STEM Challenges in the 21st Century Community Learning Centers

A Pilot Study of the Collaboration between National Aeronautics and Space Administration (NASA) and the Department of Education (DOE)

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Prepared by:

PARAGON TEC
Technology • Education • Communication

3740 Carnegie Avenue • Suite 302 • Cleveland, Ohio 44115 • 216.361.5555 • 216.361.9595 Fax
www.paragon-tec.com

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Acknowledgements

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National Aeronautics and Space Administration (NASA) Leadership

- **Robert LaSalvia**
  Deputy Chief, Educational Programs Office, NASA Glenn Research Center

- **Maria Arredondo**
  Project Manager, Educational Programs Office, NASA Glenn Research Center

- **Dr. Patricia Shaffer**
  Evaluation Manager, Office of Education, NASA Headquarters

Education Support Services (ES2) Evaluation Team Members

- **Danielle Mills-Woodson**
  ES2 Project Manager

- **Sarah Egan-Reeves**
  Senior Project Coordinator
  Pilot Study Lead

- **Richard Gilmore**
  Senior Project Coordinator
  Technical Lead

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I. Executive Summary

Through investment in Science, Technology, Education and Mathematics (STEM) education projects across its education portfolio, the National Aeronautics and Space Administration (NASA) aims to strengthen the Nation's future workforce, attract and retain students in STEM disciplines, and engage Americans in NASA's mission.[1] Research continues to show that STEM education programs fuel an increased interest in STEM careers among America's youth[2]. By connecting with learners of all ages, NASA is ultimately helping the United States remain globally competitive and sustain a strong national economy.

In May 2013, the Federal STEM Education Five-Year Strategic Plan was issued by the National Science and Technology Council's (NSTC) Committee on STEM Education (CoSTEM). This plan presents "five priority STEM education investment areas where a coordinated Federal strategy can be developed, over five years, designed to lead to major improvements in key areas" and notes "identifying, using, and sharing evidence-based approaches" as a coordination approach across Federal investments in STEM education.[3] As a lead Federal Agency, the Department of Education (ED) will play 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[4]."

It was thought that NASA Education's portfolio of STEM projects could augment ED's efforts. While, ED had launched the 21st Century Community Learning Centers (21CCLC) STEM Initiative in 2011, NASA and ED partnered together in 2013 to support and expand the STEM programming within the 21CCLC program through 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. Specifically, NASA Education provided three NASA-developed STEM Challenges as well as support to ED's 21CCLC grantees in the three aforementioned states.

The 21CCLC provides formula grants to all fifty states in order to support academic enrichment opportunities during non-school hours for students and their families, particularly students who attend schools in under-resourced communities. 21CCLC also helps students meet state and local standards in core academic subjects through a broad array of enrichment activities that can complement their regular academic programs. 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.

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

2 Sahin, A. (2013). STEM Clubs and Science Fair Competitions: Effects on Post-Secondary Matriculation. *Journal of STEM Education: Innovations & Research*, *14*(1), 5-11.

3 Federal STEM Education Strategic Plan (May 2013). Retrieved from http://www.whitehouse.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf

4 Ibid.

A defining characteristic of the NASA Education portfolio is the strategic infusion of NASA unique mission content and subject matter experts (SME) into programming and curriculum support materials. STEM Challenges are creative applications of NASA-related STEM and cross-cutting concepts. They challenge existing assumptions and encourage learners to demonstrate their knowledge of STEM subjects while enhancing innovation, critical thinking, and problem-solving skills.

This pilot study offers a formative evaluation of the implementation of this three-month collaboration. Specifically, NASA Education was interested in learning how its STEM Challenges could be implemented in the 21CCLC project. In order to learn how NASA Education can better support 21CCLC sites in the future, Paragon TEC was tasked with conducting an implementation evaluation study of the collaboration between NASA and the ED as 21CCLC conducted a series of NASA-developed STEM challenges with students in out-of-school time (OST). The present evaluation focused on answering the four *guiding research questions,* listed below, that NASA provided to Paragon in the form of a pilot study for potential future collaborations between NASA and ED. With each question is a summary of the present study's findings. It is worth mentioning that this study utilized both qualitative and quantitative data sources in order to get both numerical results and a "big picture" overview of the collaboration. Also, while twenty-two 21CCLC sites participated in the collaboration, a representative sample of six key sites was selected for the purposes of this study.

1) **To what extent did 21CCLC sites utilize NASA content, training and supports?**
   a) Based upon site visits, all sites utilized NASA content training and supports to implement the Challenges.
   b) Most sites implemented multiple STEM Challenges, though only one was required.
   c) All sites participated in at least one SME Live Event.
   d) 21CCLC facilitators, who had varying STEM education backgrounds, were all able to implement a STEM Challenge successfully.

2) **To what extent were NASA's content and supports aligned to 21CCLC objectives and needs?**
   a) Site interviews confirmed that NASA's content and supports were aligned to 21CCLC objectives and needs.
   b) It is worth noting that 21CCLC sites have very similar goals and objectives with respect to STEM programming.
   c) Sites continued to utilize further NASA STEM Challenges after the requirements of the study were fulfilled, which indicates that this content was highly aligned to 21CCLC objectives and needs.
   d) All sites reported that NASA's STEM Challenges built the sites' respective capacities to present STEM programming to students.
   e) NASA's STEM Challenges provided sites with hands-on activities appropriate for the afterschool setting.

3) To what extent did students find NASA's materials engaging?

a) During the interviews, all sites reported that the NASA's activities and materials were appealing and engaging for their students, though technical difficulties sometimes limited the impact of SME interactions.

b) Relevant Dimensions of Success (DoS) protocol ratings were high. In fact, the Materials Dimension as well as the Engagement in STEM Dimension had the highest average scores out of all Dimensions.

4) What recommendations would 21CCLC staff make to improve usability, access, or alignment of NASA's resources, training and support?

a) Maintain a one day, face-to-face training in which all of NASA's STEM Challenges are presented in equal fashion with hands-on activities, simulating student requirements.

b) Provide paper copies of training materials in advance of the training date.

c) Ensure 21CCLC facilitators have access to the STEM Challenges website and can locate materials on an ongoing basis. NASA content trainers should model how to access NASA Challenge Website and materials.

d) Utilize a video conferencing platform when interfacing sites with NASA SMEs. Furthermore, establish training protocols to mitigate technical difficulties that may arise with the platform.

e) Increase the interaction between NASA SMEs and students participating in the STEM Challenges. Specifically, provide opportunities for students to develop rapport with the SMEs.

Based upon the findings of this study, it is clear that the collaboration between NASA and ED regarding STEM Challenge use by 21CCLC sites was highly successful. With continued refinement, such collaborations have the potential to produce excellent return on investment in the long term. Exhibit A, below, summarizes the average scores on each of the twelve Dimensions across the four Domains of the DoS protocol.

Exhibit A: DoS Results Summary

	Features of Learning Environment				Activity Engagement		
Domain	Organization	Materials	Space Utilization	Domain	Participation	Purposeful Activities	Engagement in STEM
Average Score (Out of 4)	3.33	3.88	3.22	Average Score (Out of 4)	3.55	3.55	3.77

	STEM Knowledge and Practices				Youth Development in STEM		
Domain	STEM Content Learning	Inquiry	Reflection	Domain	Relationships	Relevance	Youth Voice
Average Score (Out of 4)	3.22	3.66	3.66	Average Score (Out of 4)	3.55	3.22	3.22

II. Methodology

A. Description of the Collaboration

According to the task notification for this evaluation, the overarching goal for the interagency collaboration was to align resources among the agencies to address the national need for a STEM-educated workforce. These objectives parallel NASA Strategic Goal 6 to "share NASA with the public, educators, and students to provide opportunities to participate in our mission, foster innovation and contribute to a strong National economy." The objectives also support ED in accomplishing its mission to promote student achievement and preparation for global competitiveness by inspiring more of tomorrow's workforce to pursue STEM-related subjects and fields. As we describe later, the planning and implementation of the collaboration diverged. For example, while NASA originally envisioned each 21CCLC interacting with NASA SMEs up to three times, the final requirement was one SME interaction. NASA Education relied upon the following criteria to select STEM challenges for the initial ED collaboration:

- project-based content appropriateness for middle school students,
- relevance to agency missions,
- use of the engineering design process,[5]
- and video submission format in the challenge.

Accordingly, the following three NASA-developed STEM Challenges[6] were selected:

- Parachuting onto Mars (POM)
- Spaced Out Sports (SOS)
- Exploration Design Challenge (EDC)

These three challenges typically require three to five days to implement in an OST setting. Although the content knowledge varied, all three challenges had a project-based approach where students work on designing a product by collecting data to refine its design. Exhibit B presents a brief comparison of these three challenges by target grade, science, technology, engineering and math concepts addressed, and the duration of activities.

[5] See http://www.nasa.gov/audience/foreducators/plantgrowth/reference/Eng_Design_5-12.html#.UzCdUFdKJFs for more information about the Engineering Design Process.
[6] See https://www.nasa.gov/education/SoI/STEMchallenges for more information on NASA STEM Challenges.

