this study.
Which of the following activities did you participate in during your most recent school year? This might be the current school year.	Adapted from HSLS of 2009, Student Baseline Survey	Science club Science competition Science camp Science study groups or a program where you were tutored in science None of these	N/A	This question is intended to identify student engagement in extracurricular science activities, which is a dependent variable for this study.

Question	Source	Answer Options	Scale	Justification Notes
During the most recent school year, how often have you done the following science activities? This might be the current school year.	Adapted from HSLS of 2009, Student Baseline Survey; Last two answer options from the Noyce Enthusiasm for Science scale and the AWE Rating Scale for Sense of Community (2009)	Read science books and magazines Access web sites for computer technology information Visit a science museum, planetarium, or environmental center Play games or use kits or materials to do experiments or build things at home Watch programs on TV about nature and discoveries	Never Rarely Sometimes Often	This question is intended to identify student engagement in outside of school time science activities, which is a dependent variable for this study.
Please indicate the extent to which you agree or disagree with each of the following statements. Select one in each row.	Noyce Enthusiasm for Science scale/Common Instrument	Science is something I get excited about	Strongly Disagree Disagree Agree Strongly Agree	This question is part of a validated scale intended to ascertain student enthusiasm/interest in science, which is a dependent variable for this study.
	Noyce Enthusiasm for Science scale/Common Instrument	I like to take things apart to learn more about them		
	Noyce Enthusiasm for Science scale/Common Instrument	I like to participate in science projects		
	Noyce Enthusiasm for Science scale/Common Instrument	I'd like to get a science kit as a gift (for example, a microscope, magnifying glass, a robot, etc.)		

Question	Source	Answer Options	Scale	Justification Notes
	Noyce Enthusiasm for Science scale/Common Instrument	I like to see how things are made (for example, ice-cream, a TV, an iPhone, energy, etc)		
	Noyce Enthusiasm for Science scale/Common Instrument	I like to watch programs on TV about nature and discoveries		
	Noyce Enthusiasm for Science scale/Common Instrument	I am curious to learn more about science, computers or technology		
Please indicate the extent to which you agree or disagree with each of the following statements. Select one in each row.	Noyce Enthusiasm for Science scale/Common Instrument	I like to work on science activities	Strongly Disagree Disagree Agree Strongly Agree	This question is part of a validated scale intended to ascertain student enthusiasm/interest in science, which is a dependent variable for this study.
	Noyce Enthusiasm for Science scale/Common Instrument	If I have kids when I grow up, I will take them to a science museum		
	Noyce Enthusiasm for Science scale/Common Instrument	I would like to have a science or computer job in the future.		
	Noyce Enthusiasm for Science scale/Common Instrument	I want to understand science (for example, to know how computers work, how rain forms, or how airplanes fly)		
	Noyce Enthusiasm for Science scale/Common Instrument	I enjoy visiting science museums or zoos		

Question	Source	Answer Options	Scale	Justification Notes
	Noyce Enthusiasm for Science scale/Common Instrument	I get excited about learning about new discoveries or inventions		
	Noyce Enthusiasm for Science scale/Common Instrument	I like reading science magazines		
	Noyce Enthusiasm for Science scale/Common Instrument	I pay attention when people talk about recycling to protect our environment		
	Noyce Enthusiasm for Science scale/Common Instrument	I am curious to learn more about cars that run on electricity		
	Noyce Enthusiasm for Science scale/Common Instrument	I get excited to find out that I will be doing a science activity		
	Noyce Enthusiasm for Science scale/Common Instrument	I enjoy reading science fiction books		
	Noyce Enthusiasm for Science scale/Common Instrument	I like learning about science on the internet		
	Noyce Enthusiasm for Science scale/Common Instrument	I like online games or computer programs that teach me about science		
	Noyce Enthusiasm for Science scale/Common Instrument	Science is boring		
	Noyce Enthusiasm for Science scale/Common Instrument	I do science-related activities that are not for schoolwork.		

Question	Source	Answer Options	Scale	Justification Notes
	Noyce Enthusiasm for Science scale/Common Instrument	I like science		
	Noyce Enthusiasm for Science scale/Common Instrument	Science is one of my favorite subjects		
	Noyce Enthusiasm for Science scale/Common Instrument	I take science only because I have to		
	Noyce Enthusiasm for Science scale/Common Instrument	I take science only because it will help me in the future		
	Noyce Enthusiasm for Science scale/Common Instrument	Before joining this program, I was interested in science and science-related things		
	Noyce Enthusiasm for Science scale/Common Instrument	Before joining this program, I participated in science activities outside of school		
	Adapted from the AWE Middle School Students Pre-Activity Survey	I like to design a solution to a problem		These questions are intended to ascertain student enthusiasm/interest in engineering, which is a dependent variable for this study.
	Adapted from the AWE Middle School Students Pre-Activity Survey	I like to be part of a team that designs and builds a hands-on project		
	Adapted from the AWE Middle School Students Pre-Activity Survey	I'm curious to learn how to program a computer game		

Question	Source	Answer Options	Scale	Justification Notes
	Adapted from the AWE Middle School Students Pre-Activity Survey	I like to design and build something mechanical that works		