Concord Evaluation Group

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Mission: Solar System Evaluation

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Background

With funding from NASA, *Design Squad Nation*, a program of WGBH Boston, developed a collection of educational resources called *Mission: Solar System*, designed for kids in school and afterschool programs, grades 4 to 8. The purposes of these space-based, hands-on engineering challenges are to:

- Engage kids in engineering and in NASA's exploration of the solar system.
- Give kids fun, relevant ways to apply STEM (science, technology, engineering, and mathematics) concepts and skills.
- Let kids think like NASA engineers and apply their creative problem-solving skills.
- Spark kids' interest in engineering and space-science careers.

The standards-based challenges provided by *Mission: Solar System* (MSS) were designed to use readily available materials, offer kids many ways to succeed, could be done in an hour, and work well with both large and small groups (The full guide is available in Appendix A). The MSS Guide had the following components and, as of this report date, were downloadable at: http://pbskids.org/designsquad/links/solarsystem.

	**Leader Notes** The Leader Notes included: An overview of each challenge and its connection to NASA; tips to help educators prepare for, introduce, run, and wrap up the activity; discussion questions that explore the science, engineering, and space-related themes; and ways to make curriculum connections.

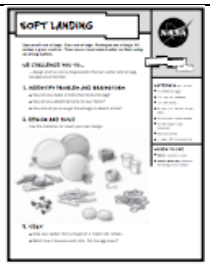
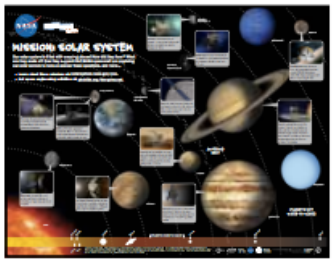
	**Kids' Handouts** These reproducible handouts step kids through each challenge, providing them with questions to brainstorm, building tips, illustrations, and interesting stories about NASA missions related to the challenges.
	**Do-It-Yourself (DIY) Videos** Each challenge had its own three-minute DIY video that showed kids doing the activity and talking about its science and engineering and its connection to NASA missions. Used as an introduction, the videos give kids a sense of the design possibilities and hope to get them excited about doing some creative problem-solving. Used as a wrap-up, the videos give educators a way to reinforce the challenges' science, engineering, and NASA connection.
	**Video Profiles of NASA Engineers** These three-minute videos featured young, dynamic engineers who tackled interesting problems related to NASA's solar system missions. They put a human face on engineering, showing engineers as well-rounded people with interesting work and personal lives. The connections to the activities are general—the primary goal is to break down engineer stereotypes and showcase engineering as a rewarding career. Each video has a sheet with discussion points and follow-up ideas to help kids make full use of the videos.
	**Wall Poster** This full-color poster gives kids a dramatic visual guide to NASA's Year of the Solar System missions. Educators were encouraged to post it so kids could easily read the mission facts, learn about solar-system designations, and see images of the spacecraft.

Figure 1. Mission: Solar System Components

In addition to the challenges and their components listed above, MSS also offered a 16-page Teaching Tips document that provided tips on:

- Running MSS challenges
- Using the design process with kids
- Facilitating open-ended challenges
- Talking with kids about engineering
- Finding related resources from NASA and Design Squad Nation
- Meeting education standards

The MSS website also included a 5-minute training video for educators so they could see the MSS resources in action before trying them with their own students.

Also available to educators was a rich set of science, engineering, and space-based resources including "printables," additional activities and guides, educator trainings, solar system tours, interactive labs, videos, and full-length programs available at http://pbskids.org/designsquad/parentseducators/guides/mission_resources.html.

In addition, educators participating in the evaluation could also access the full complement of STEM resources housed at the *Design Squad Nation* website http://pbskids.org/designsquad/parentseducators/.

To introduce educators around the country to the MSS resources, WGBH conducted a series of webinars and presentations throughout 2013. The resources were also promoted using social media like Facebook and Twitter, WGBH e-mail newsletters to educators, and websites like PBS LearningMedia (formerly Teacher's Domain) and the Design Squad website.

WGBH contracted with Concord Evaluation Group (CEG) to conduct an independent evaluation of the MSS resources.

Methodology

Overview

The evaluation took place in the fall of 2013 and consisted of several components:

1. **Field Test Experiment** – CEG recruited 14 programs (8 middle school classrooms and 6 afterschool programs) to participate in an experiment. Upon enrollment in the study, programs were randomly assigned to a Treatment or Control Group condition. In late September, all 14 programs completed student pre-test surveys (see below). Following the pre-test, Treatment Group programs were encouraged to use the MSS challenges in any way that made sense for their specific needs. We did not prescribe how the resources should be used. Control Group programs did not use the MSS challenges until after the end of the study. During October, CEG conducted field observations (see below) at the 7 Treatment Group programs. In November, all 14 programs completed the student post-test. Educators from the 7 Treatment Group programs also participated in telephone or in-person interviews (see below).

    a. **Student Pre- and Post-test Surveys** - In collaboration with WGBH, CEG will developed online pre- and post-test surveys to assess students':
        i. subject matter knowledge (of the constructs covered in the resources);
        ii. attitudes towards NASA and other space activities; and
        iii. interest in joining activities (such as camps), studying or someday working in a space-related careers.

    b. **Field Observations** - CEG visited the seven Treatment Group sites to observe how the resources were used and how engaged students and educators appeared to be.

    c. **Educator Interviews** - CEG conducted in-depth interviews with educators from the seven Treatment Group sites to learn about the resources':
        i. feasibility,
        ii. usability,
        iii. appeal,
        iv. usefulness, and
        v. relevance to diverse populations of students, as well as the

vi. impact on educators' comfort and ability to lead such activities.

2. **National Educator Survey** - CEG adapted the educator interview instruments developed for the local study for administration to educators who participate in online webinars or other community engagement activities to gather their feedback on the appeal, usefulness, and professional impact of the resources.

Our evaluation questions were tied directly to the project goals and included:

- **Impact on students:** What was the impact on kids' knowledge, attitudes and interests? Were the kids engaged by the challenges?

- **Impact on educators:** How satisfied were educators with the resources? Were the resources feasible, appealing, useful, usable, and relevant? Did the resources impact educators' comfort level in leading such challenges with their students?

Recruitment

To recruit classrooms and afterschool programs for the field test, CEG invited local members of its research panel to participate. CEG's research panel contains thousands of individuals, including teachers and club directors, who have previous participated in or have indicated an interest in participating in a study with CEG.

Fourteen programs were chosen to participate in the study, based on their proximity to the evaluator (for field observations) and to ensure the most diverse sample possible (geographic, racial/ethnic and socioeconomic composition of the student body, as well as experience level of the educator). Programs were offered a $100 honorarium in exchange for their participation and to offset the cost of supplies.

The national educator survey was conducted online and all educators who participated in webinars or other online activities developed for the project were invited to participate in the survey.

How the MSS Challenges Were Used

In the field test, educators in the Treatment Group were instructed to use the MSS resources in the ways that best met their needs and the needs of their students. In all cases, MSS was used as a standalone program, rather than

being fully integrated into a curriculum, because none of the programs were planning to cover engineering, the design process, or any of the science constructs included in MSS during the timeframe in which the field test was to be completed.

Educators used their own discretion to determine the order in which they would try the challenges and which resources (e.g., video clips) to use in addition to the challenges.

- Six out of eight educators simply did the challenges in the order in which they appeared in the Guide. The other two educators allowed their students to choose the order.
- Two out of eight educators viewed the Teacher Training video.
- Two out of eight educators downloaded and used the Teaching Tips resource.
- All eight educators showed the DIY Challenge Videos to their students. Some educators showed the videos before the challenges to prepare their students, others showed the videos during the challenges to spark ideas in their students who were struggling, and still others showed the videos after the activity to wrap-up and prevent the kids from using the ideas in the videos instead of coming up with their own.
- All eight educators showed the Engineer Videos after the challenges.
- Six out of eight educators used the Design Squad website to further explore the concepts and ideas included in MSS.

Sample

Field Test Experiment

Fourteen programs (8 middle school classrooms and 6 afterschool programs serving middle schoolers) participated in the field test experiment. Seven of the eight schools were public schools, one was a public charter school. The afterschool programs were based at YMCAs, Boys and Girls Clubs, and at public middle schools. The programs were located in Massachusetts, Rhode Island and New Hampshire.

The table below summarizes some key characteristics of the programs. Overall, the Treatment and Control Group programs were similar in terms of the proportion of students served who were African-American (18% and 22% respectively), Latino/a (21% and 18%, respectively), or low income (46% and 47%, respectively).