Exhibit B: Three NASA-developed STEM Challenges

	Parachuting onto Mars	Spaced out Sports	Exploration Design Challenge
Challenge Description	Students will use the engineering design process to develop a landing system that creates the most drag to safely land a spacecraft dropped from a great height.	Students apply their understanding of Newton's laws of motion to design a game or activity for a microgravity environment.	Students use the engineering design process to build a prototype radiation shield that effectively blocks simulated space radiation on a spacecraft that will carry astronauts beyond low Earth orbit and on to an asteroid or Mars.
Challenge Grade Levels	5-8	5-8	5-8
Challenge Duration	Three 45-minute sessions	1 hour prep 45 min.-1 hour for Newton's Laws activity 2-3 hours for challenge	90 minutes
Challenge Product	Student teams will create and submit a video featuring the process they followed to arrive at the drag device that best slowed the descent of their spacecraft.	Student teams will create a Game Instruction Sheet about their game design and an accompanying video for submission to NASA.	Student teams will create and submit a video featuring the process they followed to arrive at their best radiation shielding design for a spacecraft.

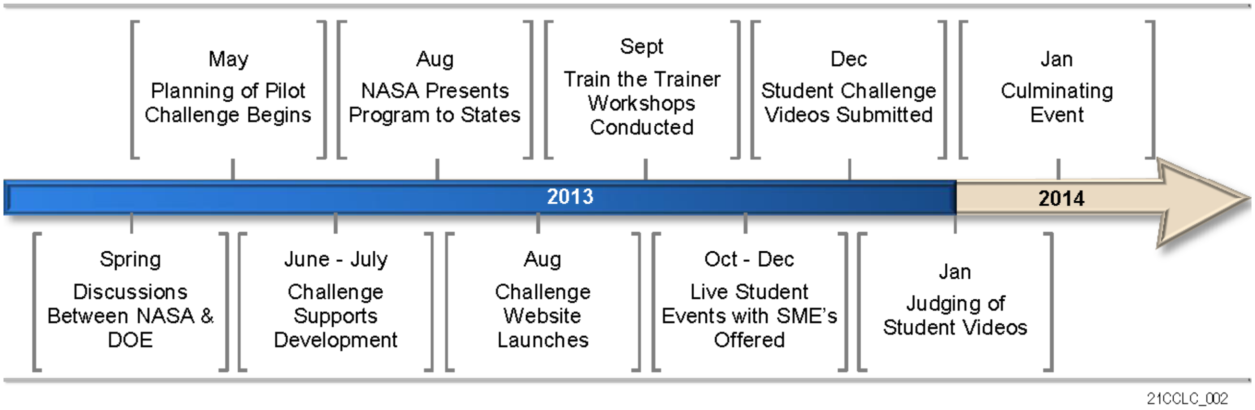
Each of NASA's STEM Challenge included the following materials for effective implementation:

- Description of Challenge,
- Educator Guide/Lesson Plan,
- Challenge Checklist for Instructors,
- Mission Briefing Videos for each challenge,
- Sample PowerPoint Presentation,
- Educator Helpful Hints,
- Student Instruction Sheet,
- Rubric,
- Video Submission Instructions,
- and Extension Links.

Exhibit C, on the following page, presents the timeline and activities of this collaboration project. NASA planned for the collaboration to consist of the following activities:

- site selection,
- face-to-face training to 21CCLC sites and providing support materials,
- implementation of NASA Challenges at 21CCLC sites,
- NASA SME involvement,
- and a culminating student activity.

Exhibit C: Timeline of Events

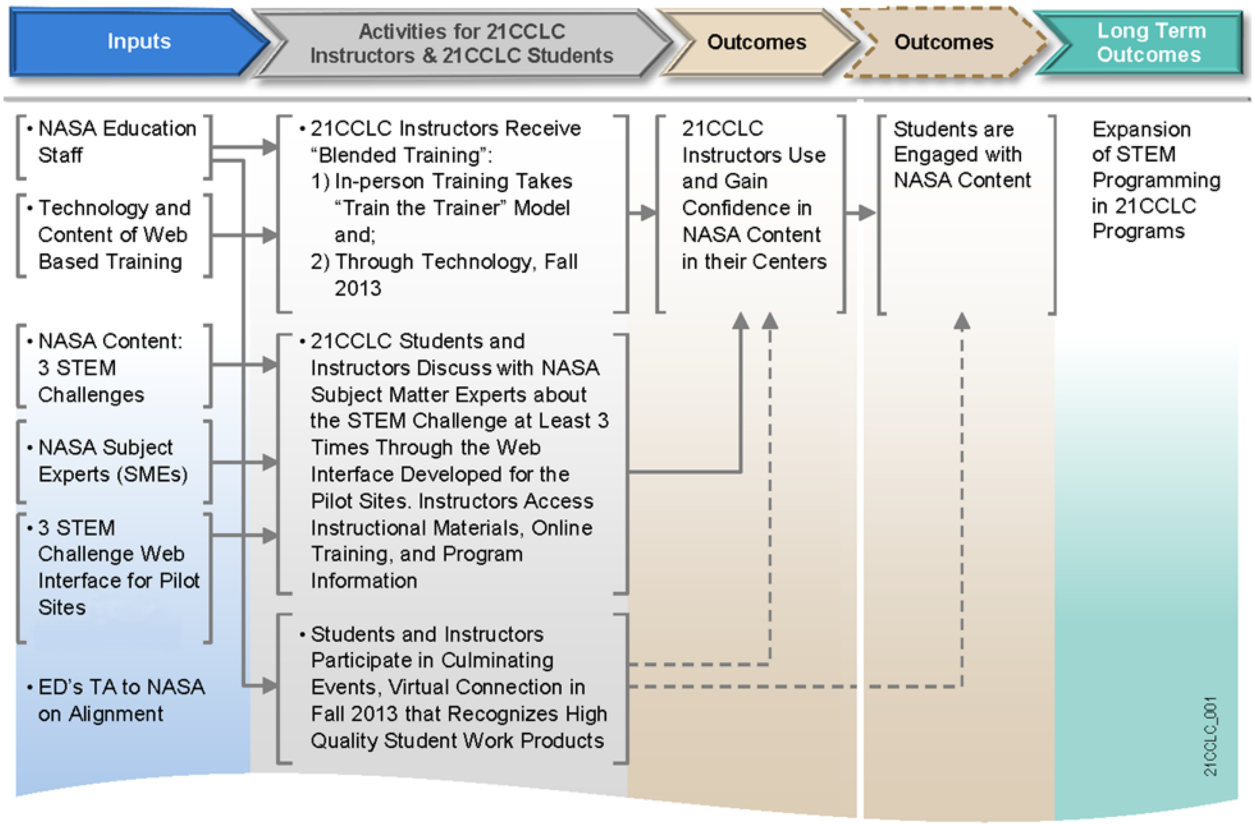


B. Approach to Evaluation

In order to answer the guiding research questions and to generate actionable recommendations, Paragon TEC designed data collection and analysis to identify and differentiate intended and actual implementation of planned activities. Because the purpose of this evaluation was to learn from the implementation and to generate recommendations to improve NASA's training and support for 21CCLC sites, this evaluation used intended process and outcomes as a primary guide to examine how 21CCLC sites utilized training and support and implemented NASA's STEM Challenges. Data collection and analysis was conducted in such a way as to highlight discrepancies between the actual versus intended implementations. To begin, NASA Education's intentions for each collaboration activity (e.g. in person training, interacting with NASA SMEs, etc.) were identified. Later, the evaluation team interviewed the 21CCLC staff at selected sites. The evaluation team's questions focused on whether 21CCLC staff experience was consistent with NASA Educations intended results.

The logic model (Exhibit D), on the following page, maps the intended flow of inputs, outputs and outcomes from the NASA Education Staff and ED (partners) to the instructors, students and families to 21CCLC project outcomes. NASA Education staff's intention was for the training and support materials that they provided to make 21CCLC instructors confident in implementing the NASA-developed STEM Challenges. NASA Education staff also envisioned that the STEM Challenges would engage students. During the development of the collaboration project, evaluation team members met with NASA Education staff regularly to communicate as details emerged.

Exhibit D: Pilot Project Logic Model (as of May 2013)



C. Site Selection

A total of twenty-two 21CCLC sites in three states (Colorado, Michigan, and Virginia) participated in this collaboration. The U.S. Department of Education selected these States and sites based on interest and availability for training. All of the 21CCLC sites participating in this collaboration provide service to students in grades five through nine in public schools with a low socio-economic designation. The twenty-two 21CCLC sites participating in this pilot project, identified by state, are as follows: six sites in Colorado, eight sites in Michigan, and eight sites in Virginia. Due to the brevity of the data collection timeline, six 21CCLC sites were selected as a representative sample. These key sites were chosen based upon site availability, location, and STEM Challenge implementation in order to maximize the diversity of the sample. All sites were located in urban school districts. The following are pseudonyms of the sites visited:

- Site A (middle school, Colorado)
- Site B (middle school, Virginia)
- Site C (high school, Colorado)
- Site D (middle school, Michigan)
- Site E (middle school, Virginia)
- Site F (middle school, Virginia)

D Data Collection

In order to increase validity of information utilized for this report, the evaluation team collected data from multiple sources. The data used by the evaluation team to answer the guiding research questions was derived from several different sources, including:

- a document review,
- support team interviews,
- training observations,
- website analytics,
- and engagement observations.

Surveying participants was not an option due to the pilot project timeline and data collection constraints of the Paperwork Reduction Act (PRA). Data collection activities were reviewed by the NASA Institutional Review Board (IRB) Committee for the Protection of Human Subjects (CPHS) in Houston, TX. See Appendix A for the IRB exemption letter. Exhibit E, below, provides a short summary of the data sources utilized. Details regarding each of the data collection activities as well as the respective data analyses follow.

Exhibit E: Data Source Summary

Data Source	Summary
1. Document Review	Review of documents, website, and materials produced by NASA Education staff for implementation, training, and support.
2. Support Team Interviews	Interviews with NASA Education staff members, who were involved in planning and implementing the training, support to 21CCLC and sessions with NASA content experts.
3. Training Observations	Observation of in-person train-the-trainer sessions.
4. Website Analytics	Review of the documents and logs that inform access to the online training and support site, and access to NASA content experts, and instructional materials produced by NASA.
5. Engagement Observation	Documentation of STEM activities at the six key 21CCLC sites to understand how NASA Challenge is implemented in their 21CCLC classrooms using the Dimensions of Success Protocol.

1. Document review

This information provided an understanding of the overall goals, objectives, approach, design and implementation of the collaboration project. A review was conducted of:

- available training documentation on the STEM Challenges website,
- materials (PowerPoint slides and activity guides) produced by NASA Education staff for training and support of 21CCLC sites,
- and 21CCLC site information provided by ED staff.

Additionally, the evaluation team reviewed the 21CCLC site descriptive information (location, challenge selected, and contact information) in order to select six sites to visit, observe and interview.

2. Support team interviews

Interviews were conducted with NASA Education staff members, who were involved in planning and implementing the training support to 21CCLC. The NASA Education staff included those individuals responsible for the training sessions, live web seminars, on-demand video training, STEM Challenge Guide, and Help Desk support. The interview protocols were developed in order to learn the scope of activities (goals of activities and specifics of activities) as well as NASA's vision regarding how 21CCLC sites should utilize support and implement the STEM Challenges.

The interviews were primarily conducted in group settings consisting of NASA content trainers as well as other NASA Education staff. Two members of NASA's educational staff were interviewed individually, but the time constraints of this pilot study prevented further one-on-one interviews. Interviews were audio recorded and response notes were documented. Audio recordings were transcribed and compared with documented response notes for response data accuracy. In the event of missing data and/or unclear responses from the interviewee, a follow up communication (e.g. email, phone conversation, etc.) occurred to ensure the response data was complete. Completed interview response notes were categorized by interview topic and question and reviewed in order to answer the implementation evaluation questions. Please see Appendix B for NASA Education staff interview protocols.

3. Training observations

Observations were conducted of in-person facilitator training sessions. It should be noted that these training sessions were intended to utilize a train-the-trainer model. However, in five of the six key sites, the facilitators attended directly. This caused some confusion during data collection, as some of the evaluation protocols were not designed with this scenario in mind. Evaluation team members took notes by focusing on the engagement of participants and documented general feedback by training participants in order to evaluate if training was delivered as planned and if it achieved intended outcomes.

4. Website analytics

The evaluation team reviewed documents and logs that tracked access to the following:

- the online training and STEM Challenges websites,
- access to NASA content experts,
- and downloads of support materials produced by NASA.

5. Engagement observation

In person observations of STEM engagement activities at five 21CCLC sites were conducted to understand how NASA's STEM Challenges were implemented in their 21CCLC classrooms using the DoS protocol[7]. DoS is an observation tool that focuses on twelve dimensions of quality in STEM out-of-school programs (see Exhibit F at end of section), which are grouped into four broader domains. Exhibit G, on the following page, contains further details on the twelve Dimensions and their groupings within the four Domains.

Two members of the evaluation team, certified in the use of the DoS protocol by the Program in Education, Afterschool, and Resiliency (PEAR) team, conducted one observation of Challenge activities at five 21CCLC sites. Each of the twelve DoS dimensions were rated using a rubric indicating evidence of excellence, where a rating of "1" indicates evidence is absent, "2" indicates there is inconsistent evidence, "3" indicates there is reasonable evidence, and "4" indicates there is compelling evidence. According to the developers of the DoS tool, ratings of three or four on a dimension are desirable ratings.

6. Site visit and interview

Six site visits and interviews were conducted with site directors and/or change facilitators to determine how sites utilized NASA training and materials and to collect suggestions for improving NASA's training and support. Interviews were audio recorded and response notes were documented. Audio recordings were transcribed and compared with documented response notes for response data accuracy. In the event of missing data and/or unclear responses, a follow up telephone conversation was held with the interviewee in order to ensure the response data was complete. Completed interview response notes were categorized by interview topic and question and reviewed in order to answer the implementation evaluation questions. Please see Appendix C for site interview protocols.

7. End Observation

An observation of the online culminating event held on January 13, 2014 was conducted to review selected student presentations and interaction with NASA and ED Leadership.

[7] Shah, A. Wylie, C. Gitomer, D., Noam, G. (2013). *Technical Report for the Dimensions of Success: An Observation Tool for STEM Programming in Out-of-School Time*. Released by Program in Education, Afterschool, and Resiliency (PEAR) at Harvard University and McLean Hospital.

Exhibit F: The Four Domains and Twelve Dimensions of the DoS

Domain	Dimension
FEATURES OF THE LEARNING ENVIRONMENT – To what extent is the environment suitable for STEM programming?	1. Organization 2. Materials 3. Space Utilization
ACTIVITY ENGAGEMENT – To what extent is the activity engaging students?	4. Participation 5. Purposeful Activities 6. Engagement with STEM
STEM KNOWLEDGE AND PRACTICES – To what extent do students understand STEM concepts, make connections, and participate in practices of STEM professionals?	7. STEM Content Learning 8. Inquiry 9. Reflection
YOUTH DEVELOPMENT IN STEM – To what extent do interactions encourage student participation, activities are relevant to students' lives and experiences? Additionally, are students are encouraged to voice their ideas and opinions and make meaningful choices?	10. Relationships 11. Relevance 12. Youth Voice

Exhibit G: Key Prompts for each DoS Dimension

Features Of The Learning Environment		
Organization • Are the activities delivered in an organized manner? • Are materials available and do transitions flow?	Materials • Are the materials appropriate for students, aligned with the STEM learning goals, and appealing to the students?	Space Utilization • Is the space utilized in a way that is conducive to OST learning? • Are there any distractions that impact the learning experience?
Activity Engagement		
Participation • Are students participating in all aspects of activities equally? • Are some students dominating group work?	Purposeful Activities • Are the activities related to the STEM learning goals?	Engagement in STEM • Are students doing the cognitive work while engaging in hands-on activities that help them explore STEM Content?
Stem Knowledge And Practices		
STEM Content and Learning • Is STEM content presented accurately during activities? • Do the students' comments, questions, and performance during activities reflect accurate uptake of STEM content?	Inquiry • Are students participating in the practices of scientists, mathematicians, engineers, etc.? • Are students observing, collecting, data, building explanations, etc.?	Reflection • Do students have opportunities to reflect and engage in meaning making about the activities and related content?
Youth Development In Stem		
Relationships • Are there positive student-facilitator and student-student interactions?	Relevance • Is there evidence that the facilitator and students are making connections between the STEM content and activities and students' everyday lives and experiences?	Youth Voice • Are students encouraged to voice their ideas/opinions? • Do students make important and meaningful choices that shape their learning experience?

III. Findings

A. Evaluation Question 1: To What Extent Did 21CCLC Participants Utilize NASA Content, Training, and Supports?

In order to support 21CCLC sites to implement NASA Challenges, NASA Education provided training, support materials and opportunities to interact with NASA SMEs. In this section, how NASA Education staff structured these support services and 21CCLC site's experiences of these services are reported. The evaluation team focused analysis on comparing how NASA Education staff envisioned NASA content, training and support should be utilized, what strategies NASA Education staff took to promote utilization, and the report of 21CCLC sites utilizing NASA content, training and supports.

1. NASA Education's approach to support services

NASA Education's support team planned the following types of support services so 21CCLC sites would be able to implement NASA's STEM Challenges:

1. Training of site personnel included an 8-hour meeting during which representatives from the 21CCLC sites learned how to implement the STEM Challenges from NASA content trainers. A webinar with NASA content trainers reviewed Challenge implementation with facilitators.
2. On-Demand virtual materials which includes online training and materials, videos to be used to implement NASA's STEM Challenges.
3. Virtual meeting with NASA SMEs. These SMEs were made available to answer questions associated with NASA's STEM Challenges.

NASA planned these support services based on its experience in similar projects. It is well-known to NASA that teachers require training in 21st Century education[8]. NASA Education leveraged existing assets including SME and content related to current NASA missions and projects. Exhibit H, on the following page, summarizes NASA's approach.

Exhibit H: Intended Outcomes of Face-to-Face Training and Other Online Support

Types of NASA Support	Intended Outcomes
Face-to-Face Training	Facilitators feel confident to implement NASA Challenge and understand math and science concepts needed to implement NASA Challenge
Web-based Live Conference	Each 21CCLC sites accesses at least one training for those challenge facilitators who did not attend the face-to-face training.
NASA SME	Each 21CCLC site interacts in real time with a NASA SME in order to develop an understanding of the connection between the Challenge they are working on and the real world Missions currently being focused on by NASA.

[8] Jost, M., Carter, T., Lipscomb, N., Worrell, T. W., & Shimmel, K. (2011). NASA Summer Research Institute: Enhancing 21st Century Teachers' Capacity for STEM Instruction. *National Teacher Education Journal*, *4*(4), 61-69.

a. Face-to-Face training

The face-to-face training was conducted in each of the three states. State 21CCLC administrators were tasked by the ED to select individual 21CCLC grantee sites to participate in the NASA Challenge. NASA Education staff designed the face-to-face training in order to support the implementation of NASA's STEM Challenges by making 21CCLC site staff:

1. Feel comfortable and confident in implementing a NASA-developed STEM Challenge.
2. Build proper content knowledge to support students in working on STEM Challenges.
3. Feel confident to provide training, as needed, to other instructors by using online training resources and materials.