Table 1:
Program Characteristics

	Proportion of Students Served Who were…		
	African-American	**Latino/a**	**Low Income**
Formal (School) Programs			
Program F1 – Treatment Group	50%	20%	70%
Program F2 – Treatment Group	15%	10%	20%
Program F3 – Treatment Group	5%	5%	15%
Program F4 – Treatment Group	2%	2%	10%
Average within group	***18%***	***9%***	***29%***
Program F5 – Control Group	1%	1%	20%
Program F6 – Control Group	10%	5%	30%
Program F7 – Control Group	40%	30%	70%
Program F8 – Control Group	2%	1%	35%
Average within group	***13%***	***9%***	***39%***
Informal (Afterschool) Programs			
Program I1 – Treatment Group	10%	40%	60%
Program I2 – Treatment Group	40%	50%	90%
Program I3 – Treatment Group	5%	5%	40%
Average within group	***18%***	***32%***	***63%***

	Proportion of Students Served Who were…		
	African-American	**Latino/a**	**Low Income**
Program I4 – Control Group	62%	17%	87%
Program I5 – Control Group	30%	60%	75%
Program I6 – Control Group	0%	0%	0%
Average within group	***31%***	***26%***	***54%***
Treatment Group Average	18%	21%	46%
Control Group Average	22%	18%	47%

Across the 14 programs, 196 students participated in the field test. Of the 196 students, 109 (56%) were boys and 87 (44%) were girls.

All of the educators (formal and informal) in the field test reported that they had at least some experience leading hands-on science activities with students.

National Educator Survey

Forty-four individuals responded to our invitation to complete a survey for the national educator study. At the start of the survey, we asked respondents to indicate whether they had yet reviewed the MSS resources or used them in a classroom. Eleven out of the 44 (25%) indicated that they had not yet had a chance to use or review the resources. We asked these respondents whether they would like us to contact them again in about a month. Four requested that we not contact them again because they were not educators but, rather, consultants or engineers who were simply interested in learning about the resources. We contacted the remaining seven educators a month later to see if they had had a chance to review or use the resources, but none had.

So, our final sample of educators for the national educator survey included 33 individuals from across the country. Seven of the 33 educators had experience using the MSS resources with their students (hereafter referred to as Group A), while the remaining 26 educators had only had a chance to review the MSS resources (Group B).

The sample was split nearly in half by formal and informal educators (46% each). Elementary and middle school educators comprised half of the sample (50%).

Table 2:
Educator Characteristics

Characteristics	Group A Frequency and Percent (N = 7)	Group B Frequency and Percent (N = 26)	Total Frequency and Percent (N = 33)
Educator Type			
Formal educator	2 (29%)	13 (50%)	15 (46%)
Informal educator	5 (71%)	10 (39%)	15 (46%)
Missing/Unknown	0 (0%)	3 (12%)	3 (11%)
Organization Type[1]			
Middle school (6-8)	1 (14%)	6 (23%)	7 (27%)
Elementary (K-5)	1 (14%)	5 (19%)	6 (23%)
Public library	0 (0%)	5 (19%)	5 (19%)
Community education	3 (43%)	1 (4%)	4 (15%)
High school (9-12)	1 (14%)	2 (8%)	3 (11%)
STEM outreach	0 (0%)	3 (12%)	3 (11%)
Afterschool program	1 (14%)	0 (0%)	1 (4%)
Science center	0 (0%)	1 (4%)	1 (4%)
Missing/Unknown	0 (%)	3 (12%)	3 (11%)
How Did You Learn about MSS?			
WGBH newsletter	2	4	6
WGBH webinar	4	6	10
Design Squad website	1	5	7
PBS LearningMedia	1	4	5
Social media	0	1	1
Colleague	0	4	4
Conference	0	5	5
Email from another organization	1	5	6

Educators were based across the United States. States represented in the educator survey included:

[1] Educators could indicate more than one type of organization and some educators worked in K-12 school settings, so the totals may be greater than 100%.

- Arizona (n = 1)
- California (n = 2)
- Florida (n = 1)
- Georgia (n = 1)
- Illinois (n = 1)
- Indiana (n = 1)
- Kansas (n = 1)
- Louisiana (n = 1)
- Maryland (n = 3)
- Massachusetts (n = 1)
- Michigan (n = 1)
- Minnesota (n = 1)
- Missouri (n = 1)
- New York (n = 2)
- North Dakota (n = 1)
- Ohio (n = 2)
- Pennsylvania (n = 3)
- South Carolina (n = 1)
- Texas (n = 5)
- Utah (n = 1)
- Vermont (n = 1)
- West Virginia (n = 1)

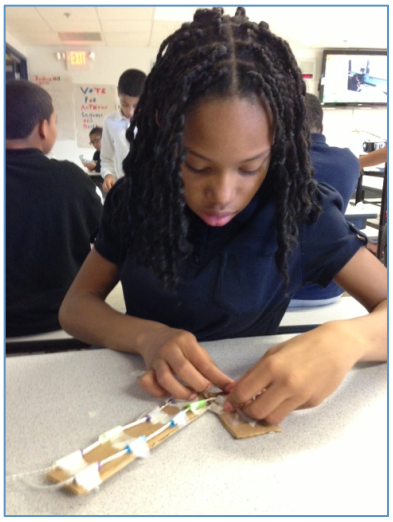
Findings

Impact on Students

Knowledge about NASA and Science Concepts

We assessed student knowledge about NASA and the science concepts covered in MSS by asking students to complete a set of eight questions at the start of the field test and at the end of the field test. Correct answers on each of the eight questions were each worth one point. The questions included:

1. True or False: NASA uses airbags (like the ones in a car) to land rovers on other planets.
2. True or False: NASA does NOT use magnets to study other planets.
3. True or False: NASA uses mechanical arms (like the ones a robot might have) to pick-up things on other planets.
4. True or False: NASA uses gravity to launch spaceships into space faster.
5. True or False: When a person jumps off something high, they can absorb some of the energy by bending their knees.
6. True or False: Magnets are created when a bunch of electrons spin in the same direction around an atom's nucleus (center).
7. True or False: A table is an example of a lever and fulcrum.
8. True or False: When a person stretches a rubber band, they build up kinetic (motion) energy.



The average pre-test and post-test scores for both groups are reported in the table below. There was a statistically significant increase in knowledge scores for the Treatment Group versus the Control Group.[2] This indicates that the MSS had a positive impact on student learning in the programs that used the MSS challenges.

[2] We conducted a general liner model test, correcting for intraclass correlations and found $F_{(7,188)} = 11.723$, $p = 0.000$.

Table 3:
Knowledge Scores (Average Number Correct out of 8) Across Groups

Treatment Group Pre-Test Average and Standard Deviation	Treatment Group Post-Test Average and Standard Deviation	Percent Change in Treatment Group Scores	Control Group Pre-Test Average and Standard Deviation	Control Group Post-Test Average and Standard Deviation	Percent Change in Control Group Scores
N = 83			N = 113		
3.66 (1.58)	4.53 (1.34)	24%	3.42 (1.84)	2.46 (1.48)	-28%

We also asked students in the Treatment Group whether they felt that MSS taught them anything about space exploration; 53% reported that MSS taught them "a lot," while 44% reported that MSS taught them "a little." Only 3% reported that MSS did not teach them anything about space exploration.

Satisfaction with Mission: Solar System

We asked students in the Treatment Group to report on how much they enjoyed MSS, whether they would like to do more challenges like MSS, as well as what they liked most and what they liked least about MSS. As summarized in Figure 2 below, the majority of students reported that they enjoyed MSS "a lot" (67%) or at least "a little" (24%).

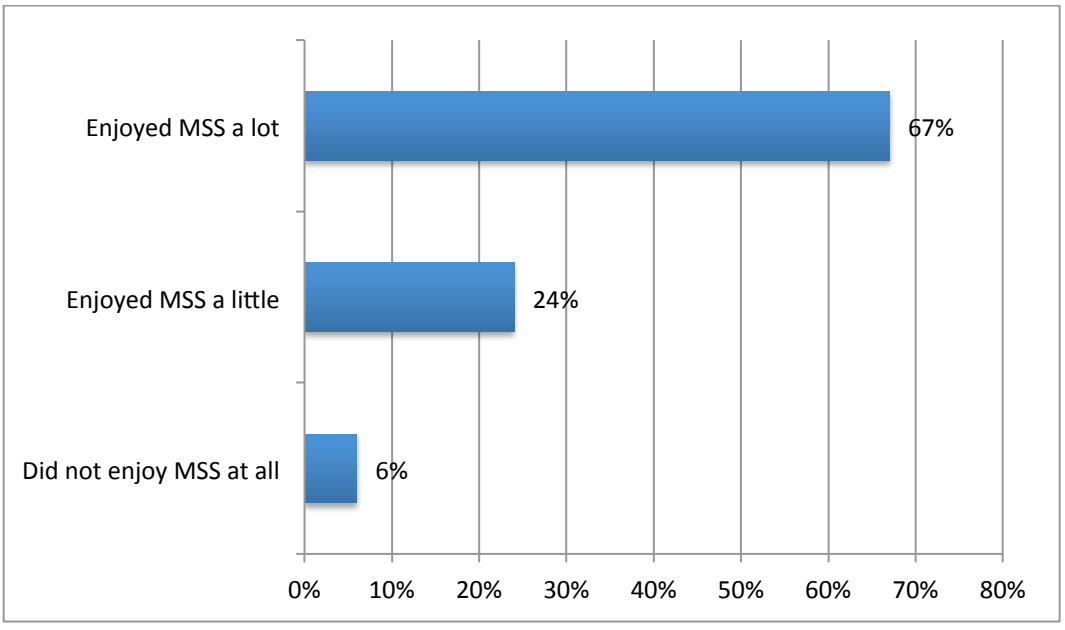


Figure 2. Student enjoyment of Mission: Solar System.