NASA content trainers used the following training approaches during the face-to-face training to achieve the above goals.

1. NASA content trainers spent an hour familiarizing participants in structure of STEM Challenges and with NASA's relevant resources. The purpose and outcome of the program were described, and website access information provided. The collaboration's goal, which was to provide a STEM learning experience that engages and inspires students, was conveyed.
2. NASA content trainers modeled each step students would take as they worked on the STEM Challenges. During trainings in Colorado, Michigan and Virginia, NASA content trainers spent approximately one hour presenting the challenge and then offered the hands-on activities accompanying each challenge. The evaluation team observed that all participants were engaged with the activity.
3. In each of their presentations NASA content trainers introduced examples of widely-held misconceptions and spent time identifying pre-requisite content knowledge, which students would need to understand in order to work on NASA's STEM Challenges. For example, during training in Virginia, NASA trainers introduced the difference between mass and surface area, and its relation to gravity and acceleration the group then spent 15 minutes discussing how to introduce these concepts to students using common classroom objects. The trainers also showed a video clip of the Apollo 15 Mission moon landing, including a scene of an astronaut dropping a hammer and feather in minimal gravity, to debunk the common misconception that heavier objects drop faster.
4. NASA content trainers also requested all participating 21CCLC sites participate in one live web-based conference to review the challenge requirements and answer questions from challenge facilitators. NASA content trainers indicated webinars would be available as a follow up to the face-to-face training.

NASA Education staff reported that the site facilitators' content knowledge and pedagogical skills were a significant factor affecting the successful implementation of one of NASA's STEM Challenge, which are project-based learning activities. Not all after school program instructors have sufficient STEM education background to facilitate student inquiry in such a process. Thus, the one-day training, in the content trainers' own words, was to "provide enough background knowledge refreshers, good conversation around instructional practices for the implementation of the challenges."

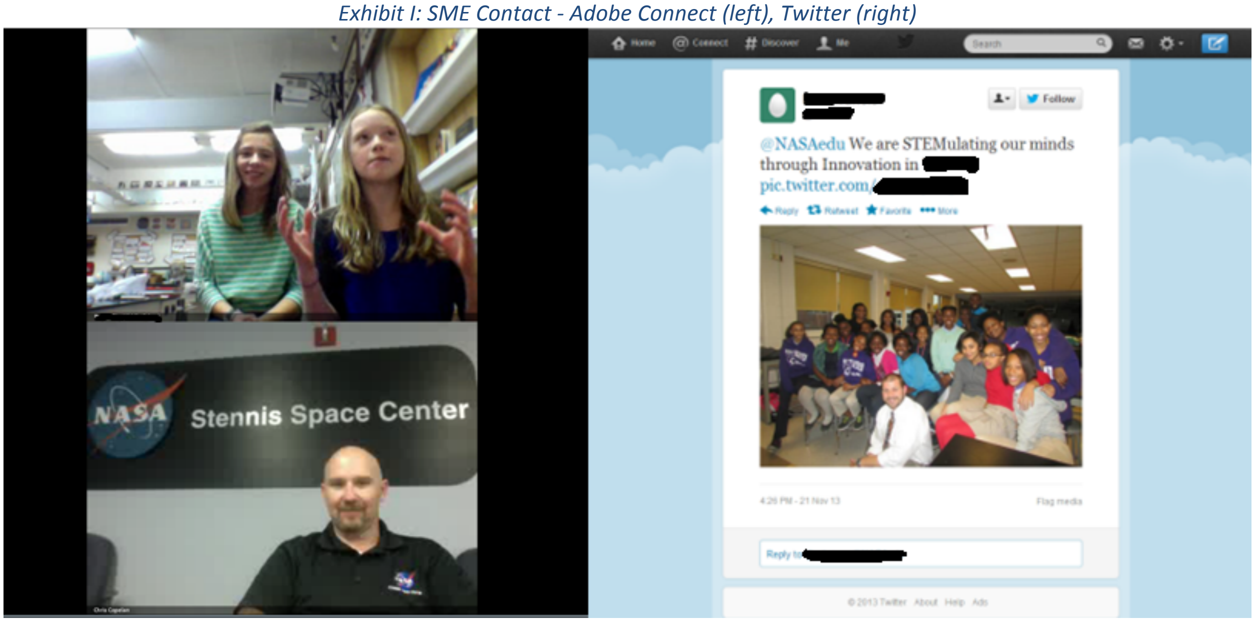
b. Online materials and support

NASA Education also created several training overview and classroom management videos for each of the STEM Challenges utilized in this collaboration. Pre-existing video content available for each of the STEM Challenges was also made available. All videos were organized by associated STEM Challenges on the website. The NASA Education support team anticipated that 21CCLC sites would use these videos when implementing the NASA-developed STEM Challenges as well as to train any 21CCLC instructors who did not attend the face-to-face training. Materials checklists and student handouts were also provided to support all STEM Challenges for sites to use at their discretion.

c. Access to NASA SMEs

The NASA Education support team also arranged for each 21CCLC site to have an opportunity to communicate with a NASA SME. Each of the three NASA content trainers was responsible for identifying and coordinating with an SME with expertise relevant to the content area of the STEM Challenge selected by each site. The goal of providing an interaction with a SME who is currently working on a NASA Mission or project related to the challenge was to inspire and support students as they worked on the Challenge. Due to time constraints, some SME connections were shared by more than one site. During these connections sites were also able to interact with other sites. Sites reported being able to see what other schools were doing was inspiring. This feature was not a planned part of the activity but yielded positive reactions.

Exhibit I: SME Contact - Adobe Connect (left), Twitter (right)



Sites connected with the SME via Adobe Connect or Twitter (see Exhibit I, above). When using Twitter, sites were given a designated hashtag by which to code their questions to the SME. The SME tweeted responses using the same hashtag. When using Adobe Connect sites logged into a designed virtual room and were able to view and interact with the SME by talking directly or using the chat window. When possible sites used the video feature, it allowed them to be seen by the SME. In an email from NASA Education, sites were presented with dates and times the SME were available and sites submitted their ideal dates to NASA. Sites were assigned either Adobe Connect or Twitter as the mode of connection.

It is important to note that NASA Education staff was aware of potential risks of these support services. NASA Education staff had some control over the risks, but not all of them. Below are some potential risks anticipated by NASA Staff:

- Some instructors (sometimes volunteer parents) may need far more training to support their students to work on NASA Challenge because they do not have math and science background and do not know inquiry based instruction. NASA Education relied on each 21CCLC site to select instructors who were likely to learn and able to implement the NASA Challenge.
- Train-the-trainer model heavily relies on each training participant to train others. NASA Education staff was concerned some sites may not be able to provide training to instructors. NASA Education staff did not have much control over how instructors work together at each site. The evaluation team found, from the interviews with 21CCLC sites, four sites did not need to provide training to other instructional staff. Two sites both provided training to other instructors. At both sites, trainer and trained instructor worked together to develop the instructional plan.
- Some 21CCLC sites did not have sufficient access to technology or the Internet to fully utilize online support provided by NASA. NASA Education selected YouTube, Adobe Connect, and Twitter to communicate with NASA Challenge Trainers and to see videos because they did not need to go through the firewall and students can access by using their own devices. At the beginning of this pilot project, NASA Education staff was not sure if these efforts could increase accessibility to support materials and NASA Content Expert.
- The timeline for this collaboration was very limited. NASA Education staff was cognizant of their lack of experience working with 21CCLC programs and how the proposed timeline would work.

2. Six 21CCLC sites' report on how they utilized NASA content, support, and materials

Reports from the six key 21CCLC sites indicated face-to-face training achieved its intended goals, however, support through the Internet was not utilized as NASA Education team had intended. Below is a presentation of reports from the six key 21CCLC sites about their experiences with the above support services.

a. Face-to-face training

Did 21CCLC site instructors feel confident to implement NASA Challenge after the face to face training?

All six key sites reported the one day face-to-face training made them sufficiently confident to implement one of NASA's STEM Challenges. All 21CCLC site staff who attended the training opined that the hands-on activities utilized by the NASA content trainers were engaging, and they also liked the approach taken by trainers, especially going through each step of the STEM Challenge activities on which students would be working. The 21CCLC site staff who attended the training role-played being one of the 21CCLC students during the training. As one attendee stated, "We did what the kids had to do so it made it easy for us interpret it for the kids." The 21CCLC site staff stated that they planned to use the same methods in activity delivery as the content trainers had used. This parallels several decades of research on the so-called "apprenticeship of observation" popularized by Dan Lortie's *Schoolteacher: A Sociological Study* (1975). In short, teachers tend to teach as they, themselves, were taught.

Did 21CCLC site instructors learn science concepts?

NASA Education considers it to be critical for instructors to have accurate knowledge about STEM concepts for supporting students' meaningful engagement with STEM. Likewise, ED enforces this tenet through the requirement of teachers being highly qualified in the content areas that they teach. It became evident, in the training sessions, that some of the 21CCLC staff held misconceptions about science. The 21CCLC staff who attended training were very receptive to the discussion and some went so far as to take notes. During subsequent interviews with 21CCLC site staff, the evaluation team did not hear any negative comments or confusion about what was presented during the face-to-face training. One site, which did not have any prior experience with STEM education, reported a new belief in the ability for complex abstract ideas to be delivered in approachable ways.