As summarized in Figure 3, most students also reported that they would like to do more challenges like these in the future. Most students (59%) reported that they would like to do more challenges like these or might like to (36%). Only 5% reported that they would not like to do more challenges like MSS.

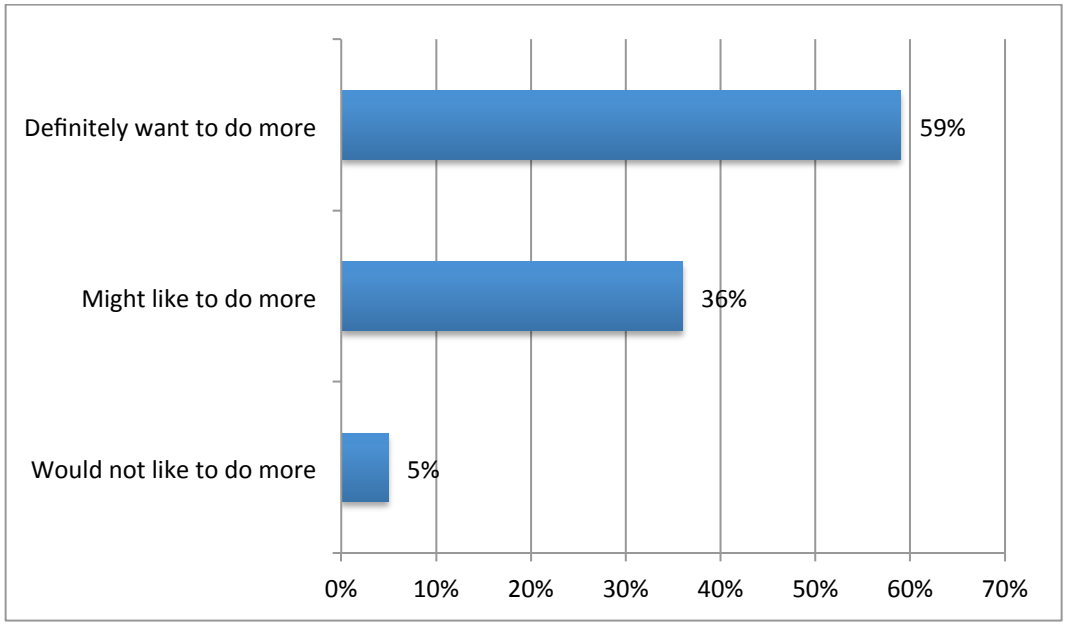


Figure 3. Student interest in doing more challenges like Mission: Solar System.

During our observations at Treatment Group sites, we observed that, without exception, the majority of students appeared to be enjoying the challenges. In all programs we visited, students were attentive, engaged, and enthusiastic during observations.

We observed students bringing innovation to their designs. For example, during an observation of the coring challenge, one design used dominoes while others used structures and a slingshot incorporated into their designs. Students brought in extra materials including dominoes, electronics, wood blocks or cubes (Rubik's Cube) to add support, small wheels, plastic soda bottles, string and yarn.

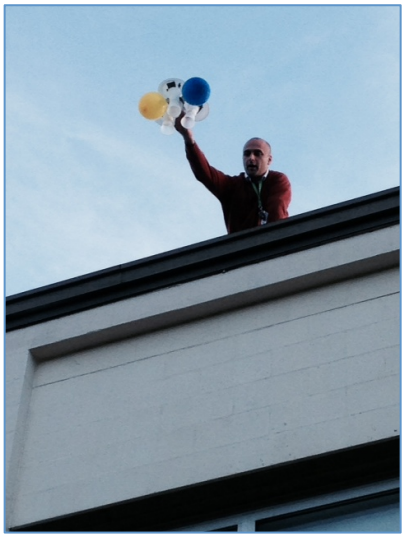
We observed that students across grades and across levels (special education students and gifted students) worked together in pairs or teams at each of the programs we visited. They generally seemed to work well together, with

some rare exceptions where students worked independently instead of with their partners or teams.

We asked students what they liked most about MSS.

Students reported that they liked being challenged as well as the chance to work together with other students to solve problems:

- *The most I liked about the challenges was that we had to think a lot and work as a team with the other kids.*
- *It was fun testing the designs and working with other people and making stuff to withstand falls and stuff.*
- *Being in a group with my friends.*
- *What I like most about the challenges is that we got to work in teams and it was easy to create the air bag.*
- *I also liked that the challenges were actually challenging.*
- *The robots arm was hard, but I got to solve the problem.*
- *The thing that I like the most was that you get to learn new things, but you also get to have fun and meet and make new friends and reunite with old friends.*



- *I loved the fact we got to explore, create, and design so many things!! I really wish I could study/learn more!*
- *I liked the challenging aspect of the projects.*
- *I liked building and figuring out different things about the challenges.*
- *I liked working as a team and doing the project right and complete.*
- *Team cooperation and creativity.*
- *Working with teams designing cool structures.*
- *That it was fun building stuff and working like a team.*
- *I liked how we could actually work together.*
- *I liked how all of the challenges made me build more than I have ever done.*
- *The building of the design and how to keep are egg safe because everyone worked together.*
- *That we got to build things in a group.*
- *I liked that we got to be in groups and work together to build thing that involved space, it was somewhat of a challenge.*
- *They helped us work together and get thinking.*
- *Is to learn things right and to get prepared for the challenge.*
- *We got to make things and test them and learn from our mistakes.*

- *I liked how we got to work as a team.*
- *I like that I could work with my friends and I liked that I was doing something that I like.*
- *I really liked working with a group. Everyone had different interests, and different ideas. The challenges were really interesting and thought provoking.*
- *I liked how we had to work together with a team and design a process to land a egg. When we dropped the egg I was kind of nervous and happy at the same time because we all worked together as a great team even though we did not survive the drop I am happy because the way we worked together and all listened to each others' ideas was very nice. Then after we combined our ideas into a perfect idea. Well, not perfect, but I think we put too much pressure on the egg to drop with all the tape so in conclusion I think it was a very fascinating experience.*

- *That we got to do something different for once and we got to use different materials.*
- *Coming up with a solution to the problem.*

Some students reported that they enjoyed the challenges because they got to learn more about NASA or space exploration:

- *I like how they were related to astronomy cause I love science.*
- *The thing that I liked the best about the challenges was to be able to learn about NASA science and be able to build new things.*
- *I liked that you got to work with other people to create and fulfill a challenge somewhat like NASA does.*
- *That we got to design our own prototype thing, that was similar to things that people use in actually life, to launch stuff, such as NASA does.*
- *I liked that we learned that we can relate normal things we use everyday to what people in space exploration.*
- *Learning about space!*
- *I liked that we got to learn and design thing just like the people from NASA.*
- *The creativity part and learning about space.*
- *I liked how we got to learn more about outer space.*
- *What I liked most about everything is to find out how our world knows so much about space because of these space explorations.*

- *The thing I liked most about the challenges was the fact that I got to learn way more about space and how they sorta find things on space or the exploration of space.*
- *What I liked most about the challenges were the challenges themselves. They were just so much fun and we were learning so much about NASA at the same time I really enjoyed all of these space challenges.*
- *What I liked most about the challenges were that we got to have fun with people in the class while learning about space and gravity I enjoyed it a lot.*

Some students reported that they appreciated having the freedom to develop their own designs and use their creativity:

- *I liked that the projects could be made how you wanted them.*
- *I liked that they were all related to each other and that I was able to make my own designs.*
- *You get to choose how you build the thing.*
- *I like that we had to make our own model.*
- *That it was a hands-on experience and you got to build the design that you thought of.*
- *I liked how we could express ourselves and use our imagination.*
- *I liked how we got mostly freedom on how we made, tested, and designed our projects.*
- *What I liked most about these challenges is that we get to invent and try and see different creations to give ideas for next creation.*
- *I liked how we were able to come up with our own designs and how we tested them afterwards.*
- *I enjoyed the project thoroughly, I thought it was fun, innovative, and let my imagination run free.*

Some students simply reported that they enjoyed the challenges:

- *I enjoyed all the challenges.*
- *Building/Creating things.*
- *Building models about the subject.*
- *I thought that they were fun.*
- *The Egg Challenge.*
- *They were really fun.*
- *It was fun to work with the balloons.*
- *What I liked most about the challenges was creating the challenges.*

- *I enjoyed building the projects.*
- *I liked how all of the were "hands on".*
- *That they allowed me to engineer some really cool things like a robotic arm and an airbag/egg-a-vator.*
- *The thing that I like the most about the challenges is the challenge itself.*
- *I mostly liked the core sampler because it was fun and interesting.*
- *That we got to build things like robot arms and test them out in games.*
- *I liked how instead of doing boring school work, we could learn in a fun way.*
- *We got to do a lot of fun stuff that had to do with creating cool things.*

We also asked students what they liked *least* about MSS.