However, observations led the evaluation team to suspect that not all 21CCLC instructors grasped accurate STEM concepts. At Site D, which was implementing the POM STEM Challenge, one instructor was observed to be incapable of answering a student's question about a science concept. The student in question asked whether someone's arm becoming numb altered the mass; the instructor did not know if the mass would be changed. It is important to note that this site never had STEM programming prior to the implementation of this STEM Challenge and that this instructor did not have any background in STEM.

During the observations, the evaluation team did not observe instructors conveying inaccurate representations of scientific concepts. However, the way instructors facilitated the discussion around science concept varied from site to site. At three sites, instructors asked questions to encourage students to connect science concepts with the STEM Challenge tasks. As an aside, the evaluation team rated such practices as 4 on the Reflection dimension of the DoS protocol. At two other sites, instructors asked questions to students, but students' reflection was limited to answering closed-ended questions rather than open-ended reflection prompt. Students had opportunities to engage in STEM practices including asking questions, analyzing data and constructing explanations (DoS Inquiry rating of 4). Unfortunately, they were limited in opportunities to make connections to personal experiences and/or larger STEM issues (DoS Relevance rating of 3).

From the observations, it is difficult to determine if the degree of prior STEM programming shaped the way instructors facilitate students' exploration of scientific concepts. Among two sites with no prior experience with STEM programs, different levels of students' engagement with reflective discussion were evident. On the day of observation, Site C had two students working on the NASA-developed STEM Challenge, and those students were observed as having high engagement with reflective discussion. In contrast, Site D was observed as not having all students on task, and there was a classroom management issue of the eighteen students participating in the STEM Challenge there. The facilitator at Site D had difficulty in encouraging all students to reflect on the science content. In the rest of the sites the evaluation team observed facilitators asking reflective questions and students answering them. It was discovered that Site E had extensive experience with STEM program. In fact, Site E is a STEM-designated school, and instructors were knowledgeable about inquiry based and project based instruction.

Other comments

As described above, 21CCLC site facilitators were in agreement that face-to-face training made them ready to implement NASA's STEM Challenge. In addition, based upon the interviews, 21CCLC sites described the following aspects of the training was helpful:

- Facilitators reported that the materials provided by NASA were helpful and they felt they had everything they needed to implement NASA Challenge at the end of the training. These materials include samples of the hands-on products students would create and a folder with handouts describing the Challenges. Participants in the last training were encouraged to take the access inventory of supplies to use with their students.
- Facilitators also reported the helpfulness of LiveBinders[9]. For example, one instructor from Site C reported, "Just an easier way to get to our direct things… it's a nicer shortcut to get to our materials." Similar comments were received from a staff member of Site E.
- NASA trainers, who provided instructional strategies based on their own experiences, were reported to be helpful.
- Facilitators preferred to learn about all three of the NASA-developed STEM Challenges was better than learning only one.

[9] A web-app that simulates a 3-ring binder. See http://www.livebinders.com/

b. Online materials and support

Did 21CCLC sites participate in online training?

All twenty-two sites participated in online training at least once. However, online training was not generally utilized as NASA Education had planned. While the NASA Education support team intended for sites to use the training materials to train others on an ongoing basis, Site C was the only site to use the train-the-trainer model. The Site's Director attended the training and then met with the Challenge facilitator several times before implementation began. The facilitator used the on-demand training materials to provide the background knowledge needed to successfully implement the Challenge. The site had very little experience with STEM programing and their facilitator did not have any teaching experience. Despite the lack of STEM experience Site C submitted a high-scoring video and participated in the culminating event. The other five key sites had STEM Challenge facilitators attend the face-to-face training directly. Consequently, there was no need at those sites for train-the-trainer to be implemented.

According to four of the six key sites, materials provided during face-to-face training were sufficient for implementing the selected STEM Challenge. Additional online training models were generally considered to be superfluous by sites. Only two key sites reported that they used and were satisfied with the online training and supports. The on-demand materials available were considered by sites to be sufficient for implementing the challenge.

Locating the STEM Challenges website was difficult for some sites. The STEM Challenges site was embedded in NASA.gov, and participants were encouraged to use a link on the 21CCLC website to access it. This led to confusion as to what URL was to have been used to access STEM Challenge materials. Site F and Site D reported having to fall back on a Google search in order to find their selected STEM Challenge materials, bypassing the official STEM Challenges website entirely.

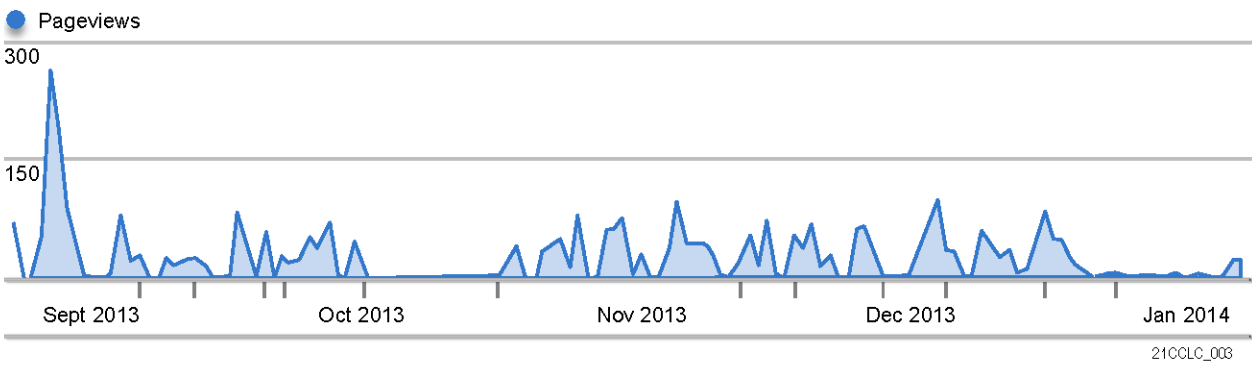
Utilization of NASA materials

NASA Education made materials available on a website so facilitators could use them to implement NASA Challenges. From the interviews with 21CCLC staff and observations of the implementation of NASA Challenges at each 21CCLC site, all sites used materials, such as video and worksheets, provided by NASA Education. All six key sites reported using materials that were online. The key sites also reported employing PowerPoints, checklists, explanations of glossaries, and video clips. Sites also reported reviewing webinars.

Sites continued using NASA materials after the primary Challenge was completed — a significant finding. This indicates that there is an on-going need for STEM education content and that NASA's materials and supports that were effective and appealing for sites to fill this need. Exhibit J, below, is a usage report, showing how many times online training and material sites were accessed. The increase in usage in September of 2013 can be attributed to two factors. One is that an email introducing the Challenges was sent to participants in early

September including a link to the Challenges website. The other factor was that face-to-face training took place during that time and participants were encouraged to access the website during the training sessions.

Exhibit J: Page views Timeline



During the first half of October 2013, the Federal government experienced a shutdown. All Federal Agency websites were rendered unusable during the duration of the shutdown. As Exhibit J depicts, website views stopped during much of the month of October 2013. Usage picked up to pre-shutdown levels once the website came back online. The evaluation team contends that the impact of the government shutdown was the direct cause of the decline in use of the online training materials. The STEM Challenges website was disabled during this time, and access to NASA staff was not possible. As stated previously, participants felt that finding challenge materials was difficult. There was already confusion as to what URL to use when accessing the STEM Challenges website, and the nearly three week shutdown only added to that confusion. Below, Exhibit K summarizes some aggregate page view data.

Exhibit K: Website Usage

	Page Views	Unique Page Views	Average Time on Page
Total	3,597	1,786	2:28

c. Live connection with NASA SMEs

NASA Education required each site to communicate with NASA SME at least once. The technical platforms used for live student events were Adobe Connect and Twitter. Four of the six key sites connected with SMEs via Adobe Connect, and one key site used Twitter. The remaining one key site used both platforms at different times. Sites selected the dates they were able to connect, and NASA assigned the mode of connection. Dates and times of connections were based on SME availability. 21CCLC sites were presented with a set of available dates, times, and medium of connection when a SME was available to connect with them. 21CCLC sites selected the medium of connection on a first come first serve basis. NASA Education selected Adobe Connect because it allows participants to join a video conference without having to download software. This is in contrast to alternatives such as Blackboard which require the installation of JAVA. Adobe Connect is an interface used often by NASA.

The majority of the sites reported SME contact as being beneficial to their students; but, due to technical difficulties, the maximum potential benefit was not realized. Out of the six key sites, five sites reported having technical difficulty of some sort when connecting with NASA SMEs. The most common technical difficulty reported was loss of sound, which can often be attributed to network latency. In such cases, all sound from NASA would suddenly stop. Schools reported that logging out of Adobe Connect and logging back in would fix the problem but students would lose valuable time interacting with the SME. Three of the four sites that used only Adobe Connect (Sites C, D, and F) reported that they had significant audio problems. As a result, these three sites had limited participation. Specifically, Site F typed in questions, but their questions were not answered. Another site's Adobe Connect continued to refresh and there was no sound. Students watched the video feed with no sound and read the chat box in an attempt to participate. While all these technologies aimed at real-time interaction between students and 21CCLC sites, site responses indicate that Adobe Connect was better than Twitter. Sites reported the following three aspects:

a) Students had to wait as much as twenty minutes to receive answer from NASA SME via Twitter. (Site E)
b) When they put questions on Twitter, they popped up somewhere else. Although students liked it, the instructor reported she was not sure how much information students are getting from the conversation. (Site E)
c) Twitter's length-limit constrained questions instructors and students could ask. (Site A)

In addition, timing the interaction with NASA SME was challenge both in terms of where the site was in the process of implementing the NASA-developed STEM Challenge as well as simply scheduling. For example, Site A suggested it would have been more helpful for students to talk to their SME earlier in the implementation. Site E reported the time allowed to interact with NASA SME was not convenient for the 21CCLC afterschool programming. Finally, Site B requested that future SME contact be more salient to the STEM Challenge being utilized.