Some students reported that they did not enjoy specific aspects of the design process, such as designing, building, or presenting their findings:

- *I did not like the building.*
- *I did not like sketching the ideas.*
- *I didn't like the writing that much, but it has to be done in order to do the projects.*
- *Rebuilding.*
- *I didn't like having to draw a plan.*
- *We had to do a lot of paper that I didn't think was necessary for this assignment but maybe the teacher did.*
- *When we had to read and write about space, because I like to do more hands on stuff than work.*
- *I didn't like how we had to go by certain directions. I think we should have been able to be creative and make it a certain way.*

Some students reported having difficulty with other students in their groups:

- *Some of my groups and the some of the challenges.*
- *How some of the people in your group didn’t like your idea and didn’t want to use it at all and there might be like 1 or 2 people who just take over the whole group or build there own designs by themselves.*
- *I didn't like how my group members wanted other ideas than me.*
- *The groups we were in.*
- *Not picking your own groups.*
- *I found it was harder and less fun when there was a huge group.*
- *That one person had more control than the others.*

- *Listening to others.*
- *What I liked least about the challenges was when other people didn't agree with each other.*
- *That we didn't get to pick our groups.*
- *I didn't like that some people were not interested in the project, making it a little hard. Some people also tried to boss everyone else around, even though they did not know what they were talking about.*
- *People didn't give people enough respect as they deserved including me sadly. But overall I think we did pretty good at teamwork but we should've listened better.*
- *Some of my teammates were not participating in as much work as the other group members.*

- *We did not get to work with who we want. I can work better with who I choose.*
- *Some people don’t like to work and I don’t like some of the people I worked with.*

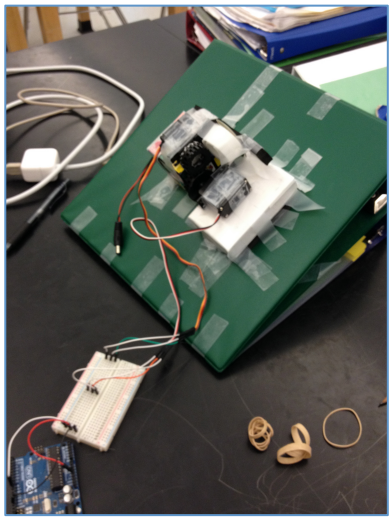
Some students reported that they were unhappy with not always having a successful design or knowing all the answers:

- *What I least liked was that the balloons would keep on popping whenever the tape was took of the balloons and it was a distraction of my work that my team was working on.*
- *The answers that I did not know.*
- *Some of the things were hard to understand.*
- *Failing.*
- *It was difficult with the magnetic field to find the strongest magnetic point.*
- *I didn't like when our invention didn't work.*
- *I didn't like how some of the challenges did not succeed on some of them.*
- *When something didn’t work out good.*
- *Is to lose or fail the challenges because I don't like losing a game.*
- *Fixing the problems and flaws in our design.*
- *Some things were hard to test and sometimes we couldn't tell what we did wrong.*
- *Trying to get it to work.*
- *Failing and having to retry.*

- *The thing I liked least about this challenge is probably that our idea didn't work. And I believe it's my fault that this because I put so much tape it pressurized the egg during the fall.*
- *What I liked least about these challenges is that I failed in most and that some challenges were difficult to brainstorm.*

Some students reported that they did not have sufficient time to work on their challenges:

- *Little amount of time.*
- *I did not like the limited amount of time we had to build/create our projects.*
- *There was a time limit.*
- *We did not get as much time as I wanted.*
- *The small amount of time.*
- *We only had a certain amount of time to do these challenges.*



Finally, some students reported that their programs did not have enough materials to complete the challenges:

- *I didn't like how that we didn't have enough stuff.*
- *We didn't have much materials.*
- *We only had limited materials.*
- *I did not like the restrictions, like what supplies to use, how much time we have, etc.*

Interest in STEM and 21st Century Skills

We assessed the impact of MSS on student interest in STEM (such as science, math, technology and building things) and interest in 21st Century skills (such as working with teams and helping others). We compared student responses on a set of questions administered in the pre-test survey and the post-test survey to discover whether there were any observable differences between the Treatment and Control Groups over time. For each question, students were asked to report how "true" each statement was about them, on a scale from 1 (False) to 5 (True).[3] The data are summarized in the table below.

Student interest in STEM and 21st Century skills was high at pre-test and at post-test in both groups. There were no significant improvements over time between

[3] 1 = False, 2 = Mostly false, 3 = In the middle, 4 = Mostly true, 5 = True

the Treatment and Control Groups. This is likely due to a "ceiling effect" which occurs when pre-test scores are so high that there is almost no room for improvement on post-test surveys – in other words, the students started the field test interested in STEM and 21st Century skills and their interest did not increase or decrease appreciably over time. The two exceptions appear to be student interest in math and science. The average math interest score in the Treatment Group was moderate at the start of the field test and did not change over time. The average science interest score in the Control Group was moderate at the start of the field test, and also did not change over time.

Table 4:
Pre- and Post-Test Student Interest Scores Across Groups

	Treatment Group Pre-Test Average and Standard Deviation	Treatment Group Post-Test Average and Standard Deviation	Percent Change in Treatment Group Scores	Control Group Pre-Test Average and Standard Deviation	Control Group Post-Test Average and Standard Deviation	Percent Change in Control Group Scores
	N = 83			N = 113		
I like math.	3.68 (1.27)	3.69 (1.35)	0%	4.45 (1.40)	4.35 (0.68)	-2%
I like science.	4.48 (0.73)	4.51 (0.76)	1%	3.89 (0.96)	3.50 (1.40)	-11%
I like technology.	4.43 (0.87)	4.43 (0.82)	0%	4.05 (1.10)	3.85 (0.95)	-5%
I like building things.	4.45 (0.77)	4.33 (1.04)	-3%	4.19 (1.07)	3.99 (1.16)	-5%
I like creating things.	4.58 (0.75)	4.49 (0.83)	-2%	4.43 (0.91)	4.25 (1.03)	-4%
I like working with teams.	4.27 (0.85)	4.27 (0.83)	0%	4.23 (1.06)	4.33 (1.03)	2%
I like helping others.	4.43 (0.85)	4.35 (0.91)	-2%	4.47 (0.78)	4.31 (0.95)	-4%
I like solving problems (like mysteries or puzzles).	4.01 (1.19)	3.89 (1.21)	-3%	4.00 (1.18)	4.45 (0.82)	10%

Interest in NASA and Space Exploration

We also assessed the impact of MSS on student interest in NASA and space exploration. To do so, we compared student responses on a set of questions administered in the pre-test survey and the post-test survey to discover whether there were any observable differences between the Treatment and Control Groups over time. For each question, students were asked to report how "true"

each statement was about them, on a scale from 1 (False) to 5 (True).[4] The data are summarized in the table below.

Similar to previous findings, we found no appreciable difference between the Treatment and Control Groups with respect to changes in interest in NASA and space exploration over time. On average, students in the Treatment Group were moderately interested in NASA and space exploration at the start of the field test and remained so after doing the MSS challenges.

Table 5:
Pre- and Post-Test Student Interest in NASA and Space Exploration Across Groups

	Treatment Group Pre-Test Average and Standard Deviation	Treatment Group Post-Test Average and Standard Deviation	Percent Change in Treatment Group Scores	Control Group Pre-Test Average and Standard Deviation	Control Group Post-Test Average and Standard Deviation	Percent Change in Control Group Scores
	N = 83			N = 113		
It's fun to learn about outer space.	4.36 (0.93)	4.20 (1.10)	-4%	3.99 (1.31)	4.36 (0.85)	9%
I would like to join a club or camp where I can learn about science and technology.	3.94 (1.20)	3.63 (1.37)	-8%	3.56 (1.49)	3.92 (1.37)	10%
It would be cool to work for NASA someday.	3.80 (1.29)	3.63 (1.41)	-4.5%	3.22 (1.47)	2.52 (1.45)	-22%
I would like to have a job someday where I can explore outer space.	3.34 (1.30)	3.31 (1.52)	-1%	3.65 (1.44)	3.19 (1.47)	-13%

We also asked students in the Treatment Group whether they felt that MSS made them more interested in learning about space; 38% reported that MSS made them "a lot more interested," while 51% reported that MSS made them "a

[4] 1 = False, 2 = Mostly false, 3 = In the middle, 4 = Mostly true, 5 = True

little more interested" and 11% reported that they were not more interested in learning about space.

Impact on Educators

Feasibility

In the national educator survey, we asked educators to report how feasible the MSS resources were to use in their educational settings on a scale from 1 (Not feasible at all) to 2 (Somewhat feasible) to 3 (Highly feasible).

As summarized in the below, all educators that reported using the resources reported that the resources were somewhat or highly feasible in their settings (100%). One respondent commented, "I am a principal....my teachers loved it. We need more!!!" Another reported, "We have been having issues showing videos because of the classroom space. I hope that in my other programs, we will be able to use online content with the smartboard in the classroom."

Table 6:
Reported Feasibility of Resources Among Educators that Used Them

Resource	Number of Educators that Used This	Proportion Reporting it was Feasible
Mission: Solar System guide	7	7 (100%)
Leader notes	7	7 (100%)
Kids' handouts	7	7 (100%)
Project challenges	7	7 (100%)
Do-It-Yourself (DIY) videos	4	4 (100%)
Video profiles of NASA engineers	5	5 (100%)
Wall poster	5	5 (100%)

We asked educators that reviewed the resources, but did not have a chance to use them yet in their educational settings, to predict how feasible the MSS resources would be for them. As summarized in the below, all educators that reviewed the resources reported that they expected the resources to be feasible for their specific educational settings (100%).

One educator reported that time was a major, potential constraint for her. Another reported, "My issue will be getting with the middle school and high school females that I want to involve." A third reported, "My only problem right now is determining what to cut out my current 30 day course to implement

changes or what adaptions need to be set in place to ensure students have prior knowledge."

Table 7:
Expected Feasibility of Resources Among Educators that Reviewed Them but Did Not Use Them

Resource	Number of Educators that Responded	Proportion Reporting it was Feasible
Mission: Solar System guide	23	23 (100%)
Leader notes	22	22 (100%)
Kids' handouts	22	22 (100%)
Project challenges	23	23 (100%)
Do-It-Yourself (DIY) videos	22	22 (100%)
Video profiles of NASA engineers	21	21 (100%)
Wall poster	23	23 (100%)

Usability

In the national educator survey, we asked educators to report how usable the MSS resources were on a scale from 1 (Not usable at all) to 2 (Somewhat usable) to 3 (Highly usable). Usability was defined as "easy to comprehend, easy to follow, and easy to implement without confusion."

As summarized in the below, all educators that reported using the resources reported that the resources were somewhat or highly usable (100%).

Table 8:
Reported Usability of Resources Among Educators that Used Them

Resource	Number of Educators that Used This	Proportion Reporting it was Usable
Mission: Solar System guide	7	7 (100%)
Leader notes	7	7 (100%)
Kids' handouts	7	7 (100%)
Project challenges	7	7 (100%)
Do-It-Yourself (DIY) videos	4	4 (100%)
Video profiles of NASA engineers	5	5 (100%)
Wall poster	5	5 (100%)

We asked educators that reviewed the resources, but did not have a chance to use them yet in their educational settings, to predict how usable the MSS resources would be for them. As summarized in the below, all educators that reviewed the resources reported that they expected the resources to be usable (100%).

Table 9:
Expected Usability of Resources Among Educators that Reviewed Them but Did Not Use Them

Resource	Number of Educators that Responded	Proportion Reporting it was Usable
Mission: Solar System guide	23	23 (100%)
Leader notes	22	22 (100%)
Kids' handouts	22	22 (100%)
Project challenges	23	23 (100%)
Do-It-Yourself (DIY) videos	22	22 (100%)
Video profiles of NASA engineers	21	21 (100%)
Wall poster	23	23 (100%)

Appeal

In the national educator survey, we asked educators to report how appealing the MSS resources were on a scale from 1 (Not appealing at all) to 2 (Somewhat appealing) to 3 (Highly appealing). As summarized in the below, all educators that reported using the resources reported that the resources were somewhat or highly appealing (100%).

Table 10:
Reported Appeal of Resources Among Educators that Used Them

Resource	Number of Educators that Used This	Proportion Reporting it was Appealing
Mission: Solar System guide	7	7 (100%)
Leader notes	7	7 (100%)
Kids' handouts	7	7 (100%)
Project challenges	7	7 (100%)
Do-It-Yourself (DIY) videos	4	4 (100%)
Video profiles of NASA engineers	5	5 (100%)
Wall poster	5	5 (100%)

We asked educators that reviewed the resources, but did not have a chance to use them yet in their educational settings, to rate how appealing the MSS resources were to them. As summarized in the below, all educators that reviewed the resources reported that they found the resources to be appealing (100%).

Table 11:
Reported Appeal of Resources Among Educators that Reviewed Them but Did Not Use Them

Resource	Number of Educators that Responded	Proportion Reporting it was Appealing
Mission: Solar System guide	23	23 (100%)
Leader notes	22	22 (100%)
Kids' handouts	22	22 (100%)
Project challenges	23	23 (100%)
Do-It-Yourself (DIY) videos	22	22 (100%)
Video profiles of NASA engineers	21	21 (100%)
Wall poster	23	23 (100%)

Usefulness

In the national educator survey, we asked educators to report how useful the MSS resources were to help them educate their kids about the solar system on a scale from 1 (Not useful at all) to 2 (Somewhat useful) to 3 (Highly useful). As summarized in the below, all educators that reported using the resources reported that the resources were somewhat or highly useful for educating their kids about the solar system (100%).

Table 12:
Reported Usefulness of Resources Among Educators that Used Them

Resource	Number of Educators that Used This	Proportion Reporting it was Useful
Mission: Solar System guide	7	7 (100%)
Leader notes	7	7 (100%)
Kids' handouts	7	7 (100%)
Project challenges	7	7 (100%)
Do-It-Yourself (DIY) videos	4	4 (100%)
Video profiles of NASA engineers	5	5 (100%)
Wall poster	5	5 (100%)

We asked educators that reviewed the resources, but did not have a chance to use them yet in their educational settings, to rate how useful the MSS resources might be to them. As summarized in the below, all educators that reviewed the resources expected the resources to be useful to them (100%).

Table 13:
Expected Usefulness of Resources Among Educators that Reviewed Them but Did Not Use Them

Resource	Number of Educators that Responded	Proportion Reporting it was Useful
Mission: Solar System guide	23	23 (100%)
Leader notes	22	22 (100%)
Kids' handouts	22	22 (100%)
Project challenges	23	23 (100%)
Do-It-Yourself (DIY) videos	22	22 (100%)
Video profiles of NASA engineers	21	21 (100%)
Wall poster	23	23 (100%)

Educators in the field test also commented on the usefulness of the various MSS resources. Educators who watched the Teacher Training video reported:

- *I liked the demonstrations. I liked the variety in the examples.*
- *It was good to get an overview of the lessons before starting. The videos really helped to get an idea of what the lessons will look like.*

Educators who used the Teaching Tips resource reported:

- *I liked how they contained useful tips about what might not work well and how to avoid problems.*
- *Helpful and clearly written!*

Educators reported the following about the videos, generally:

- *I love the real world connections to actual NASA engineers and their careers.*
- *I liked that the clips included scientists from the field, kids completing the challenges, and simulations/info from space. I wished there were more videos to help kids connect the challenge to what actually happens out in space.*
- *I loved the clips. The challenge clips give the students a visual to help get them started and the engineer clips give the students examples of "real"*

engineers doing "real" jobs, with a personal touch of how they got interested in engineering.

- *I loved not having to search for the real-world application.*
- *I thought they were helpful.*
- *I did like the video and clips, and I think the students enjoyed seeing them as well.*

Educators who used the Design Squad website reported:

- *I love the website. I show the videos of the Heroes all of the time and my students participate in the challenges that are offered.*
- *I've used this website in the past so I was already familiar with it.*
- *The website is very easy to use. It has very useful information and I can always find what I am looking for quickly.*
- *Ease of use. Good video access.*
- *Have been using activities for years and just love the activities. I do modify them to increase the rigor for 8th graders which is required by my district*
- *The website was very helpful and I liked it.*

Relevance

In the national educator survey, we asked educators to report how relevant the MSS resources were to their student population (in other words, were the materials appropriate for their students and did they meet their needs?). Educators rated the relevance of the resources on a scale from 1 (Not relevant at all) to 2 (Somewhat relevant) to 3 (Highly relevant). As summarized in the below, all educators that reported using the resources reported that the resources were somewhat or highly relevant to their students (100%).

Table 14:
Reported Relevance of Resources Among Educators that Used Them

Resource	Number of Educators that Used This	Proportion Reporting it was Relevant
Mission: Solar System guide	7	7 (100%)
Leader notes	7	7 (100%)
Kids' handouts	7	7 (100%)
Project challenges	7	7 (100%)
Do-It-Yourself (DIY) videos	4	4 (100%)
Video profiles of NASA engineers	5	5 (100%)
Wall poster	5	5 (100%)

We asked educators that reviewed the resources, but did not have a chance to use them yet in their educational settings, to also rate the expected relevance of the resources to their students. As summarized in the below, all educators that reviewed the resources expected the resources to be relevant to their students (100%). One educator reported, “I'm hoping they will be engaging and challenging for middle school students with ‘deliverability’ by high school engineering students.”