Sites did appreciate the value of real time interaction with NASA SMEs. Site C experienced technical difficulty and they ran out of time to stay on line, hence students did not have an opportunity to ask questions to NASA SME. However, the instructor reported it was valuable to their students, "There was value to it, especially for our population and because we have a large Hispanic population at our school and the scientist they were talking to was Hispanic, so that was really neat and kids were like 'I bet he speaks Spanish.'" On the occasion where multiple sites were present for an SME contact, sites reported that their students benefited from seeing what other schools were doing. The school to school contact inspired students to improve their designs. Students thought it was "cool" to see other kids from across the county doing the same things they were doing. Taken together, 21CCLC sites saw the value of real-time interaction. However, the technological challenges prevented 21CCLC sites from fully benefiting from the support from NASA SMEs.

B. Evaluation Question 2: To What Extent Were Content and Support Aligned to 21CCLC Site Objectives and Needs?

According to site reports, the main goal of 21CCLC programs was to provide after school activities that improve students' academic performance in school. The secondary goals and objectives centered on providing enrichment activities aimed at college and career readiness. Exhibit L, on the following page, presents how sites identified alignment between center objectives and NASA's content and support.

The six key 21CCLC sites varied in their experience on providing STEM related activities ranging from no past experience, as in Sites C and D, to emphasizing STEM at their site as in the case of Site E, which is designated as a STEM school by the State of Virginia. Some 21CCLC sites interviewed did not have specific objectives when it came to STEM programming. Half of the sites reported having provided STEM programming in the past, mostly in the area of robotics. Only one key site reported STEM programming as its priority area because this site was in a STEM school. When asked about needs, all sites reported needing inexpensive and engaging activities that appeal to students in an out of school setting. Time for professional development during the school year was limited so training in the summer is ideal.

All key sites reported seeing alignment between their site objectives and the NASA-developed STEM Challenges. The sites reported the helpfulness of NASA's STEM Challenges in meeting 21CCLC's college and career readiness objectives. All sites agreed implementing NASA's STEM Challenges met their needs concerning improving student's grades, at least indirectly. In particular, the STEM Challenges required students to perform basic math computation and data collection in realistic scenarios. Sites E and B reported a crossover benefit in the regular classroom performance by students who participated in the STEM Challenges. Sites focused on promoting student interest in STEM careers attesting to NASA's STEM Challenges enabling students to see science as fun and encouraged students to look into STEM careers. Students learn all content subjects through the lens of STEM at one 21CCLC site and reported that the NASA Challenges provided opportunities to experience their STEM learning in new, exciting, and engaging way.

The sites varied in their view of how participating in this collaboration contributed to their respective capacities in providing STEM programs. Sites with no prior STEM experience were able to build STEM programming capacity because of the collaboration. Sites with more experience in providing STEM activities saw NASA's STEM Challenges as a valuable addition to their respective repertoires of programs and activities.

All sites reported that the materials needed for completing the challenge were appropriate and inexpensive. Sites referred back to the face-to-face training demonstration in helping site coordinators know what materials to purchase. All key sites reported NASA's STEM Challenges were engaging and appealing to students in an afterschool setting, particularly due to their hands-on design. Four of the six sites offered students a choice between participating in the

NASA STEM Challenge or other unrelated activities. Week after week, students chose to continue participating in the NASA Challenge activity.

Exhibit L: 21CCLC Objectives and Alignment with NASA Challenge

	Site Objectives	Prior STEM Experience	Alignment of Challenge to Site Objectives
Site A	Developing 21st Century Skills, Problem solving, College readiness	Moderate	NASA Challenge is in line with problem solving skill. Unmet need: Could not ask questions to NASA Content Expert and it was not very engaging.
Site B	STEM focus careers, Improve reading and math	Moderate	"Pilot opened eyes of coordinator." NASA Challenge will help improve math grade. Unmet need: NASA Content Expert did not address NASA Challenge
Site C	Improve grades, identify areas where students can improve.	None	NASA content and support aligned with center goals.
Site D	College and career readiness	None	NASA Challenge and training build STEM capacity in the center. NASA Challenge sparking student interest.
Site E	Raising students awareness and making STEM a part of students' everyday life	High	NASA Content aligned well with site's objectives and activities. Unmet need: Twitter was not useful. Adobe Connect or Skype will be better.
Site F	Inspire students, Increase reading and math scores, Encourage students to pursue STEM careers	Moderate	NASA Challenge inspired students to look into STEM careers. NASA Challenge showed students science can be fun

C. Evaluation Question 3: To What Extent Did Students Find the Materials Engaging?

NASA Education desires learning happening in classrooms using STEM Challenges should to be authentic, (i.e., students are actively engaged in meaningful, realistic tasks) and relevant (i.e., students connect learning their out-of-school lives and society). The NASA Education STEM Engagement line of business requires that programs utilize NASA-unique resources (e.g. mission-related content, technology, data, facilities, technical workforce, research labs at universities, university personnel, etc.) as a context for activities in order to be considered authentic. As it stands, NASA Education envisions student engagement as being more than students on task; NASA Education intended for there to be a reflective discussion among students.

During the interviews with 21CCLC staff, all sites reported that the STEM Challenges were appealing and engaging for their students. Four of the six key sites offered students the choice of participating in NASA's STEM Challenge or other educational activities. Week after week, students chose to continue participating in the STEM Challenges that NASA designed. Five of the six key sites continued working on additional NASA STEM Challenges after they completed their first challenge. One site, Site E reported that students enjoyed making their videos and that students enjoyed an opportunity to engage with the Engineering Design Process in a relevant and authentic way.

To provide data on student engagement, pairs of evaluation team members conducted observations at five of the six key sites. Due to inclement weather one observation was canceled. Data was collected by DoS-certified observers in alignment with the DoS protocol. The evaluation team observed each key site once during a site visit. Sites provided dates when their students would be completing a hands-on aspect of the STEM Challenges. For the purpose of this pilot study, the evaluation team scored all twelve dimensions. Exhibits J and K highlight results on the following six dimensions: Materials, Activity Engagement, STEM Knowledge, Inquiry, Reflection, and Relevance. These particular dimensions illuminates differences among sites concerning the influence of the NASA training and content. Exhibit M, below, shows the average scores (out of 4), on these six dimensions.

Exhibit M: Average Score on Six Dimensions

Dimension	Materials	Engagement with STEM	STEM Content Learning	Inquiry	Reflection	Relevance
Average Score (Out of 4)	3.88	3.77	3.22	3.66	3.66	3.22

Source: Student Engagement Observation of five 21CCLC sites

In Exhibit N, below, there is an overview of each site's STEM engagement level and factors that may have shaped the way NASA Challenge was implemented.

Exhibit N: Comparison of DoS STEM Engagement Categories and Site Characteristics

Site	Features of Learning Environment	Activity Engagement	STEM Knowledge & Practice	Youth Development	Center Experience with STEM Program	Did Instructor Observed have STEM Background?
Site B	High	High	High	High	Moderate	Yes
Site C	Low	Low	Low	Low	None	No
Site D	Low	High	High	High	None	No
Site E	High	High	High	High	High	Yes
Site F	Low	High	High	High	Moderate	Yes

Source: Observation of NASA Challenge implementation, interviews with 21CCLC sites

Although the above scores indicate that, on average, quality STEM engagement happened as students worked on NASA Challenge, there were notable differences across sites. At some sites, students evaluated the process of their own work and connected the STEM Challenge to their lives and wider society. Other sites exhibited only superficial reflection where students answered instructors' closed-ended questions.

Observations of five key sites suggest that instructor skill and teacher-student rapport are necessary ingredients for promoting deep engagement with STEM activities. In the subsections below, observations of five key sites focusing on variances are provided. There was little variance across sites with respect to materials, which seems to indicate all sites used materials that appeal to students and aligned with STEM learning goals. However, differences in engagement with STEM, STEM Content Learning Reflection, and Relevance were discovered.

1. Materials

The materials students used during the observation were, in general, very hands-on and appealing. Students were engaged in such activities as constructing parachutes and testing designs at many of the sites. Almost all sites used materials and followed the sequence instructed by the NASA's STEM Challenge. Similarly, instructors were observed presenting tasks clearly, so students could follow along with the activities. At most sites, students were on task with STEM Challenge materials, such as watching a video. Site D, though, had classroom management issues, and there were many students who were utilizing the materials. The high average score of this dimension seem to be evidence that instructors followed the steps NASA Education staff presented during the training.

2. Engagement with STEM

Sites generally scored highly in this domain, because students were fully engaged with STEM. Students were designing and redesigning their product and participating in discussions at higher orders of Bloom's Taxonomy. Differences across sites were closely tied to the extent to which students did cognitive work during the hands-on activities. At four sites students engaged both STEM and cognitive tasks. For example, after they dropped their parachutes they discussed with each other how their design could be improved and hypothesized outcomes. In contrast, another site had students who were participating in "hands-on" activities by merely following the facilitator's directions. These students were "minds-off" while the facilitator did all of the cognitive work. Rather than students discussing the importance of understanding and determining center of gravity in meaningful ways that would affect their overall STEM Challenge, the facilitator simply asserted relevant scientific facts. The instructor did not have a math or science background.