Table 15:
Expected Relevance of Resources Among Educators that Reviewed Them but Did Not Use Them

Resource	Number of Educators that Responded	Proportion Reporting it was Relevant
Mission: Solar System guide	23	23 (100%)
Leader notes	22	22 (100%)
Kids’ handouts	22	22 (100%)
Project challenges	23	23 (100%)
Do-It-Yourself (DIY) videos	22	22 (100%)
Video profiles of NASA engineers	21	21 (100%)
Wall poster	23	23 (100%)

Educator Comfort Level

In the national educator survey, we asked educators to report on the impact, if any, that the MSS resources had on their comfort and ability to lead hands-on activities like these. Educators rated the impact on a scale from 1 (No impact at all) to 2 (Some impact) to 3 (High impact). As summarized in the below, all educators that reported using the resources reported that the resources had an impact on their comfort and ability to lead hands-on activities (100%).

Table 16:
Reported Impact of Resources Among Educators that Used Them

Resource	Number of Educators that Used This	Proportion Reporting it was Impactful
Mission: Solar System guide	7	7 (100%)
Leader notes	7	7 (100%)
Kids’ handouts	7	7 (100%)
Project challenges	7	7 (100%)

Resource	Number of Educators that Used This	Proportion Reporting it was Impactful
Do-It-Yourself (DIY) videos	4	4 (100%)
Video profiles of NASA engineers	5	5 (100%)
Wall poster	5	5 (100%)

We asked educators that reviewed the resources, but did not have a chance to use them yet in their educational settings, to also rate the expected impact of the resources on them. As summarized in the below, all educators that reviewed the resources expected the resources to have an impact on them (100%). One educator reported, “I think these are excellent resources. I have shared them freely and the other educators are thrilled because it increases their comfort and ability to lead hands-on activities.”

Table 17:
Expected Impact of Resources Among Educators that Reviewed Them but Did Not Use Them

Resource	Number of Educators that Responded	Proportion Reporting it was Impactful
Mission: Solar System guide	23	23 (100%)
Leader notes	22	22 (100%)
Kids’ handouts	22	22 (100%)
Project challenges	23	23 (100%)
Do-It-Yourself (DIY) videos	22	22 (100%)
Video profiles of NASA engineers	21	21 (100%)
Wall poster	23	23 (100%)

We asked educators in the field test to describe the ways in which MSS impacted their approach to teaching. The following table summarizes the number of educators (out of eight) who reported seeing “some impact” or “high impact:”

Table 18:
Impacts on Educators

Impacts	Count
How much did MSS impact the way you approach teaching, if at all?	6 out of 8
How much did MSS impact your understanding and awareness of the engineering design process, if at all?	6 out of 8
How much did MSS impact your knowledge of the solar	7 out of 8

Impacts	Count
system, if at all?	
How much did MSS impact your interest in using hands-on engineering activities in your classroom, if at all?	7 out of 8
How much did MSS impact your comfort level with providing engineering activities to your students, if at all?	8 out of 8

Educators reported:

- *I liked the real-world connections and will continue to look for them when introducing an engineering design challenge.*
- *Since I am familiar with the Design Squad approach I don't know that MSS impacted my approach however it certainly provided a way to teach the design process as it connects to space science.*
- *It got me doing more hands-on lessons. I want to teach engineering now.*
- *I think it made me more of a facilitator than a deliverer of information. I could get down with the kids and see how they learn.*
- *I am a recent college graduate of an Elementary Education program and MSS really reinforced the way I was taught to teach science and engineering. It did not change my approach at all but it did extend my knowledge of this way of teaching.*
- *It didn't impact how I teach.* (n = 3)

Quality

We asked all educators in the national educator survey to rate the quality of the MSS resources. Among the seven who used the resources, six rated MSS as "excellent" while one rated MSS as "good." Among the 26 educators who reviewed the MSS resources, but did not use them yet, 14 rated it as "excellent" and seven rated it as "good." The remainder did not respond to the question.

We asked educators in the national sample and the field test sample to report what they liked most about MSS. Educators reported that MSS helped them to reinforce the design process and to apply the challenges to real world problems:

- *I especially liked the real world connections to NASA and to the real world engineers.*
- *The activities support the Engineering Design Process and act as a precursory lesson to the solar system unit.*
- *We used these activities as our curriculum for the first few weeks of the evening science program. Students have completed other Design Squad challenges so these reinforced their knowledge and use of the design process.*

- *I used the activities to introduce the engineering design process to my students.*
- *The kids are better at naming the parts of the process. They learned a lot of vocabulary as well.*
- *I think they gave a real life thing for the kids to hook the knowledge to.*
- *Due to my program being an after school program, the challenges were the main focus of the learning taking place in the classroom. Although I had done some basic engineering lessons before, these activities gave the students a more in-depth and better understanding of the engineering design process.*
- *MSS was a great program. I really like that the engineering design process was laid out for kids to follow step by step on the handouts. MSS gave specific questions for the students to answer and think about throughout the entire challenge.*

Other educators reported that they were impressed with the inclusion of women and minority scientists in the resources and how this may help their students envision themselves in a STEM career someday:

- *Examples of women and minorities participating in NASA projects! We need to see that these groups are a normal part of science and technology! This informational data is essential for students to envision themselves as part of NASA, and STEM!*
- *I appreciate the diversity of race and culture through the videos. I also appreciate the hands-on focus.*

Some educators reported that they appreciated how user-friendly and accessible the MSS components were and how much it helped them lead hands-on activities, even in non-traditional educational settings:

- *It increases ease of use for those not familiar with hands-on projects.*
- *I love the fact that we could make things from ordinary materials, easily found. We work with undeserved, low income children. I want them to think that they can go home and invent things with stuff they can find.*
- *Ease of use and implementation into every classroom setting.*
- *Clear directions...colorful...easy to look at and read.*
- *I use the Design Squad video to help introduce the concept. Also use could use ordinary items to build objects.*
- *How well organized and developed they are.*
- *User friendly.*
- *Everything is very clear for the teacher and very appealing to the students.*
- *Their availability to use in non-traditional settings.*

- *Very child friendly.*
- *Kid friendly..teacher friendly...kids learn by doing!!!*

Some educators simply reported that they enjoyed the various MSS components:

- *Teacher notes are the best.*
- *Hands-on activities linked to careers in engineering.*
- *The booklets (Guide) (n = 2).*
- *DIY videos.*
- *It's beautifully done, engaging and spot on for teaching about the solar system in an exciting way.*
- *Good collection of well informed resources.*
- *Well designed and implemented and exciting looking.*
- *I liked the unifying theme of MSS. It was great to have something that could be used this way but also each activity built on each other. I liked the supplemental video that showed space or scientists in the field. My students definitely enjoyed the challenges and walked away with new understandings.*
- *High interest activities, high level science, current science and technology.*
- *The kids loved the challenges. The challenges were really unique and fun.*
- *Definitely the learning happens in the debrief when they talk about what they did and how it pertained to the NASA video, or to the learning target that we had for the day. One of them had to present their findings. I think it was the third week. And when they did that, and when they each spoke about what they did, then you could really see kids, the understanding coming through more.*

We also asked educators in both samples to report what they liked *least* about MSS. The greatest challenge encountered by educators was not having sufficient time to complete the challenges:

- *Time (not enough).*
- *Not enough time to do it all.*
- *The challenges took more time than the plan suggested.*
- *As an after school program director I had difficulty completing challenges due to my time restrictions. Challenges that were only suppose to take one day took us almost three weeks due to the short amount of time, once a week we had. With that said, as a teacher, I think the timing would have been good in a classroom.*
- *Core and robo-arm were frustrating. Need 2 hours for the challenges.*

During the observations, we noted that all the programs seemed to move very quickly in order to finish the challenges before their time was up. In one case, we observed a class that was only able to do the introduction and design of their projects during a single 50-minute class period. The building of the project was to happen the next day in class.

Educators also made other suggestions for ways to enhance the resources:

- *Wish the poster were larger! So much information on a small paper... would like to have it much larger for impact!*
- *Some design challenges encourage only one way of problem solving (AKA what was showcased in the video).*
- *I wish you had used interactive games to help supplement but actually all went well ...we enjoyed the mission.*
- *We need more STEM support at elementary level. Please develop more STEM and engineering design projects.*
- *I didn't like that the links provided in the book didn't always connect to the video materials so I had to search for them.*
- *I think that direct connections to current solar system science standards would make utilizing the lessons even more impactful.*
- *I think maybe the activities could be more open ended where the supplies used could be less definite and open to more of a real life situation where engineers decide what they are using.*

We asked educators in the national sample what kinds of resources they look for to use in their educational settings.

Table 19:
Resources Sought by Educators

	Formal Educators (N = 14)	**Informal Educators (N = 13)**
Hands-on activities	13	12
Videos	13	8
Lesson plans	11	11

Finally, we asked educators whether they would be likely to use the MSS resources in the future and whether they would recommend MSS to other educators. All (100%) of the educators in the field test sample and 22 out of 28 (79%) of the national educator sample reported that they were likely or very likely to use the resources in the future. Twenty-two out of 27 (81%) reported that they

were likely or highly likely to recommend MSS to another educator (field test educators were not asked this question).