21CCLC sites varied in terms of space. Only three of the key sites had enough space where students could work on their STEM Challenge (e.g. dropping parachute, looking into computer, etc.). Rooms were often small, and students had to move to hallways. Consequently, there were distractions (e.g. other after school activities happening nearby, like cheerleading practice, or teachers talking loudly in the hallway). High STEM engagement was tied to having sufficient space. Sites that did not have appropriate space and setting (e.g. students had to go to hallway) were centers that never had STEM programs in the past.

3. STEM content learning

The key sites presented reasonable evidence that the activities presented STEM content with only a few minor errors. Out of five sites, the evaluation team observed instructors delivering inaccurate STEM content in only one site, and students did not seem to understand the STEM concept because of it. Out of five sites, at one site an instructor was observed who could not answer students' questions about science concepts, and students did not seem to understand the STEM concept because of it. At other sites, STEM questions were not always answered by the facilitator due to time limitations or other factors, but this is true of any STEM educational experience.

5. Inquiry

At four sites, students used STEM practices and articulated their ideas to improve design. However, at Site D, students used STEM practices only superficially, which did not help students deeply engage in the thinking or reasoning of STEM professionals.

6. Reflection

At four of the key sites, students were observed presenting alternative designs by referring to STEM and science concepts or by examining data. At one site, student accounts indicated that they could not connect scientific concepts to make sense of why they need to do NASA activities. For example, the facilitator there asked why it is important to find the center of mass, and a student responded "to complete the task correctly."

7. Relevance

At three sites, facilitators supported students in reflecting on the STEM Challenges as well as the Engineering Design Process. In this way, students could connect their experiences of NASA's STEM Challenges to their lives. At Sites D and B, instructors were unable to facilitate students' discussion. In these two sites, students did talk about their experiences with NASA's STEM Challenges, but only in the context of the 21CCLC program rather than in the context of home life or society. The above suggests that while NASA Challenge engaged students doing tasks, instructor skills and knowledge are necessary for promoting the relevance of STEM to daily life. Other factors that might have shaped the way discussion was implemented include: availability of conducive classroom space and teacher-student rapport.

D. Evaluation Question 4: What Recommendations Would 21CCLC Staff Make to Improve Usability, Access, or Alignment of Resources, Training, and Support?

21CCLC sites were asked to provide recommendations and suggestions regarding the NASA Challenge program. Their recommendations are grouped by support and training NASA provided.

1. Face-to-face training

All respondents suggested that NASA present and train on all three Challenges. Although it was not in the original design of the face-to-face training, respondents overwhelmingly liked experiencing all three challenges during the training. Two sites suggested that NASA provide the student video rubric in advance, and go over it at training. Some sites were not clear on the video requirements and did not collect video of the planning process with their students. If the rubric was introduced and explained at the training the video process would be made clearer. It was suggested that paper copies of the training materials for all three Challenges be provided instead of having sites download materials from the website. Some respondents felt that paper copies would have been beneficial for all due to the fact that some 21CCLC sites do not have regular access to printers. All sites were interested in the DoS Protocol as a tool that may be useful to designers as well as evaluators. The facilitators express the lack of resources in assessing STEM programming. When assessing, it is a best practice to provide the individual you are assessing with the criteria.

2. Online materials

The website address was not easy to remember and did not show up in internet searches. Sites suggested that a simplified URL be used in order to make returning to the site easier.

a. Live connection with NASA SMEs

Sites expressed a preference for video conferences as opposed to a Twitter TweetUp. Sites expressed that the real time interaction with the SME via video conferencing was more exciting than waiting for a text response.

To increase the interest and attention of the students it was suggested that NASA give students background on the SME before the live student event. This would give students an opportunity to develop a mentor like-relationship with SME. Sites also suggested that students be able to submit questions to SMEs in advance to expedite the process. Some sites felt that the time scheduling did not match up with their availability. It was suggested that sites be asked what time works for them and then schedule the live student events to accommodate. Also, some sites suggested that the timing in which the SME interaction happens be adjusted to coincide with when the students are designing their solution so that SMEs can provide clarifications.

3. Other comments

Two sites with strong STEM programs suggested NASA align curriculum to the Next Generation Science Standards, and develop and provide a pre/post assessment to demonstrate knowledge gains. These sites connected the NASA Challenge key concepts to the regular school day instruction. This was the only the only suggestion on materials.

IV. Recommendations

This evaluation reported on the implementation of Evaluation Plan of the Pilot Collaboration between NASA and the Department of Education to use STEM Challenges at the 21st Century Community Learning Centers. Based on the findings to the evaluation questions and the systematic observations of the collaboration project, the following recommendations are for consideration as the program continues.

- Maintain a one day, face-to-face training in which all Challenges are presented in equal fashion with hands-on activities simulating student requirements. While the original NASA plan was to have training participants select one Challenge and learn it in depth during the face-to-face training. However, the sites told that it was difficult to choose one challenge without knowing much. After learning three challenges at the face-to face-training, sites reported they felt they were more confident to select Challenge for their students. Furthermore, some sites implemented all Challenges.
- NASA Education hoped to see if the train-the-trainer model works with 21CCLC sites in this pilot project, only one site needed to train other facilitators because most sites sent facilitators who actually taught the Challenge to the face-to-face training. The train-the-trainer model worked for one site. It is important to note that at this site, a two facilitator team (both trainer and trainee) presented the Challenge to students. These findings suggest that it may be worth it for NASA to explore, if train-the-trainer model could be the dominant model in the future. NASA may want to explore two further questions:
    - Why most sites could send facilitators?
    - Is it possible to ensure that 21CCLC sites can send facilitators? If the answer is yes, this will eliminate the concern associated with train-the-trainer model. If train-the-trainer model will continue with future 21CCLC collaborations, it is suggested that NASA explore strategies for more efficacious utilization. For example, one site's experience of team teaching may be one way NASA could suggest to the site.
- Provide access to training materials in advance of the training date. Provide paper copies of training materials.
- Ensure that 21CCLC Challenge facilitators have access to the Challenge website and can locate materials on an ongoing basis. NASA Trainers should model for participants through how to access NASA Challenge Website and materials. One way is providing a link in e-mail after the training, another would be meta-tagging the page to make it indexable by search engines.
- Utilize a video conferencing platform when interacting with NASA SMEs. Provide practice sessions and alternative audio solutions to avoid technical difficulties. Do not use Twitter.
- Increase the interaction with NASA SME and Challenge participants. Provide with opportunity to develop a relationship with SME.

- NASA Education needs to communicate more with NASA SMEs about NASA STEM Challenge participants, how STEM Challenges operate, and 21CCLC's expectations from NASA SMEs. One site reported that the SME assigned to them did not talk about the STEM Challenge the 21CCLC site was working on, which suggests that some SMEs may not fully understand the nature of STEM Challenges. NASA Education should consider reviewing whether NASA SMEs are well informed about NASA Challenge.

Based upon the findings of this study, it is clear that the collaboration between NASA and ED regarding STEM Challenge use by 21CCLC sites was highly successful. With continued refinement, such collaborations have the potential to produce excellent return on investment in the long term.

Appendix A: IRB Exemption Letter

National Aeronautics and
Space Aministration
Lyndon B. Johnson Space Center
2101 Nasa Parkway
Houston, Texas 77058-3696

NOTIFICATION OF APPROVAL
August 1, 2013

To:	Sarah Egan-Reeves
From:	SA/Chair, Institutional Review Board
Title:	Pilot Collaboration between NASA and the Department of Education to use STEM Challenges at 21s Century Community Learning Centers(21CCLC)

Protocol Number:	Pro0884
Method of Review:	Exemption
Type of Review:	Initial/Exemption Categories #1, #2, and #4
IRB Disposition:	Approved
Approval Validity:	August 1, 2013 to August 31, 2016
Risk Level:	Minimal Risk
Medical Monitor:	Not Required

NASA MPA Number:	NASA 7116301606HR
FWA Number:	00019876

This proposal meets the exemption categories #1, #2, and #4:

- This research will be conducted in established or commonly accepted educational settings involving normal educational practices, such as research on regular and special education
- This research involves the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior. Information obtained is recorded in such a manner that human subjects cannot be identified, directly or through identifiers linked to the subjects. Disclosure of the human subjects responses outside the research does not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects financial standing, employability, or reputation.
- This research involves the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens. These data sources are either publicly available or collected in a manner which subjects cannot be directly or indirectly identified.

IRB exemption 45 CFR 46.101 is valid for a period of 3 years. At the end of three years, the study will have to be closed or renewed. It is the investigator's responsibility to obtain renewal before the expiration date. If you wish to modify your study during its approval period, submit an amendment.

The Investigator must report any adverse reactions or unexpected problems resulting from this study to the JSC IRB Chair, JSC Human Research Program (and/or funding personnel), and the JSC Safety Office (if applicable).

The proposal was reviewed and approved by the IRB in accordance with the requirements of the

Appendix B: Interview Protocol with NASA Education staff

Purpose of the interview is to:

- Learn the scope of activities. (goals of activities and specifics of activities)
- Learn NASA's vision about how support should be utilized and how NASA Challenge should be implemented.