Summary

Key findings from the evaluation study are listed below.

Impact on Students

Knowledge about NASA and Science Concepts

- There was a statistically significant increase in knowledge scores for the Treatment Group versus the Control Group.[5] This indicates that the MSS had a positive impact on student learning in the programs that used the MSS challenges.

- Of the students in the Treatment Group, 53% reported that MSS taught them "a lot," while 44% reported that MSS taught them "a little." Only 3% reported that MSS did not teach them anything about space exploration.

Satisfaction with Mission: Solar System

- We asked students in the Treatment Group to report on how much they enjoyed MSS, whether they would like to do more challenges like MSS, as well as what they liked most and what they liked least about MSS. The majority of students reported that they enjoyed MSS "a lot" (67%) or at least "a little" (24%).

- Most students (59%) reported that they would like to do more challenges like these or might like to (36%). Only 5% reported that they would not like to do more challenges like MSS.

- During our observations at Treatment Group sites, we observed that, without exception, the majority of students appeared to be enjoying the challenges. In all programs we visited, students were attentive, engaged, and enthusiastic during observations.

- We observed students bringing innovation to their designs. For example, during an observation of the coring challenge, one design used dominoes while others used structures and a slingshot incorporated into their designs. Students brought in extra materials including dominoes, electronics, wood blocks or cubes (Rubik's Cube) to add support, small wheels, plastic soda bottles, string and yarn.

[5] We conducted a general liner model test, correcting for intraclass correlations and found $F_{(7,188)} = 11.723$, $p = 0.000$.

- We observed that students across grades and across levels (special education students and gifted students) worked together in pairs or teams at each of the programs we visited. They generally seemed to work well together, with some rare exceptions where students worked independently instead of with their partners or teams.

- Students reported what they liked most and least about MSS:
    - Students reported that they liked being challenged as well as the chance to work together with other students to solve problems.
    - Some students reported that they enjoyed the challenges because they got to learn more about NASA or space exploration.
    - Some students reported that they appreciated having the freedom to develop their own designs and use their creativity.
    - Some students simply reported that they enjoyed the challenges.
    - Some students reported that they did not enjoy specific aspects of the design process, such as designing, building, or presenting their findings.
    - Some students reported having difficulty with other students in their groups.
    - Some students reported that they were unhappy with not always having a successful design or knowing all the answers.
    - Some students reported that they did not have sufficient time to work on their challenges.
    - Finally, some students reported that their programs did not have enough materials to complete the challenges.

Interest in STEM and 21st Century Skills

- Student interest in STEM and 21st Century skills was high at pre-test and at post-test in both groups. There were no significant improvements over time between the Treatment and Control Groups. This is likely due to a "ceiling effect" which occurs when pre-test scores are so high that there is almost no room for improvement on post-test surveys – in other words, the students started the field test interested in STEM and 21st Century skills and their interest did not increase or decrease appreciably over time.

Interest in NASA and Space Exploration

- We found no appreciable difference between the Treatment and Control Groups with respect to changes in interest in NASA and space exploration over time. On average, students in the Treatment Group were moderately interested in NASA and space exploration at the start of the field test and remained so after doing the MSS challenges.

Impact on Educators

- All educators (100%) in the National Educator Survey who reported using or reviewing the resources reported that the resources…
    - …were somewhat or highly feasible in their settings.
    - …were somewhat or highly usable.
    - …were somewhat or highly appealing.
    - …were somewhat or highly useful for educating their kids about the solar system.
    - …were somewhat or highly relevant to their students.
    - …had an impact on their comfort and ability to lead hands-on activities (100%).

- We asked educators in the field test to describe the ways in which MSS impacted their approach to teaching. Most agreed that MSS impacted…
    - …the way they approach teaching.
    - …their understanding and awareness of the engineering design process.
    - …their knowledge of the solar system.
    - …their interest in using hands-on engineering activities in their classroom.
    - …their comfort level with providing engineering activities to their students.

- We asked all educators in the national educator survey to rate the quality of the MSS resources. Among the seven who used the resources, six rated MSS as “excellent” while one rated MSS as “good.” Among the 26 educators who reviewed the MSS resources, but did not use them yet, 14 rated it as “excellent” and seven rated it as “good.” The remainder did not respond to the question.

- We asked educators in the national sample and the field test sample to report what they liked most about MSS:
    - Educators reported that MSS helped them to reinforce the design process and to apply the challenges to real world problems.
    - Other educators reported that they were impressed with the inclusion of women and minority scientists in the resources and how this may help their students envision themselves in a STEM career someday.
    - Some educators reported that they appreciated how user-friendly and accessible the MSS components were and how much it helped them lead hands-on activities, even in non-traditional educational settings.

    - Some educators simply reported that they enjoyed the various MSS components.

- We also asked educators in both samples to report what they liked *least* about MSS. The greatest challenge encountered by educators was not having sufficient time to complete the challenges. During the observations, we noted that all the programs seemed to move very quickly in order to finish the challenges before their time was up. In one case, we observed a class that was only able to do the introduction and design of their projects during a single 50-minute class period. The building of the project was to happen the next day in class.

- All (100%) of the educators in the field test sample and 22 out of 28 (79%) of the national educator sample reported that they were likely or very likely to use the resources in the future. Twenty-two out of 27 (81%) reported that they were likely or highly likely to recommend MSS to another educator (field test educators were not asked this question).

Appendix A: Field Test Student Surveys

Mission: Solar System Student Survey #1

Please do your best to answer the questions.

It's OK if you don't know an answer or you want to skip a question.

Please tell your teacher when you are done.

*1. Your name

2. Program or school name:

- ◯ 21st century after school program
- ◯ 4H After School Science Club
- ◯ Boys and Girls Club of Dorchester
- ◯ Boys and Girls Club of Fitchburg Leominster
- ◯ Doherty Middle School
- ◯ Duxbury Middle School
- ◯ Global Learning Charter Public School
- ◯ Harwich Middle School
- ◯ King Philip Middle School
- ◯ Robert J Coelho Middle School
- ◯ Silver Lake Middle School
- ◯ STEM Middle Academy
- ◯ Tiverton Middle School
- ◯ Wareham Middle School
- ◯ Other (please specify)

Mission: Solar System Student Survey #1

3. How old are you?

- ◯ 8
- ◯ 9
- ◯ 10
- ◯ 11
- ◯ 12
- ◯ 13
- ◯ 14
- ◯ 15
- ◯ Other (please specify)

4. Are you a...

- ◯ Boy
- ◯ Girl

5. True or false:

	True	Mostly true	In the middle	Mostly false	False
I like math.	◯	◯	◯	◯	◯
I like science.	◯	◯	◯	◯	◯
I like technology.	◯	◯	◯	◯	◯
I like building things.	◯	◯	◯	◯	◯

6. True or false:

	True	Mostly true	In the middle	Mostly false	False
I like creating things.	◯	◯	◯	◯	◯
I like working with teams.	◯	◯	◯	◯	◯
I like helping others.	◯	◯	◯	◯	◯
I like solving problems (like mysteries or puzzles).	◯	◯	◯	◯	◯

Below are a couple questions to see what kids know about NASA - the government agency that helps us explore outer space.

Please do your best to answer each question. It's OK if you have to guess.

Mission: Solar System Student Survey #1

7. True or False: NASA uses airbags (like the ones in a car) to land rovers on other planets.

- ◯ True
- ◯ False
- ◯ I don't know

8. True or False: NASA does NOT use magnets to study other planets.

- ◯ True
- ◯ False
- ◯ I don't know

9. True or False: NASA uses mechanical arms (like the ones a robot might have) to pick-up things on other planets.

- ◯ True
- ◯ False
- ◯ I don't know

10. True or False: NASA uses gravity to launch spaceships into space faster.

- ◯ True
- ◯ False
- ◯ I don't know

Below are a couple questions to see what kids know about SCIENCE.

Please do your best to answer each question. It's OK if you have to guess.

11. True or False: When a person jumps off something high, they can absorb some of the energy by bending their knees.

- ◯ True
- ◯ False
- ◯ I don't know

12. True or False: Magnets are created when a bunch of electrons spin in the same direction around an atom's nucleus (center).

- ◯ True
- ◯ False
- ◯ I don't know

Mission: Solar System Student Survey #1

13. True or False: A table is an example of a lever and fulcrum.

- ◯ True
- ◯ False
- ◯ I don't know

14. True or False: When a person stretches a rubber band, they build up kinetic (motion) energy.

- ◯ True
- ◯ False
- ◯ I don't know

15. True or false:

	True	Mostly true	In the middle	Mostly false	False
It's fun to learn about outer space.	◯	◯	◯	◯	◯
I would like to join a club or camp where I can learn about science and technology.	◯	◯	◯	◯	◯
It would be cool to work for NASA someday.	◯	◯	◯	◯	◯
I would like to have a job someday where I can explore outer space.	◯	◯	◯	◯	◯

Mission: Solar System Student Survey #2

Please do your best to answer the questions.