Introduction

Thank you for taking time to come to this interview. My name is XX X from Paragon TEC. Paragon TEC is tasked to evaluate the pilot NASA Challenge in 21CCLC project. The purpose of this evaluation is to understand how 21CCLC sites utilized NASA materials and to identify how NASA training and support materials can be improved.

To approach this evaluation, we decided we need to learn NASA Education's vision of how the training and support services should roll out, so that evaluation team can track if 21CCLC sites are utilizing NASA support as they are supposed to be. This way, we can collect information in a focused manner, and the evaluation report can provide concrete and actionable recommendations. This is based on our assumption that everything was thought through and intentional, but we also understand that sometimes things are not planned and people in the office may have different visions. If you are not aware of NASA's vision or if you think some ideas are not shared among NASA Education staff, please let us know. In this case, we will ask broad questions to 21 CCLC sites.

We reviewed the materials. Today's questions are to confirm if our understanding is correct. After this interview, we will create interview questions to 21CCLC sites. Do you have any question?

In- person Training

1. Describe the in-person training plan.
    - When will it happen?
    - Who will be participating? Are participants instructors? How were participants selected?
    - How long is the training?
    - Who will be providing the training?
    - What is the outcome of this training?

2. Tell us what message does this training communicate to participants about 21CCLC should be utilizing NASA support and how 21CCLC should be implementing NASA Challenges
    - What support should 21CCLC utilize? When?
    - Is there a required number of website access for each 21 CCLC site?
    - How does NASA ensure that these messages are communicated to the participants?

3. How will the participants to the in-person training train others?
    - Is there training materials?
    - How many people will the participants train?
    - How will NASA know that trainers trained others?
    - What should the in-person training participants convey to their sties? What should 21 CCLC site staff know about how to utilize NASA resources and how to implement NASA Challenges?

4. What design considerations did you made with this train-the-trainer training?
    - What are risks? What strategies did you take to mitigate the risk? For example, how did you make sure that trained trainers can train others?

<u>Online Training</u>

1. Describe the online training plan.
    - When will it happen?
    - Who will be participating? Will participants be instructors? How were participants selected?
    - How long is the training?
    - Who will be providing the training?
    - What will the training cover?
    - What are outcomes of this training?

2. During the training, what messages do you want to convey about how 21CCLC should be utilizing NASA support and how 21 CCLC should be implementing NASA Challenges
    - What support should 21 CCLC use? How should they use the support? When?
    - Is there required number of website access for each 21 CCLC site? Which materials should 21 CCLC be using? Are there materials that all 21 CCLC sites must use?

3. What design considerations did you made with online training?
    - What are risks? What strategies did you take to mitigate these risks? For example, how did you make sure that all 21 CCLC site staff has access to webinar? How did you make sure that the training duration meet 21 CCLC site staff's schedule?

<u>Website to access NASA Content Experts</u>

1. Describe the website to access NASA Education Experts and the purpose of accessing NASA Content Experts.
    - What should 21 CCLC sites do? When?
    - Who should be contacting NASA Content Experts?
    - Is contact initiated by site or by NASA Content Expert?
    - What is the role of NASA Content Experts in supporting NASA Challenge implementation at 21 CCLC sites?

- What kind of questions should 21 CCLC sites ask to take a full advantage of NASA Content Experts? Do the questions vary by NASA Challenge?
- How many times should 21 CCLC sites contact to NASA Content Experts?
- What types of support or answers will NASA Contents Experts provide? Will it be solely content knowledge (for example, how to calculate force or gravity)? Will it be an inspirational story (e.g. how NASA developed soft landing vehicle, importance of team work)? Will NASA Experts act as a facilitator to encourage students to move forward with NASA Challenge (e.g. asking open ended questions, guiding thinking process step by step)?

2. What design considerations did you make with this website to access NASA Content Expert?
   - What is the best scenario of 21 CCLC's use of NASA Content Expert?
   - What is the worst scenario of 21CCLC's use of NASA Content Expert?
   - What are the consequences to 21CCLC sites' implementation of NASA Challenges?

Culminating events

1. Describe culminating event
   - What are goals of the event?
   - When will it happen?
   - Who will be participating? How did you select participants?
   - How long will the event be?
   - What will students and 21 CCLC sites do?

2. What activities are planned to achieve the goal of the event?

3. What are the criteria for selecting best work? How was it communicated to the site?

Appendix C: Interview protocol with 21CCLC sites

Introduction

My name is XXXX and this is XXXX. We are from Paragon TEC in Cleveland, OH. Paragon TEC is conducting an evaluation of the pilot project of NASA Challenge in 21 CCLC classrooms. As part of this study, we are collecting data from 9 of the pilot sites to learn about how this pilot project went.

The evaluation of this pilot NASA Challenge in 21CCLC classroom project will provide insight into how NASA can improve training and support materials for 21CCLC sites to implement NASA Challenges. So, our interview questions focus on how your site utilized NASA training and materials and your suggestions for improving NASA's training and support. This is not an evaluation of your site or your instruction. We ask questions so that how NASA can improve its materials and training for 21CCLC sites.

At the end of this pilot project in September, we will be writing a report for NASA. In the report, we will not disclose your name. Today, we will be taking notes during our conversation. To ensure accuracy, we would like to audio-tape this conversation with your permission. Do you agree to record?   Do you have any questions?

About 21CCLC Site and involvement with 21CCLC

1. Please tell us briefly about your involvement with 21 CCLC and this pilot project.
    - How long do you work with 21 CCLC with what capacity?
    - How were you involved in this pilot project? Did you work on NASA Challenge with your students?

2. What types of math, science and technology programs did this site provide in the past two years?
    - Who provided the programming?
    - What did students do? (Here, if possible, could we prepare a description from the 21CCLC performance data and confirm with the site? This way, you can save some time. For example, "your site provided STEM programs to all XXX graders.
    - Does this reflect what was done at your site?
    - Could you tell us what project your site did?"

3. How did you see the past programming around math, science, and technology?

4. What are the site's objectives around STEM programming?

Utilization of NASA Training

1. Did you attend NASA in-person training?

2. If you attend, what did you learn from the training?

3. The goal of the training was to a) make instructional staff (training participants) feel comfortable and confident enough with materials and resources, b) so they can implement them with students and c) to support other instructional staff to implement the project. How far did the training meet these goals? (NOTE: Pre training interview, e.g. Rob's interview, talks about this. So we want to check with this with participants).

4. If you attend, how did you provide training to others?
   - Who received training? (Note: How much % of instructional staff receive the training? Did everyone worked on NASA challenge receive training?—here we may want to have some concrete description that tells us if train the trainer model could reach all instructional staff.---just to deal with common criticism to train the trainer model, i.e., trainer could not reach to others..)
   - Describe the training you provided.

5. If you did not attend in-person training, did you receive training from XX (a person who attended training from this site)? Describe what you learn.

6. How helpful was the training? What was helpful? What was not? How the training helped your site to implement NASA Challenge?
   - What made you to feel you are able to implement?
   - What made you to feel you are able to support other staff members?
   - Was there enough conversation about instructional practices (during train the trainer session, or training at your site)?
   - How was including misconception of scientific concept (during training the trainer session) helpful for you?

Utilization of NASA support materials and NASA Content Experts

1. How did your site use NASA's support materials?
   - Access
   - Content used

2. What were useful content provided to you? Why?

3. How did your site use NASA Content Experts?
   - What value did you see in having access to NASA SMEs? How did interaction with NASA SME helped students or instructors working on NASA Challenge?

Implementation of NASA Challenge

1. Describe how you implemented NASA Challenge
    - When did you start implement NASA Challenge?
    - How many classrooms implement NASA Challenge?
    - Who are students who worked on NASA Challenge? Did student volunteer? Did you select students? What was the selection criteria?
    - How long (hours) did students work on NASA Challenges?
    - What did students do?
    - What did instructors do?

2. Describe how were students engaged with NASA Challenge?
    - On a typical day, how do you describe students' engagement with NASA Challenge? (Note: if observation did not happen before this interview, you might want to ask about different types of engagement, e.g. students spend time and did something, students engagement is more of intellectual engagement, etc. ----you might want to use aspects from Dimensions of Success, also see pre-training interview where trainers talked about what engagement should look like)
    - (Share Dimensions of Success observation note with the site.) This is what we observed as an outsider. Does this reflect your observation and your experience with students? Please tell us any differences.

3. What made students engaged and what are the reasons of lack of engagement?
    - Was NASA Challenge relevant for students?
    - Did you or your staff have knowledge about how to facilitate inquiry based learning?

4. Below are some of the instructional suggestions NASA materials suggested to incorporate in your instruction. Please tell us how much each of these suggestions was helpful for you to better implement NASA Challenge. If they are difficult to use for implementing NASA Challenge, tell us why.
    - Choose an open ended question
    - Take students out of their comfort zone, and provide step by step process to work on problem solving
    - Providing safe environment where students can make mistake
    - Choose reasonable challenge
    - Keep journal of student questions
    - Model problem solving process
    - Ask what they learned, what they might change.

6. How does the qualification of instructional staff affect the implementation of the Challenge?

Alignment with 21CCLC objectives and needs

1. How did this pilot project support your 21CCLC center's STEM programming objectives?
    - How did participating in this pilot project improved the capacity of your center to implement STEM programming?

2. When you were asked to participate in this pilot project to implement NASA Challenge, what were the needs your center had to implement NASA Challenge?

3. Did NASA training, support materials and access to NASA Content Expert respond to the needs?

Improvement suggestions

1. How can NASA's training be improved?

2. How can NASA's materials be improved?

3. How can the access to NASA Content Experts be improved?

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