It's OK if you don't know an answer or you want to skip a question.

Please tell your teacher when you are done.

*1. Your name

2. Program or school name:

- ◯ 21st century after school program
- ◯ 4H After School Science Club
- ◯ Boys Girls Club of Fitchburg Leominster
- ◯ Doherty Middle School
- ◯ Harwich Middle School
- ◯ King Philip Middle School
- ◯ Medway Middle School
- ◯ Robert J Coelho Middle School
- ◯ Silver Lake Middle School
- ◯ STEM Middle Academy
- ◯ Wareham Middle School
- ◯ Other (please specify)

3. True or false:

	True	Mostly true	In the middle	Mostly false	False
I like math.	◯	◯	◯	◯	◯
I like science.	◯	◯	◯	◯	◯
I like technology.	◯	◯	◯	◯	◯
I like building things.	◯	◯	◯	◯	◯

4. True or false:

	True	Mostly true	In the middle	Mostly false	False
I like creating things.	◯	◯	◯	◯	◯
I like working with teams.	◯	◯	◯	◯	◯
I like helping others.	◯	◯	◯	◯	◯
I like solving problems (like mysteries or puzzles).	◯	◯	◯	◯	◯

Mission: Solar System Student Survey #2

Below are a couple questions to see what kids know about NASA - the government agency that helps us explore outer space.

Please do your best to answer each question. It's OK if you have to guess.

5. True or False: NASA uses airbags (like the ones in a car) to land rovers on other planets.

- ◯ True
- ◯ False
- ◯ I don't know

6. True or False: NASA does NOT use magnets to study other planets.

- ◯ True
- ◯ False
- ◯ I don't know

7. True or False: NASA uses mechanical arms (like the ones a robot might have) to pick-up things on other planets.

- ◯ True
- ◯ False
- ◯ I don't know

8. True or False: NASA uses gravity to launch spaceships into space faster.

- ◯ True
- ◯ False
- ◯ I don't know

Below are a couple questions to see what kids know about SCIENCE.

Please do your best to answer each question. It's OK if you have to guess.

9. True or False: When a person jumps off something high, they can absorb some of the energy by bending their knees.

- ◯ True
- ◯ False
- ◯ I don't know

Mission: Solar System Student Survey #2

10. True or False: Magnets are created when a bunch of electrons spin in the same direction around an atom's nucleus (center).

- ◯ True
- ◯ False
- ◯ I don't know

11. True or False: A table is an example of a lever and fulcrum.

- ◯ True
- ◯ False
- ◯ I don't know

12. True or False: When a person stretches a rubber band, they build up kinetic (motion) energy.

- ◯ True
- ◯ False
- ◯ I don't know

13. True or false:

	True	Mostly true	In the middle	Mostly false	False
It's fun to learn about outer space.	◯	◯	◯	◯	◯
I would like to join a club or camp where I can learn about science and technology.	◯	◯	◯	◯	◯
It would be cool to work for NASA someday.	◯	◯	◯	◯	◯
I would like to have a job someday where I can explore outer space.	◯	◯	◯	◯	◯

Please tell us your opinion of the Mission: Solar System challenges.

14. How much did you enjoy the Mission: Solar System challenges?

- ◯ I did not enjoy them at all.
- ◯ I enjoyed them a little.
- ◯ I enjoyed them a lot.
- ◯ I did not do any of the challenges.

Mission: Solar System Student Survey #2

15. Did the challenges teach you about space exploration?

- ◯ The challenges did not teach me anything.
- ◯ The challenges taught me a little.
- ◯ The challenges taught me a lot.

16. Did the challenges make you interested in learning more about space?

- ◯ I am not interested in learning more about space.
- ◯ I am a little more interested in learning about space.
- ◯ I am a lot more interested in learning about space.

17. Would you like to do more of these challenges?

- ◯ No
- ◯ Maybe
- ◯ Yes

18. What did you like MOST about the challenges?

19. What did you like LEAST about the challenges?

Appendix B: Field Test Educator Interview Questions

Teacher Interview Items

Background

1. Which challenges did you do?
    a. If you did not try all of them, how did you decide which ones to do?

2. Please describe your approach to integrating the activities into your curriculum. For example, did you teach a lesson on a specific topic prior to using MSS or did you teach the science lessons as you used MSS, or some other approach?

3. Did you watch the training video?
    a. Why or why not?
    b. If so, what did you like/not like about it?

4. Did you download the Teaching Tips from the website?
    a. Why or why not?
    b. If so, what did you like/not like about them?

5. Did you watch any of the 1-2 minute Challenges Videos or NASA Videos or Engineer Videos that were available on the website?
    a. Why or why not?
    b. If so, what did you like/not like about them?

6. [If not already answered] Did you use the Design Squad website?
    a. Why or why not?
    b. If so, what did you like/not like about it?

Impact on Students

7. In what ways, if at all, did the activities support or reinforce the learning that was taking place in your classroom?

8. What specific changes, if any, did you see in your students as a result of trying the activities? In what ways did the activities strengthen your students' ability to...
    a. ...identify and discuss the science concepts they applied, if at all?
    b. ...explain and use the engineering design process, if at all?
    c. ...cite examples of what an engineer does, if at all?

Impact on Teachers

9. How did MSS impact the way you approach teaching, if at all?

10. How did MSS impact your understanding and awareness of the engineering design process, if at all?

11. How did MSS impact your knowledge of the solar system, if at all?

12. How did MSS impact your interest in using hands-on engineering activities in your classroom, if at all?

13. How did MSS impact your comfort level with providing engineering activities to your students, if at all?

Satisfaction

14. How likely are you to use MSS again?

15. How interested do you think your students would be in doing engineering design challenges again?

16. Please summarize the main points that you liked about MSS.

17. Please tell us how we can improve MSS.

Appendix C: National Educator Survey

Mission: Solar System Teacher Survey

***1. Your name**

2. Which Mission: Solar System Challenges did you do? (Choose all that apply)

- [ ] Soft Landing
- [ ] Robo Arm
- [ ] Down to the Core
- [ ] Inspector Detector
- [ ] Invisible Force

3. If you did not do all of the Challenges, how did you decide which ones to do?

4. Please describe your approach to integrating the activities into your curriculum. For example, did you teach a lesson on a specific topic prior to using Mission: Solar System (MSS) or did you teach the science lessons as you used MSS, or some other approach?

5. Did you watch the Teacher Training video?

- ◯ Yes
- ◯ No

6. What did you like/not like about the Teacher Training video?

7. Did you download the Teaching Tips from the website?

- ◯ Yes
- ◯ No

8. What did you like/not like about the Teaching Tips?

Mission: Solar System Teacher Survey

9. Did you watch any of the 1-2 minute Challenges Videos or NASA Videos or Engineer Videos that were available on the website?

- ◯ Yes
- ◯ No

10. What did you like/not like about the video clips?

11. Did you use the Design Squad website?

- ◯ Yes
- ◯ No

12. What did you like/not like about the website?

13. In what ways, if at all, did the activities support or reinforce the learning that was taking place in your classroom?

14. Please tell us how much you agree with the following statements. The MSS challenges strengthened my students' ability to...

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
...identify and discuss the science concepts they applied.	◯	◯	◯	◯	◯
...explain and use the engineering design process.	◯	◯	◯	◯	◯
...cite examples of what an engineer does.	◯	◯	◯	◯	◯

15. How did MSS impact the way you approach teaching, if at all?

Mission: Solar System Teacher Survey

16. Please tell us how much the MSS materials impacted you, if at all:

	High impact	Some impact	Low impact	No impact
How much did MSS impact the way you approach teaching, if at all?	◯	◯	◯	◯
How much did MSS impact your understanding and awareness of the engineering design process, if at all?	◯	◯	◯	◯
How much did MSS impact your knowledge of the solar system, if at all?	◯	◯	◯	◯
How much did MSS impact your interest in using hands-on engineering activities in your classroom, if at all?	◯	◯	◯	◯
How much did MSS impact your comfort level with providing engineering activities to your students, if at all?	◯	◯	◯	◯

17. How likely are you to use the Challenges again?

- ◯ Highly likely
- ◯ Somewhat likely
- ◯ Neutral
- ◯ Somewhat unlikely
- ◯ Unlikely

18. How interested do you think your students would be in doing engineering design challenges again?

- ◯ Very interested
- ◯ Somewhat interested
- ◯ Neutral
- ◯ Somewhat disinterested
- ◯ Not interested at all

19. Please summarize the main points that you liked about MSS.

20. Please tell us how we can improve MSS.

21. Thank you so much for your help with the field test!

We would like to send you a check for $100 to cover the cost of materials, etc. Please let us know who to make the check payable to, and the best address for mailing the check.

THANKS!

Check payable to:

Mailing address for the check: