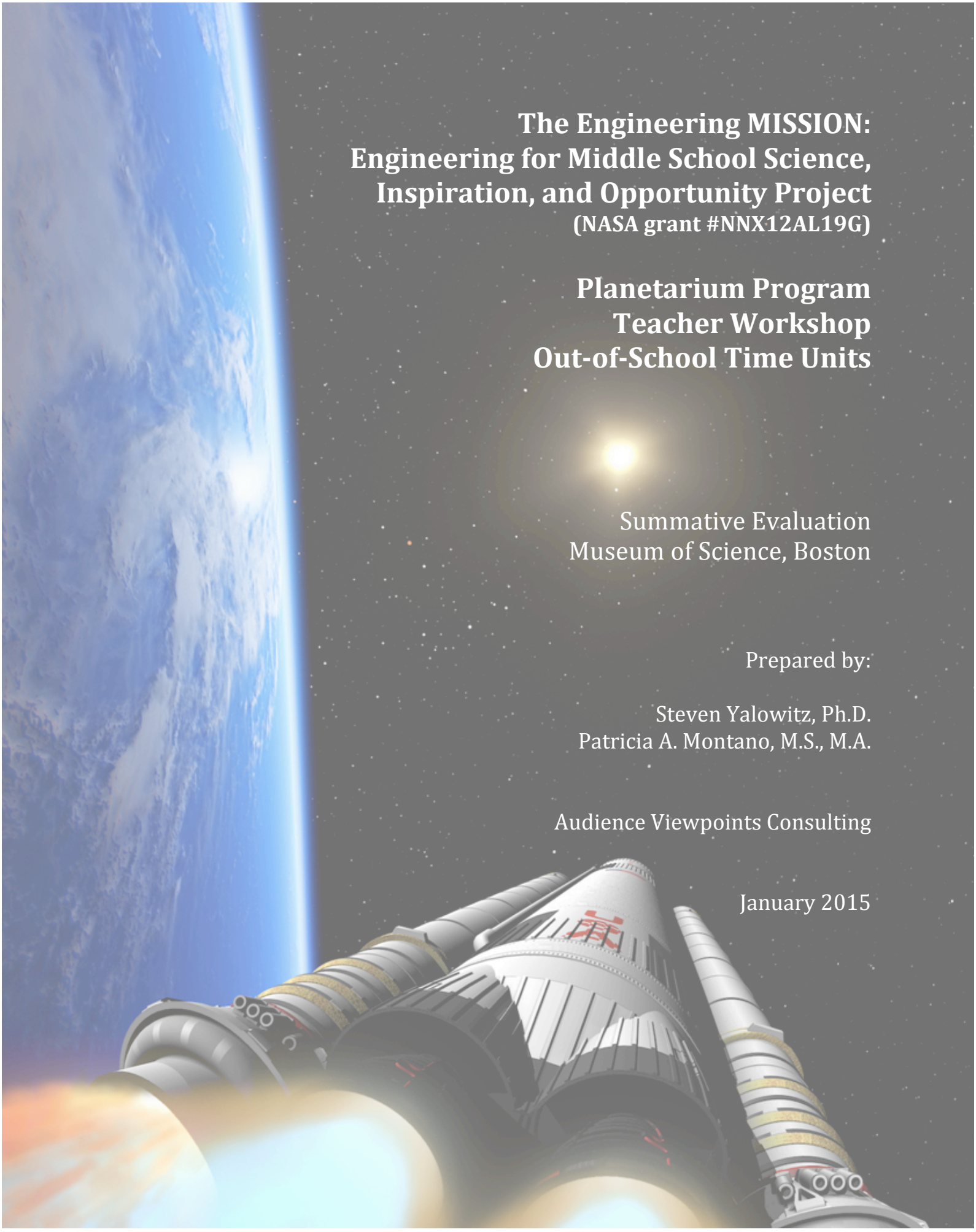

The Engineering MISSION: Engineering for Middle School Science, Inspiration, and Opportunity Project

(NASA grant #NNX12AL19G)

Planetarium Program Teacher Workshop Out-of-School Time Units

Summative Evaluation
Museum of Science, Boston

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Summative Evaluation of *The Engineering MISSION: Engineering for Middle School Science, Inspiration, and Opportunity Project*

Executive Summary

BACKGROUND

In the *Engineering MISSION* project, the Museum of Science, Boston partnered with Goddard Space Flight Center (GSFC) and the Massachusetts Space Grant Consortium (MASGC) to develop educational resources to strengthen engineering education in formal, informal, and out-of-school time environments, funded by NASA (grant #NNX12AL19G). The project created resources for use by multiple audiences in order to achieve the project goals of increasing the awareness of engineering work done during NASA missions. This included engaging early middle school and upper elementary students in the Engineering Design Process (EDP), inspiring the next generation of engineers and scientists, and supporting middle school teachers and museum and planetarium educators in engaging students and the general public.

Three main deliverables were created for the project: 1) an engineering-themed fulldome planetarium program featuring NASA's unmanned missions, 2) a summer teacher workshop designed for middle school teachers, and 3) Out-of-School Time units focused on aeronautical and aerospace engineering activities. In addition to these three main deliverables that are the focus of this evaluation, the project included the development of video assets created from the planetarium show and a workshop for planetarium educators. The resources developed for *Engineering MISSION* highlight the importance of engineering in space exploration, the engineering design process, and our society's dependence on both engineering and science to further human knowledge. As a whole, the *Engineering MISSION* project extends the museum's role as a champion of engineering education in both the formal and informal education environments, and extends ongoing work creating and introducing engineering education curricula for grades K-12.

PURPOSE

The summative evaluation was employed to determine the extent to which the project goals were being achieved through the deliverables. Given the variation in the three main deliverables, in terms of both delivery and audiences, each deliverable had its own set of evaluation questions, which guided the selection of methods for the evaluation. The evaluation questions for the planetarium program focused on how engaging and interesting audiences found the program, whether it increased positive attitudes towards engineering, and whether students were more likely to consider a career in engineering as a result of viewing the program. Evaluation questions for the teacher workshop included finding out whether teachers' needs were being met for engaging middle school students

about engineering, which aspects of the workshop were most effective, and whether teachers felt better able to communicate about engineering after the workshop. The Out-of-School Time evaluation questions focused on finding out which activities were most engaging, how the units and lessons support connecting with engineering curriculum, and how teachers and students have applied lessons from the units since participating.

METHODS

In order to answer the summative evaluation questions for this project a number of different methods, with a variety of audiences, were used. They included group discussions, in-person surveys, web surveys, and telephone interviews (see table below). For the planetarium program, surveys were used with both general visitors (n=126) and students (n=124); both groups were recruited ahead of time, watched the planetarium program, then filled out a survey about their experience. In the teacher workshop, the 25 teachers who participated filled out daily surveys each of the first four days, then a more comprehensive survey on the last day. Teachers also participated in group discussions on the final day, and 15 of the teachers answered a follow up web survey two months after the workshop. For the Out-of-School Time units, an invitation was sent to all of the teachers who participated in the two units included in this project, with 15 of them responding and participating in a telephone interview about their experience.

Study / Methods	Sample Size (n)	Purpose
Planetarium Program		To understand if general museum and school audiences find the content of the planetarium show engaging and interesting, if these two audiences show increased positive attitudes towards engineering, and to understand if students feel inspired to consider engineering as a future career.
General Visitor Surveys	126 adults and children	
School Group Surveys	124 students (5^{th}, 7^{th}, 8^{th} graders)	
Teacher Workshop	25 teachers	Understand how middle school teachers who attended the workshop react to, learn from and implement topics and activities covered in the five days of the teacher workshop.
Daily Survey	22-25	
Last Day Survey	23	
Discussion Groups	23	
Follow up Survey	15	
Out-of-School Time Units		Gather a more detailed understanding of how educators used the materials, and any perceived changes in student attitudes and behaviors.
Telephone Interviews	18 educators	

MAIN FINDINGS

Overall, the deliverables did achieve the stated objectives of engaging multiple audiences in engineering and the engineering design process, in a number of ways. The planetarium program engaged both students and the general public around the topic of NASA's unmanned missions to explore space. Teachers participating in the teacher workshop resulted in increased knowledge and confidence about engaging students in the Engineering Design Process and related topics. The Out-of-School Time activities were engaging, with both teachers and students having positive outcomes after participating in the units.

Planetarium Program

The planetarium program received good ratings for satisfaction, educational and entertainment experience, which was consistent across both students and general visitors. The majority of those who had seen other planetarium programs said the MOS program was better than similar planetarium programs they had seen. A majority also said they would recommend that other people see the program.

In terms of what participants learned from the planetarium program, over a third reported learning something new about building a spacecraft, while another quarter learned about Pluto and/or the New Horizons mission to Pluto. Other topics learned also included engineering-related content, the Hubble and Webb space telescopes, space in general, and NASA. There was evidence that the program encouraged students and general visitors to better appreciate the challenges engineers face when developing spacecraft for exploration, and also made engineering more fun. Participants also reported moderate gains in how they think about engineering, and some students said that seeing the program made them more likely to consider becoming an engineer. Students who said the program made engineering seem more fun were more likely to both consider becoming an engineer, and said it changed how they thought about engineering in general. Perceiving engineering as fun was also related to recommending the program to others, and appreciating the challenges of engineering in space.

Teacher Workshop

Ratings for the teacher workshop were very high, with a steady increase in satisfaction for the workshop over the five days; teachers used words such as inspiring, exciting, fantastic, and engaging to describe the workshop itself. The majority of teachers said the workshop was better than similar workshops they had taken, and three teachers said it was among the best, if not the best, professional development program they had ever experienced. Almost every single teacher said they would strongly recommend the workshop to other teachers, in part due to the time collaborating with and learning from other teachers. This last point was particularly useful to teachers, as discussing specific content at length with other teachers was an opportunity they did not normally get. Teachers reported significant increases in many of the outcomes measured, including feeling confident and knowledgeable about teaching science topics and the Engineering

Design Process, connecting workshop content to the curriculum, and being inspired to teach science and the Engineering Design Process.

The workshop activities teachers found most useful were meeting a former astronaut, working on an action plan, being able to choose the topic they worked on, the Engineering Adventures afterschool units, and the facilitated work time on class activities; all of these were rated a 9.0 or higher on a 10-point scale. When discussing the various workshop resources (including the planetarium program, the library time, and activities), teachers said they learned an incredible amount and even came up with multiple possibilities for including them in their lessons. All of the teachers agreed that their classroom practice would change in some way because of the workshop, and they believed these changes would be sustained over multiple years. In fact, when teachers completed a survey two months after the workshop the large majority had already found ways of incorporating content and strategies into their classes; this included specific examples like the Engineering Design Process, planetary science, waves, and gravity.

Out-of-School Time Units

Educators who participated in the two Out-of-School Time units talked about how the experience was memorable, referring to the content and how it was delivered, the positive student reactions, mentioning specific activities, and the hands-on or interactive nature of the activities. They talked about how the combination of interesting content and how it was delivered resulted in students being more excited or enthusiastic than they normally see. There were a number of specific activities mentioned, including the dropcopters, stomp rockets and wind tunnel; the hands-on nature of building or doing something with supplies was also mentioned.

Since participating, almost half of the educators had applied the content knowledge in their own classrooms, camps or after-school programs. Those who had not done so had considered it, but either had not yet gotten around to it, or the content did not match the classes they were currently teaching. In terms of teaching strategies, the large majority of educators had already applied strategies, especially the Engineering Design Process (EDP), specific hands-on strategies, or teaching strategies they picked up in the units (e.g., more open-ended activities, using different types of media or materials). Of the educators who were still working with the students who participated in the units, the large majority said they had seen some evidence of the students being influenced by their participation in the Out-of-School Time units. The educators reported seeing evidence of changes in student attitudes towards failure, as well as students applying the Engineering Design Process; both were main messages of the Out-of-School Time units. Teacher also said there was some evidence for an increase of interest among students of engineering as a possible career.

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Introduction

Engineering MISSION Project Background

In the *Engineering MISSION* project, the Museum of Science, Boston (MOS) partnered with Goddard Space Flight Center (GSFC) and the Massachusetts Space Grant Consortium (MASGC) on a NASA-funded grant (#NNX12AL19G). The project developed educational resources that strengthen engineering education in the formal, informal, and out-of-school-time environments by creating flexible resources for use by various audiences in order to achieve the following **project goals**:

- Increase student and public awareness of fields of engineering and the work of engineers by featuring NASA missions developed and operated by the Goddard Space Flight Center.
- Inspire the next generation of engineers and scientists through the development and distribution of a fulldome planetarium show and related visual education assets illustrating the challenges and triumphs of today's engineers and scientists as they explore exciting topics in and space science.
- Engage early middle school and upper elementary students in the engineering design process and engineering habits of mind through the development of hands-on aerospace engineering curriculum units for use in out-of-school-time settings.
- Educate museum and planetarium educators how to effectively engage middle school students, their teachers, and public audiences in informal engineering education by hosting a best practices training workshop using this project's products.
- Support middle school teachers in connecting the engineering and science content of the planetarium show and related visual assets with their school curriculum by hosting a best practices workshop.

There were **three main deliverables** produced for the project:

1. Planetarium program – this was a dynamic, engineering-themed fulldome planetarium show featuring NASA's unmanned missions to explore space. To support the planetarium show, the museum designed a collection of short duration, engineering-focused, space-themed visual assets that planetariums and museums can use in their live programming.
2. Summer teacher workshop – the workshop, titled the Engineering MISSION Teacher Institute, was designed for middle school teachers and was hosted to present the planetarium program resources and their applications in a cohesive manner to teachers who would use them; it included selecting specific topics of their choice and developing a related lesson plan in the workshop.
3. Out of School Time (i.e., after school) units – these hands-on activities and related content focused on aeronautical and aerospace engineering, and were designed for late elementary school after school and similar programs.

In addition to these three main deliverables that are the focus of this evaluation, the project included the development of video assets created from the planetarium show and a workshop for planetarium educators. The resources developed for *Engineering MISSION* highlight the importance of engineering in space exploration, the engineering design process, and our society's dependence on both engineering and science further human knowledge. The fulldome planetarium show and the workshop for middle school teachers were crafted to support the middle grades (5 through 9) in science, technology and engineering standards. The out-of-school-time units were aimed at the upper elementary and early middle school age levels in an effort to provide materials that would inspire youth to think about STEM careers early in their education. Lastly, the engineering-themed visual assets (created in tandem with the fulldome planetarium show) were developed for maximum flexibility for the audiences they serve.

At the heart of *Engineering MISSION* is conveying the engineering design process. Introducing the engineering design process, and the idea that science and engineering are disciplines that help people, is important during the upper elementary and early middle school years. Additionally, resources developed for *Engineering MISSION* presents engineering through the lens of our quest for knowledge about the Earth, solar system, and universe as embodied in NASA missions of exploration and discovery. The resources aim to illustrate how our scientific understanding of the natural world, and technological achievements of the human-made world is driven through the work of engineers. In various ways, audiences have seen that new technologies expand our knowledge of our planet and universe, and how our drive for knowledge pushes the development of new technologies. In total, the *Engineering MISSION* project extends the museum's role as a champion of engineering education in both formal and informal education environments, and extends on going work creating and introducing engineering education curricula for grades K-12.

This report weaves the three components of the project in each section by first addressing the planetarium program, then the teacher workshop, and finally the out-of-school time audience.

Purpose of the Evaluation

The summative evaluation was employed to determine the extent to which the project goals were being achieved through the deliverables. Given the variation in the three main deliverables, in terms of both delivery and audiences, each deliverable had its own evaluation questions, which guided the selection of methods for the evaluation. The evaluation questions for the summative evaluation include the following.

Planetarium Program:

1. To what extent do the audiences find the content engaging and interesting?
2. How much does viewing the planetarium program increase positive attitudes towards engineering?
3. Are students viewing the planetarium program inspired to consider engineering as a future career?

Teacher Workshop:

1. To what extent are educators' needs being met for engaging middle school students in engineering content, both in and out of school?
2. Which aspects of the workshop best support engaging and communicating with middle school students about engineering?
3. Do educators feel better able to communicate about engineering after participating in the workshop?

Out-of-School Time Units:

1. What is most engaging for teachers and students about the units and lessons?
2. How do the units and lessons most effectively support the engineering curriculum?
3. How have teachers applied the content and strategies in their classrooms? What evidence is there that students have been impacted by the participating in the units?

To answer these evaluation questions, a mixed methods approach using both qualitative and quantitative methods was employed. The methods selected for each component are described in the section below.

The main outcomes measured in the summative evaluation included increased positive attitudes towards engineering, cognitive learning of engineering concepts, and consideration of engineering as a potential career. The research design for this study was a One-shot Post-test only design (see p.34 in Friedman, 2008)[1].

[1] Friedman, A. (Ed.). (March 12, 2008). Framework for Evaluating Impacts of Informal Science Education Projects [On-line]. (Available at: http://insci.org/resources/Eval_Framework.pdf)

Methods

This section includes the specific methods used for each of the three studies (see Table 1), as well as the goals and topics included in each study. In order to answer the specific evaluation questions listed above for the studies, both qualitative and quantitative methods were employed. This included group discussions, in-person surveys, web surveys, and telephone interviews.

Table 1. Methods in the Engineering MISSION Study

Study / Methods	Sample Size (n)	Purpose
Planetarium Program		To understand if general museum and school audiences find the content of the planetarium show engaging and interesting, if these two audiences show increased positive attitudes towards engineering, and to understand if students feel inspired to consider engineering as a future career.
General Visitor Surveys	126 adults and children	
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Daily Survey	22-25	
Last Day Survey	23	
Discussion Groups	23	
Follow up Survey	15	
Out-of-School Time Units		Gather a more detailed understanding of how educators used the materials, and any perceived changes in student attitudes and behaviors.
Telephone Interviews	18 educators	

Planetarium Program Methods

Goals

- For general museum and school audiences to find the content of the planetarium show engaging and interesting
- For the planetarium show to increase positive attitudes towards engineering
- And for the planetarium show to inspire students to consider engineering as a future career

Viewers of the planetarium show were recruited in advance. The school groups contacted for the study were those that had already scheduled a field trip to the museum, including a 7th grade class on October 20, and 5th and 8th grade classes on November 10. They were chosen because they appeared to have no scheduling conflicts with additional programs during their visit. Prior to attending the museum, parental consent was obtained from parents/guardians for all students in the study.

The general museum group was recruited using the Museum's general and adult e-news lists and social media. One evening screening of the planetarium show was scheduled for October 21st. All the data were collected by November 14th. Written consent forms were obtained from all participating individuals on site before the study began. Oral assent was also obtained before study began, and participants were informed that they could terminate their participation in the study at any time.

Methods

Participants were given instructions to view the planetarium program as they normally would, and that afterwards a short survey would be distributed that would ask about their experience. After seeing the planetarium show, all viewers were asked for their feedback on a paper and pencil survey (see Appendix A).

Topics Covered in the Survey

- Ratings of the program
- Comparison to other planetarium programs
- What participants learned
- Impact of the program on thinking about engineering
- Recommendation for viewing the program

Teacher Workshop Methods

Goals

By the end of the workshop, teachers would be able to:

- Engage with the learning resources developed via the MISSION grant, including the planetarium show, classroom appropriate visual assets and out-of-school curriculum units
- Discuss curricular connections and classroom applications of these resources
- Become familiar with the engineering design process
- Gain awareness of the fields of engineering, the work of engineers, and understand that science and engineering are disciplines that help people.
- Connect the ways that new technologies expand our knowledge of our planet and universe with the ways our drive for knowledge in Earth and space science push the development of new technologies
- Learn new engineering and/or space science related content (what is new will vary from participant to participant
- Become inspired to engage their students in both engineering and science learning.
- Develop or increase confidence in their capacity to teach engineering and science.
- Develop and access additional resources in support of engineering and science learning.

Participation in the evaluation portion of the workshop was optional. On the first day of the workshop the evaluation study was explained, teachers were given an information page about the study and a consent form to complete.

Methods

A variety of qualitative and quantitative methods were used to evaluate the objectives of the teacher workshops: 1) a shorter daily survey, 2) a longer survey on the last day of the workshop, 3) a group discussion at the end of the workshop, and 4) a web survey two months after the workshop. See Appendices B through E for the four instruments.

At the end of each of the first four days of the workshop, teachers took a short survey, approximately 15 minutes in length, using the online platform SurveyMonkey. On the fifth and final day of the workshop, teachers were asked to complete a longer survey, one that focused on the intentions teachers had for using materials, activities, and resources from the workshop in their classrooms (see Table 2). On the final day of the workshop, teachers were also split into two groups and participated in a group discussion with an AVC evaluator. The group discussions concentrated on three main areas: the aspects of the workshop that were most useful, the extent the workshop helped teachers become more comfortable teaching engineering and science, and what teachers might do differently in the classroom as a result of attending the workshop.

Approximately two months after the workshop, teachers were contacted to complete a follow-up web survey that asked about their satisfaction with the workshop, and their use of materials, activities and resources from the workshop in their classrooms.

Table 2. Calendar of Methods, Teacher Workshop

	M	T	W	Th	F	2 Months
Instrument	Daily Survey	Daily Survey	Daily Survey	Daily Survey	Last Day Survey Discussions	Follow up Survey
# Teachers	25	22	24	24	23	15

Teacher Workshop Evaluation Focus

The focus of the evaluation was to understand how middle school teachers who attended the workshop react to, learn from and implement topics and activities covered in the five days of the teacher workshop.

Topics completed during the workshop and covered in workshop daily surveys

- Learning about content
- Learning activities/strategies for teaching content
- What teachers liked about the workshops
- What teachers thought of as most useful to them
- What teachers thought students would find most interesting

Topics covered in surveys after the workshop ended (final day and 2 months after)

- What teachers found most memorable
- What teachers found most useful
- What teachers plan to apply in the classroom
- If teachers felt more confident teaching about engineering and space science
- Whether teachers have used or will use any of the workshop activities or materials

Out-of-School Time Units Methods

In the out-of-school time portions of the report, the adults interviewed are referred to as educators rather than teachers. The term educator best fits since this part of the MISSION project was designed for instruction outside of the traditional classroom environment, in either an afterschool or camp program, where the adult might not be a certified teacher.

Goals

- To understand how educators have thought about and used the information from the out-of-school time (OST) units since participating.

- Document if educators have changed their thinking or teaching about engineering, or other STEM-related topics as a result of participating in the OST units.
- Document if educators have seen any observable changes in the students who participated in the units.

Methods

In order to get more qualitative feedback about educators' experiences with OST units, AVC employed a telephone interview with open-ended questions to gather evaluation data (see Appendix H for the instrument). These data complement the more quantitative data gathered by the MOS staff on the Out-of-School Time units about these specific units.

The MOS sent an email (see Appendix I) to all 53 educators who participated in either of the two units: 1) Aerospace Engineering or 2) Aeronautical Engineering. This email notified them that they would receive an email from AVC asking them to participate in a telephone interview about their participation in the program. The purpose of this email was to both prepare educators for receiving the invitation, and to provide a level of authority to AVC in contacting the educators. A few days after AVC was provided the list of emails, AVC contacted educators asking them to participate in a Doodle Poll (an online meeting scheduling program, www.doodle.com) to reserve a day and time to be called for the telephone interview. A reminder email was sent to educators who did not respond to the first email.

Of the 53 educators emailed, a total of 50 emails were delivered through the email system; 3 were returned as undeliverable and one was ineligible because they had not participated in the program. In a small number of cases, the contact was not the most appropriate person and the email was forwarded to the educators of the unit(s). Out of the 49 eligible emails delivered, a total of 18 educators agreed to participate, scheduled and completed a telephone interview (response rate of 37%). Telephone interviews were conducted from November 17 through December 2, 2014, and followed a specific interview protocol (see H). During the calls, interviewees' responses were typed verbatim into a www.surveymonkey.com database. The open-ended responses were deductively coded into categories, in order to identify trends in the responses.

Topics covered during the interview

- General reactions, lasting impressions, and recollections of the program
- Current application of what they learned in teaching the unit, or applications of strategies or processes
- Whether they have done any other activities or units related to engineering
- Whether they have used any of the materials in the unit since it ended
- Observations of children:
    - Behavior that could have been influenced by the units
    - Changes in attitudes towards failure (perseverance, resilience)
    - Interest in engineering in general, or considering engineering as a career
    - Applying the steps they learned in other activities, classes or areas

Characteristics of the Samples

The following sections include details about who participated in each of the studies, in order to provide context to the findings.

Planetarium Program - Characteristics of the Sample

Of all participants in the study 94% were repeat visitors to the Museum (see Figure 1). When examined by audience type, 98% of general visitors, and 90% of student participants were repeat visitors (see Figure 2). Those who had previously seen a planetarium program were comprised of 60% of all participants (see Figure 3), 69% of the general visitors and 50% of the students (see Figure 4).

Overall, the majority of participants, 56%, in the study were male (see Figure 5). Within the general visitor group, the percentage of females was greater than males (52% vs. 48%), in contrast to the student group, which was 65% male (see Figure 6). In terms of the age, it was not surprising to find a big difference between the two samples; students were all between the ages of 7 and 17, while the general visitors were most likely between the ages of 25 to 54 (24%) or 18 to 24 (17%) (see Figures 7 & 8).

Figure 1. Previous Visitation to the Museum of Science, All Participants n=250

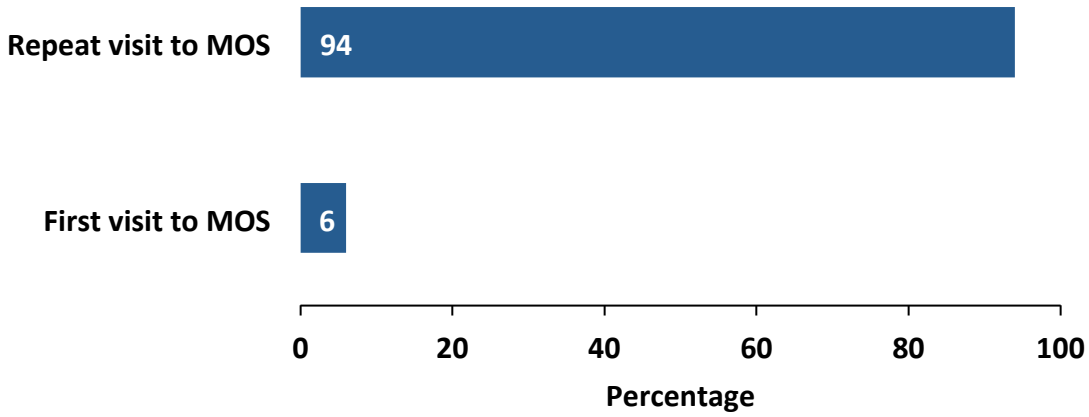
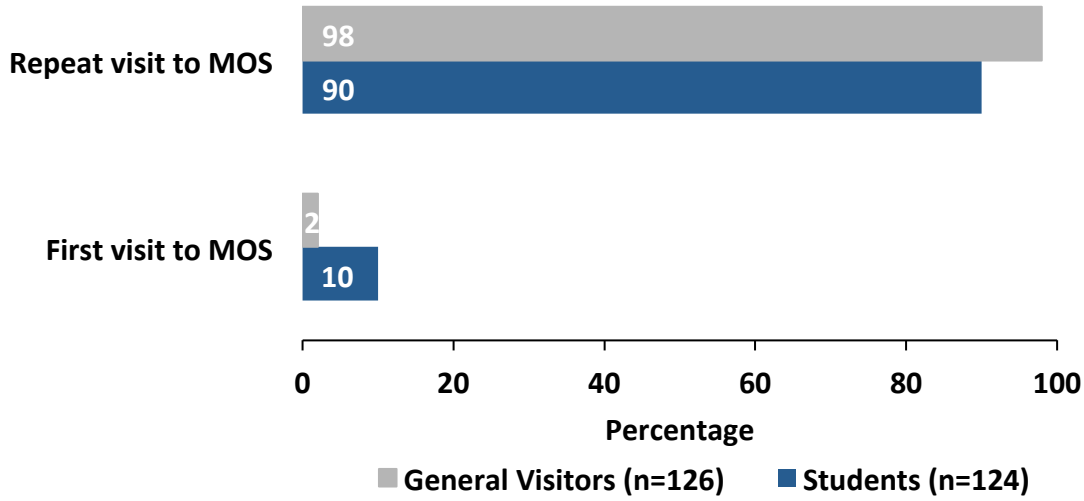


Figure 2. Previous Visitation to the Museum of Science, By Audience Type



NOTE: This difference was a statistically significant difference.

Figure 3. Previous Viewing of MOS Planetarium Program, All Participants n=247

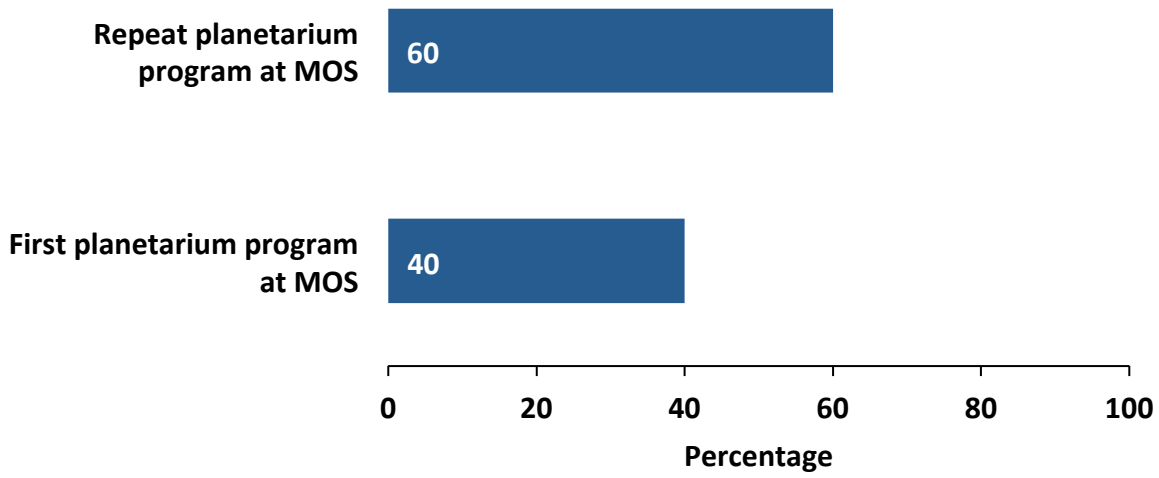
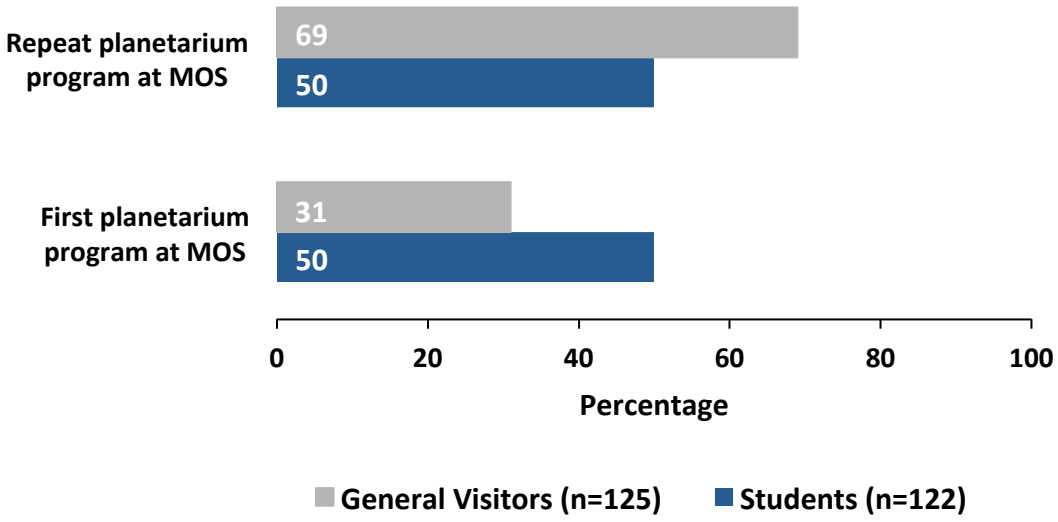


Figure 4. Previous Viewing of MOS Planetarium Program, by Audience Type



NOTE: This difference was a statistically significant difference.

Figure 5. Gender of All Participants, n=250

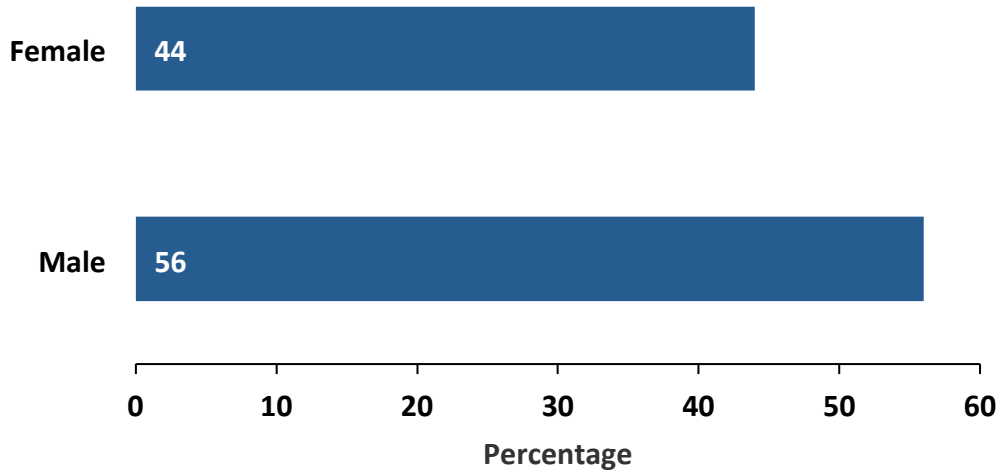
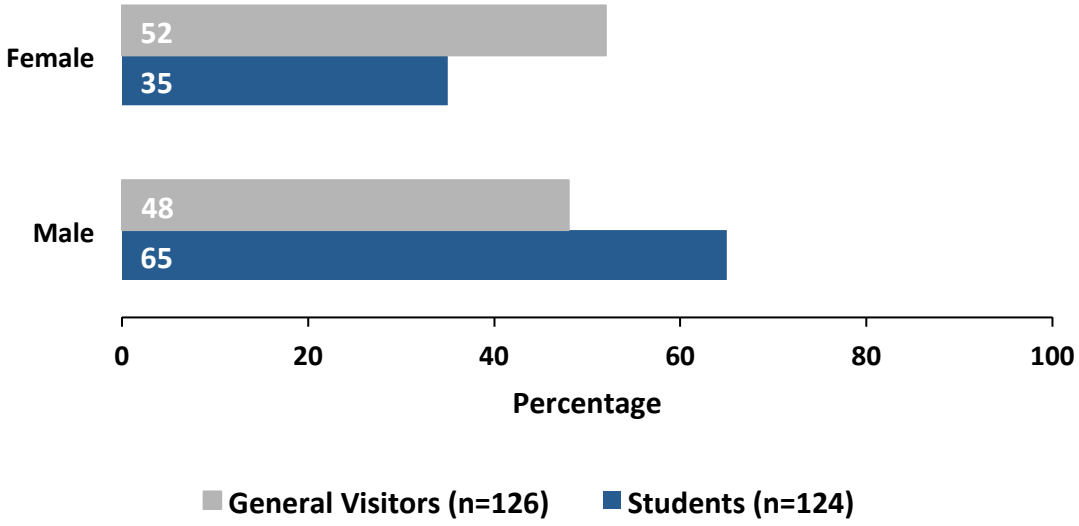


Figure 6. Gender By Audience Type



NOTE: This difference was a statistically significant difference.

Figure 7. Age Categories of All Participants, n=250

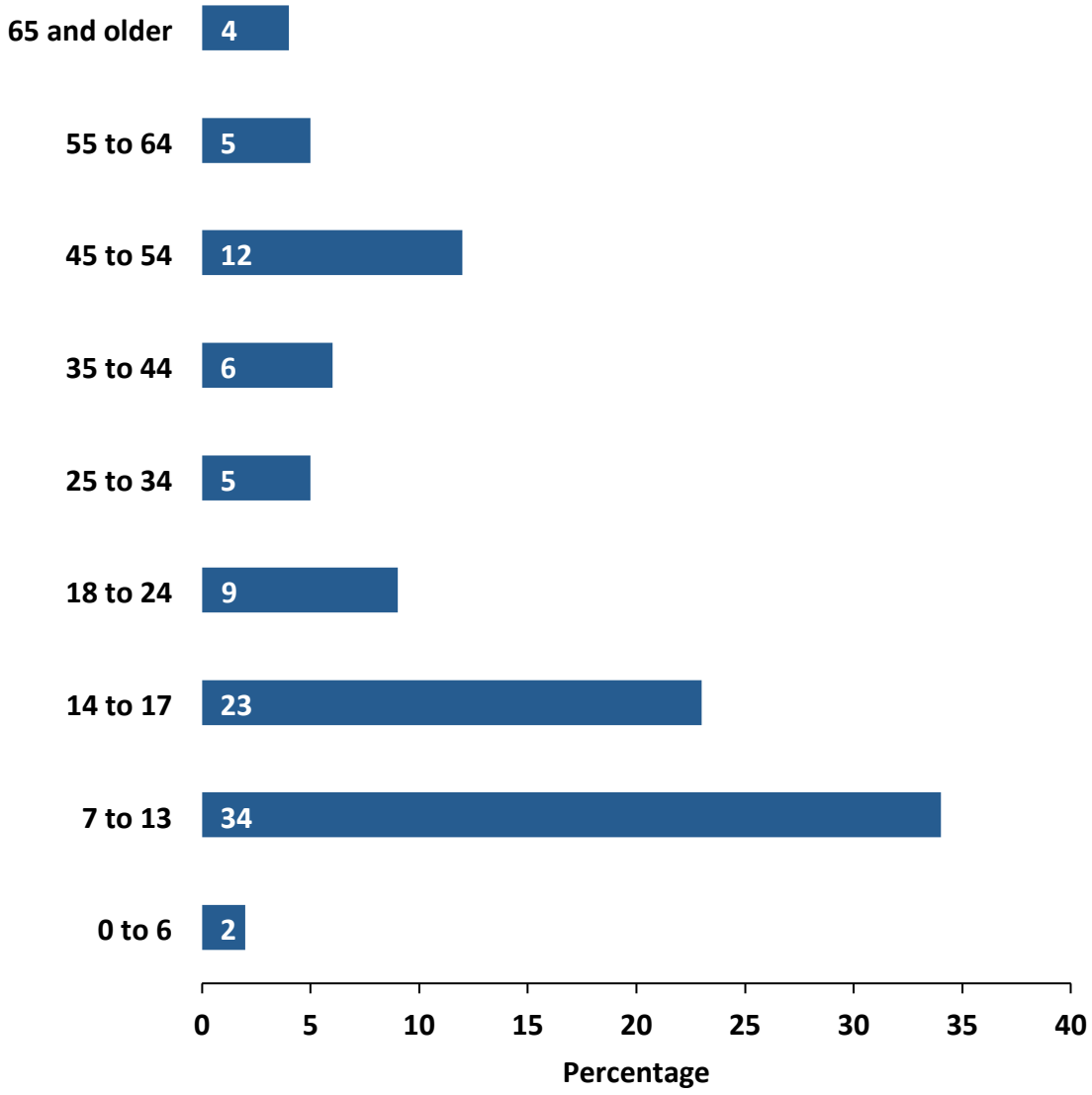
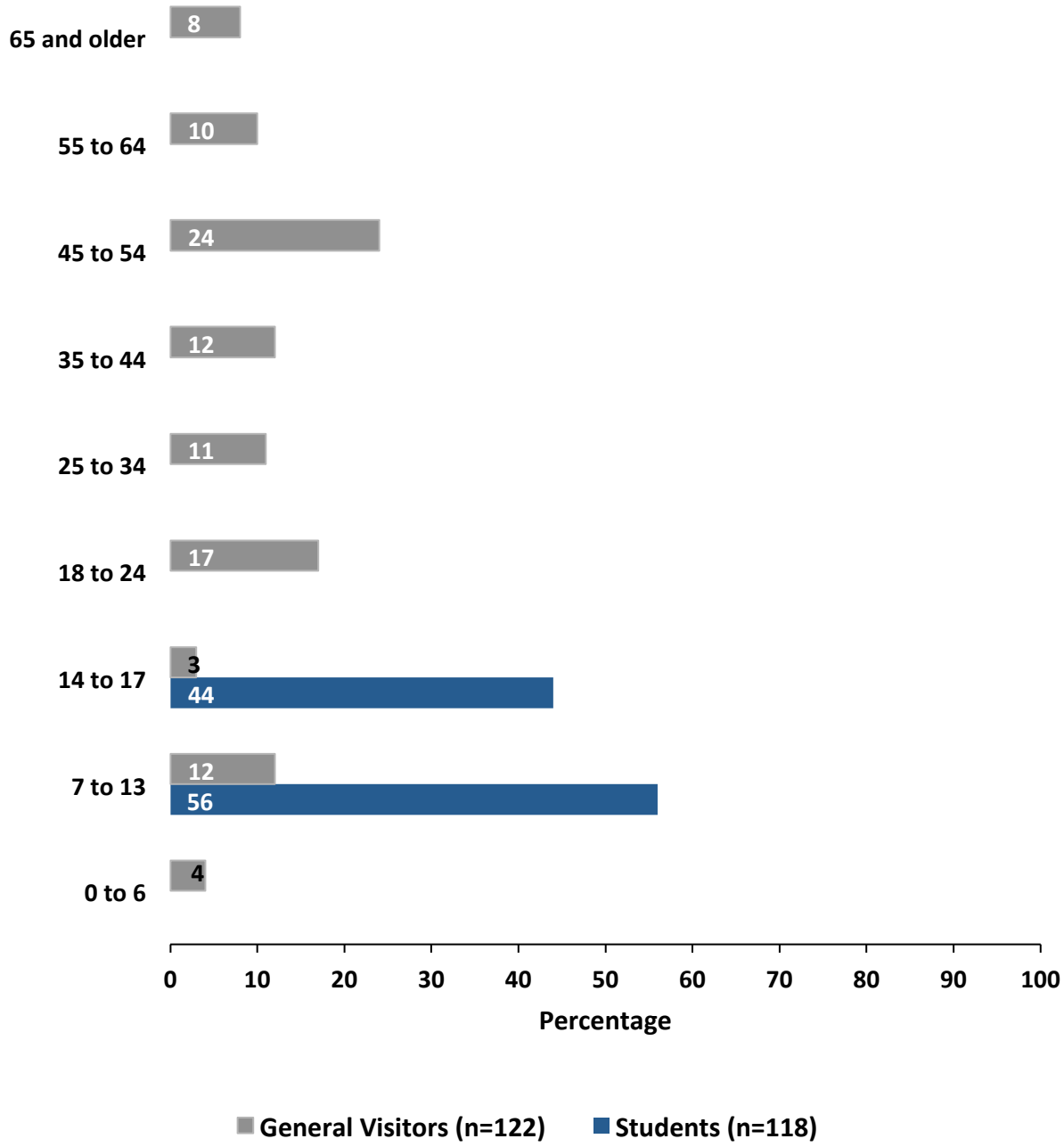


Figure 8. Age of Respondent, by Audience Type



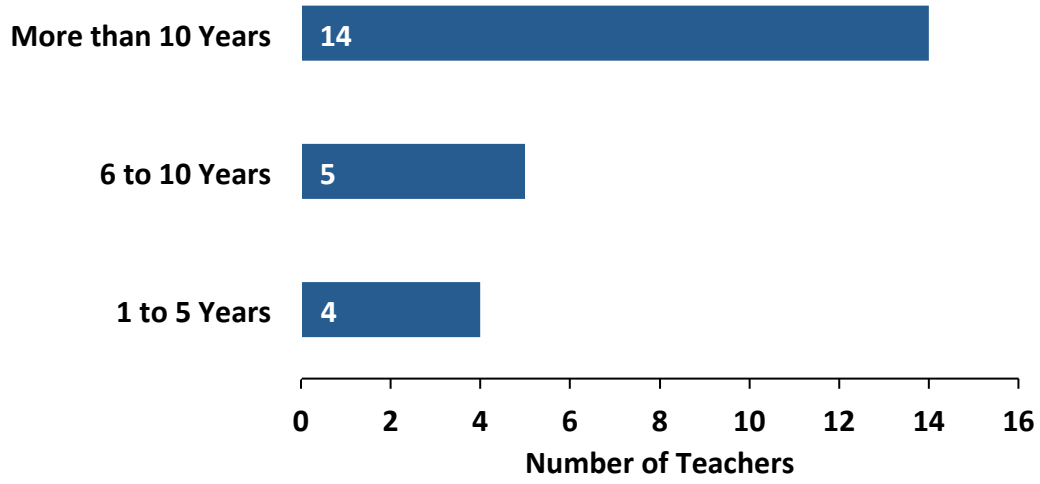
NOTE: This difference was a statistically significant difference.

Teacher Workshop - Characteristics of the Sample

A total of 25 middle school teachers participated in the workshop, with 24 teachers who attended all five days, and one teacher who attended the first two days.

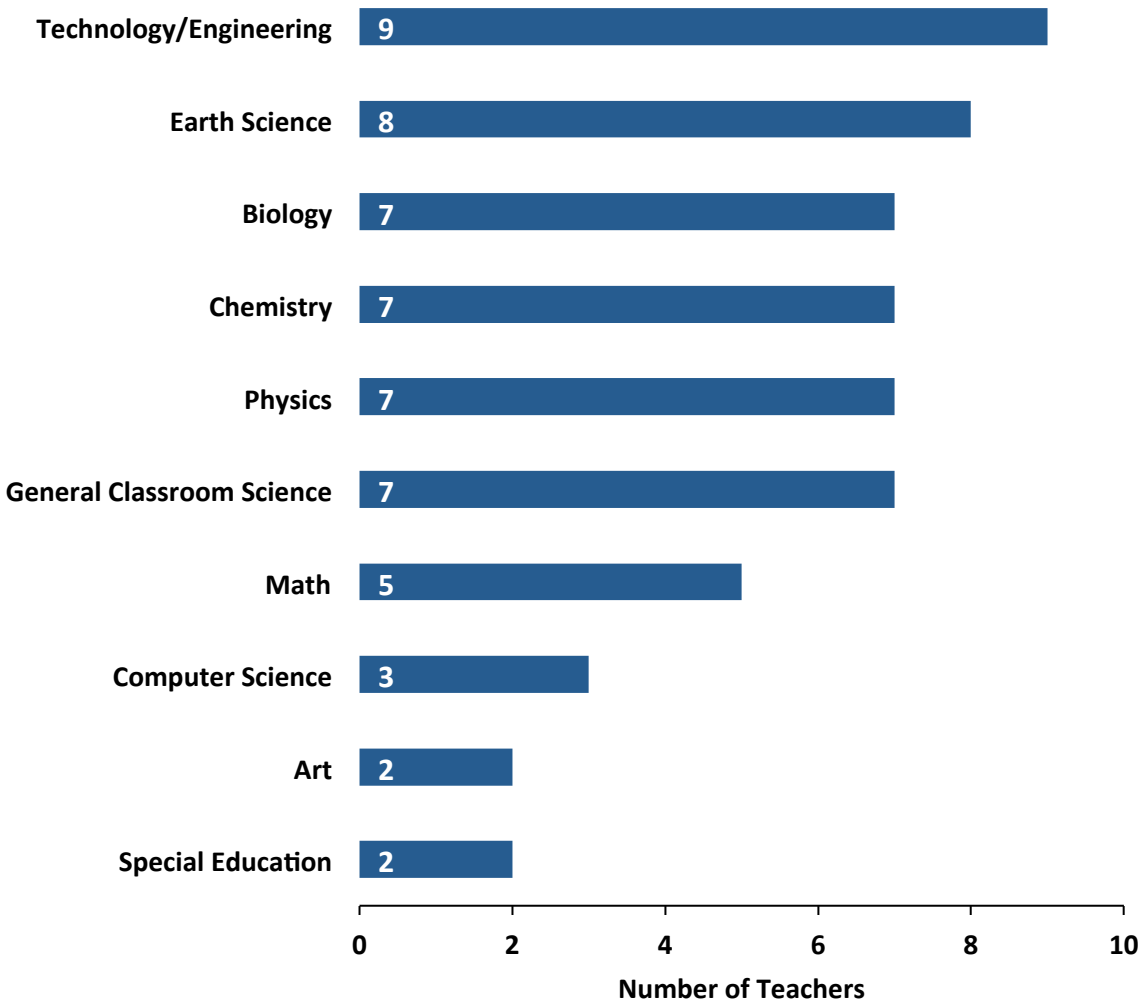
The teachers who attended currently teach science, 23 teachers to middle school grades, and 1 teacher to upper elementary grades. Over half of teachers had more than 10 years of teaching experience (n=14), followed by 5 teachers who had between 6 and 10 years of teaching experience, and 4 teachers who had between 1 and 5 years of teaching experience (see Figure 9).

Figure 9. Years of Teaching Experience, n=23



Teachers currently teach multiple science and science-related subjects at their schools (see Figure 10). The most common subject taught is a Technology/Engineering (n=9), followed by Earth Science (n=8), Biology (n=7), Chemistry (n=7), Physics (n=7), and general classroom science (n=7). Less commonly taught classes are Mathematics (n=5), Computer Science (n=3), Art (n=2) and Special Education (n=2).

Figure 10. School Subjects Taught by Teachers, n=23



NOTE: Multiple subjects are taught, thus numbers will not add to the sample size of 23 teachers.

Teacher Background in Engineering and Space Science

Few teachers had formal training or a background in engineering, or space science (see Table 3). Out of twenty-two teachers, four said they had training, or a background, in engineering, and two had training, or a background in space science. Four teachers offered a written description of their background in engineering; two had taken "Engineering the Future" at MOS, one had college classes in engineering, and one person had participated in NASA sponsored workshops. To describe their background with space science, one teacher wrote he/she had taken a college course, and another teacher wrote they had learned about space science on their own. Two teachers who had responded they did not have formal training in space science wrote that they had earned an Earth Science certificate, and had been part of Project Astro.

Table 3. Formal Training or Background in Engineering and Space Science, n=22

Formal Training or Background	Frequency
Engineering	4
Space Science	2

Teacher Visits to MOS with Students

More than half of teachers have visited MOS with students in the past, 6 teachers came to the museum with students in the past year, 8 at least once in the past three years, and 1 had visited over three years ago. Seven teachers had never visited the museum with students (see Table 4).

Table 4. Frequency of Teachers Visiting MOS with Students, n=22

Visited MOS with Students	Frequency
At least once in the past three years	8
Never visited the museum with students	7
Past year	6
Over three years ago	1

Teachers were evenly split between those that had brought a class to a planetarium program in the past, and those who had not. Half of teachers (n=11) had never seen a planetarium program at the museum with their students. Of the teachers who at one time brought a class to a planetarium program, 2 teachers replied in the past year, 6 at least once in the past three years, and 3 teachers attended over three years ago (see Table 5).

Table 5. Frequency of Teachers That Have Seen A Planetarium Program with Students, n=22

Brought a Class to a Planetarium Program	Frequency
Never seen a planetarium program at the Museum with students	11
At least once in the past three years	6
Over three years	3
Past year	2

Barriers to Participating in Museum Programs & Field Trips

Teachers experience many barriers to participating in museum programs and field trips, the main barriers being time, planning before the visit to MOS, money, and concerns over curriculum alignment (see Table 6). Time is a large barrier that teachers experience, particularly the amount of time required to travel to the museum, and the current time of the planetarium show not fitting into their schedule. Other barriers mentioned that were related to a concern with time were making sure a field trip fits within school hours, that students have enough time at the museum, and that the field trip may disrupt the teaching schedules of other teachers.

Within the barrier of planning before the visit, organizing buses for the field trip was a large barrier, along with obtaining administrator approval, coordinating with other teachers and finding chaperones. The barriers associated with planning before the visit that were less mentioned were coordinating forms, finding the time to plan, and planning the actual museum visit.

Money was mentioned as a barrier by 10 teachers. Concern over the alignment of a field trip with teacher goals and school curriculum was only expressed by 2 teachers.

Table 6. Barriers to Participating in Museum Programs and Field Trips, n=21

Metacategory	Microcategory	Frequency
Time		**20**
	Travel time	7
	Time of planetarium show	6
	School hours	4
	Enough time at museum	2
	Other teachers' schedule disrupted	1
Planning Before the Visit		**18**
	Organizing buses	4
	Administrator approval	3
	Coordinate with other teachers	3
	Finding chaperones	3
	Coordinating forms	2
	Finding time to plan	2
	Planning the museum visit	1
Money		**10**
Curriculum alignment		**2**

NOTE: Teachers mentioned multiple barriers to participating in museum programs and field trips, thus numbers will not add to the sample size of 21 teachers.

Quotes from educators about barriers to participating:

> *Time is a constraint since I come from the north. Getting here and getting the full benefit of the museum means that we have to have a focus approach. Times of the planetarium shows is also a consideration so we can see the show and still make it home for my students to take catch their buses for home.*

> *Finding chaperones, the bureaucratic process behind setting one [a field trip] up (approval forms, permission slips, etc.). The timing of Dream to Discover will be prohibitive. The vast majority of field trips have to start and end within school hours, and many schools in Boston end at 1:40. Schools from further away have to account for travel time, too. Many Boston schools could probably get to the museum by 8:15 or*

8:30, so we could start with an early show before going into the exhibit halls at the usual opening time.

Definitely the time of day that the [planetarium] presentation is available could be a barrier, as we have some distance to travel. Along with this, travel to the museum can be expensive. However, the experience is completely worth the cost of the trip.

Out-of-School Time - Characteristics of the Sample

The 18 educators were from a wide variety of different parts of the United States, with 3 from Massachusetts, 2 from Texas, 2 from California, 2 from Wisconsin, 2 from Oregon, and one each from the following states: Virginia, South Carolina, Florida, Minnesota, New Mexico, Wyoming and Alabama. In order for educators to be chosen to test the units, they needed to be teaching in either an afterschool or camp program with a group of 3rd to 5th grade children.

Asked whether they had participated in any other engineering activities since working with students in the Out-of-School Time unit, 11 of the 17 educators said yes.

Last summer I piloted something with parachutes. I did that and I presented in a conference setting about engineering. I use engineering a lot in the classroom. Sometimes I just say "let's make a paper tower" but most the time it's part of a curriculum.

We've done some submersibles. I couldn't tell you the exact name of it. It's through EiE [Engineering is Elementary]. We're still at the very beginning of the year.

See above responses about water filtration system activity, etc.

In the classroom. This STL [Sky's the Limit] was in the summer 3-5 grade students. With the entire school grade level I have.

For Engineering Adventures we did "Hop to It," "To the Rescue," and "Go Green" and this one [Liftoff].

We did Liftoff, we currently are using the "Hop to It" and the "Shake Things Up." Those are all EiE [Engineering is Elementary] curricula. We've done some other activities that include engineering. We have some that we've created on our own, some engineering challenges.

We've done quite a few. We've done Scuba Guy - take a little army guy and with balloons and pennies he has to get to natural buoyancy. We've used spaghetti and made bridges with glue and they have to see what weight their bridges can hold. We do lots of them. They love it, they're so engaged and they try. It's good.

Not with those particular youths, but we did another Engineering Adventures about time. We did another project with the MOS Boston About Time. But then beyond that we work with the Children's Museum of Houston to do some activities at our site. During the summer they (the Museum of Houston) did a whole curriculum on STEM learning.

Our after school club this year is using some engineering activities, yes. We were able to get a unit from the company Camp Invention. They use recycled materials to create things, it's similar.

I went to a conference about alternative energies, for teachers. They did give us curriculum that we're trying to follow. That was from Conoco Phillips I think.

We do them on a regular basis. We'll probably be doing the dropcopters. We do a quick engineering design. We've done speed racers made with manila folders and rubber bands and a brad and you zoom them down a polished floor. We're in the process of that - measuring, cutting, folding, scoring. I will use the dropcopters specifically as a engineering design kind of thing. Pull it out of the actual unit.

Stretching my memory here but I believe after we finished the STL [Sky's the Limit], certain activities like the dropcopter and the wind tunnel, I led those activities with different groups of children - dropcopters with 1st and 2nd graders who responded really well to it. We also used the wind tunnels to experiment with parachutes. We've used the materials and lessons since. [Interviewer: But no other units besides STL, No.

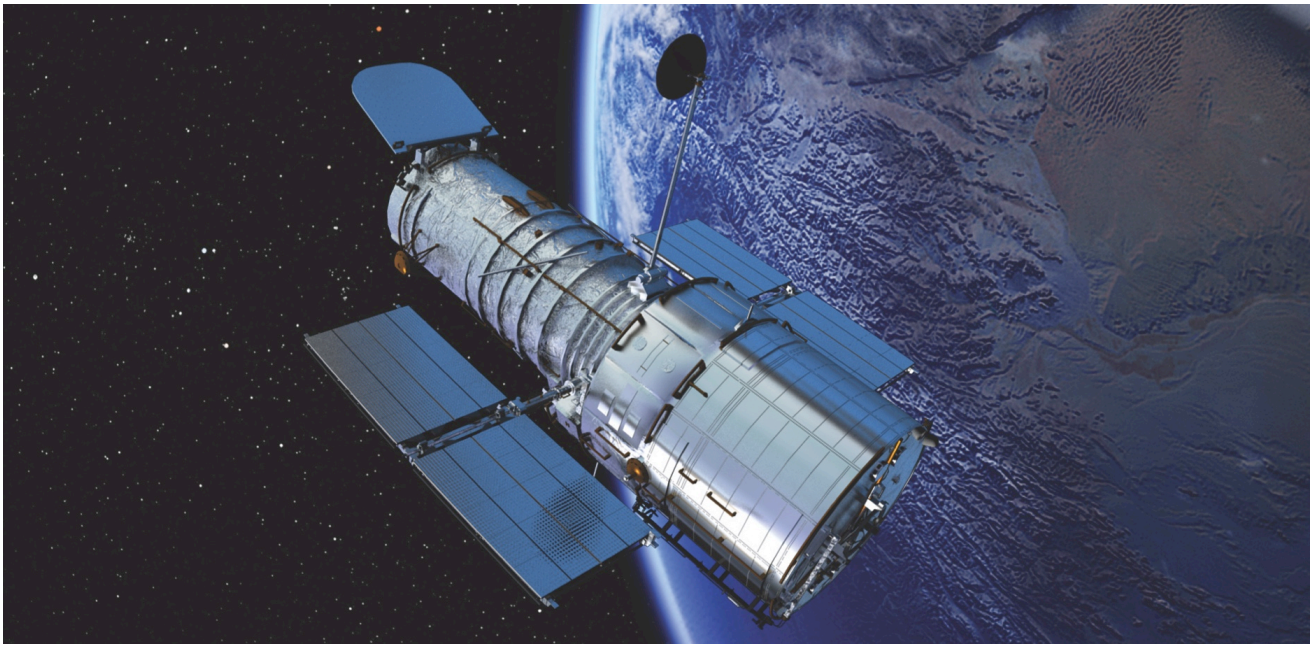


Image courtesy of the Museum of Science, Boston

FINDINGS - Planetarium Program

Overall Reaction to Planetarium Program

Participants rated the planetarium program across three areas, overall satisfaction, educational experience and entertainment experience. All participants gave relatively high ratings, with all of the averages being an 8.0 or higher on a 10-point scale (8.3 for Overall Satisfaction, 8.1 for Entertainment Experience, and 8.0 for Educational Experience) (see Figure 11). Though general visitors gave slightly higher ratings than students, these differences were not statistically significant (see Figure 12).

Figure 11. Ratings of Planetarium Program, All Participants n=256

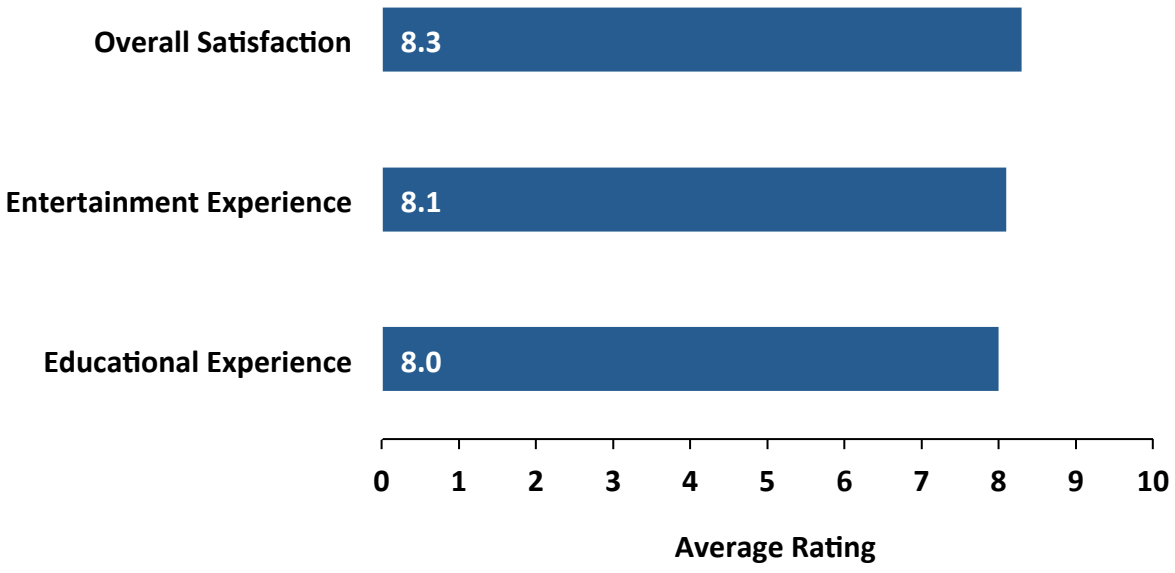
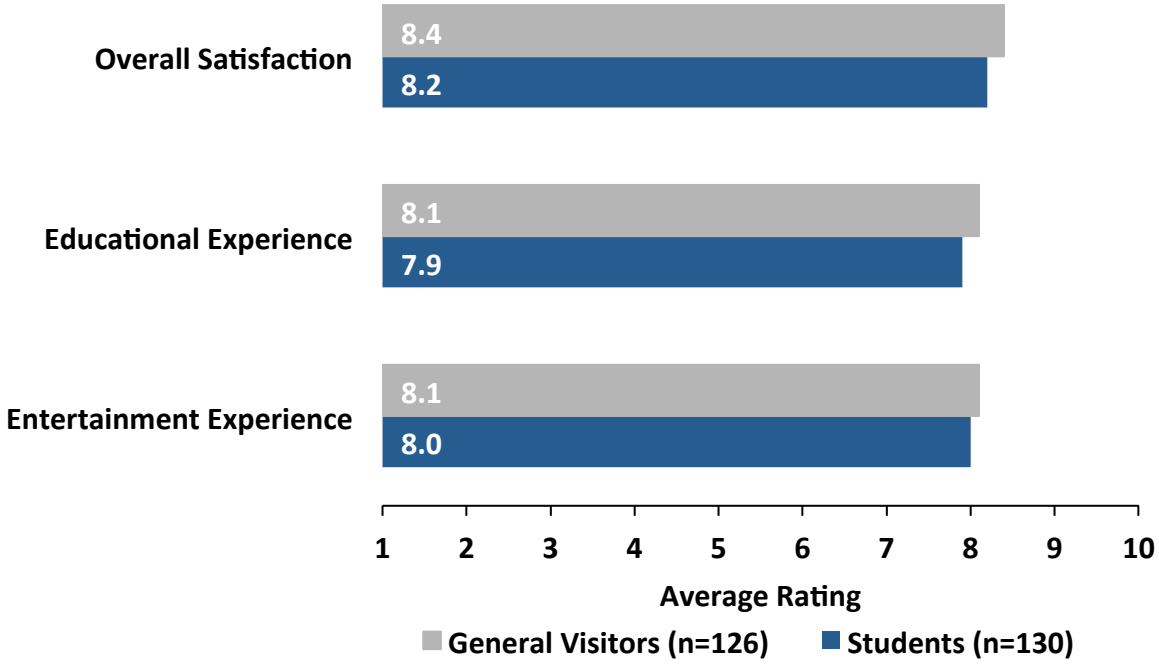


Figure 12. Ratings of Planetarium Program By Audience Type



NOTE: None of the three comparisons showed statistically significant differences.

Participants were asked to compare the currently viewed planetarium program to other planetarium programs they had seen. More than three-quarters of all participants (84%) had seen other planetarium programs, either at the Museum of Science or other places, and of this group more than half (57%) said it was better than other programs, another quarter (27%) said it was about the same and only 16% said it wasn't as good as other planetarium programs they had seen (see Figure 13). When looking at responses for general visitors and students, there was not a statistically significant difference between how the two groups responded to this item (see Figure 14).

Figure 13. Comparison to Other Planetarium Programs, n=209

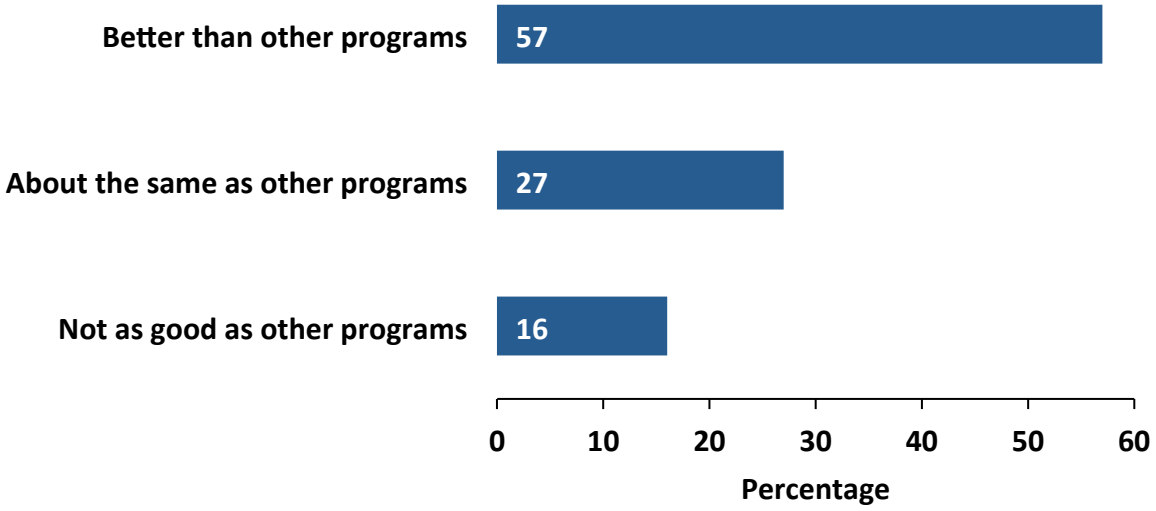
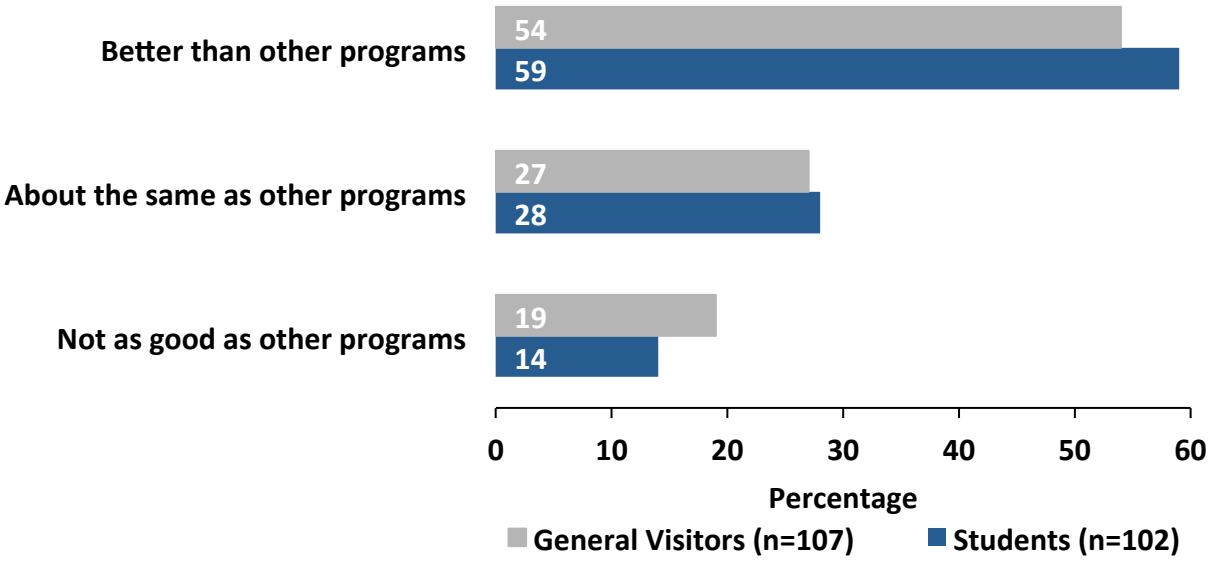


Figure 14. Comparison to Other Planetarium Programs, by Audience Type



NOTE: The comparison between general visitors and students was not a statistically significant difference. In this figure percentages add to more than 100% due to rounding.

Participants were asked if they would recommend the planetarium program to others. A little more than half (51%) were promoters, rating it a 9 to 10 on a 10-point scale, another quarter (26%) were passively satisfied, and a little less than a quarter (23%) were detractors (see Figure 15). This item is based on the Net Promoter Score (see www.netpromoter.com). When comparing general visitors and students, there was not a

statistically significant difference in their likelihood of recommending the planetarium program (see Figure 16).

Figure 15. Recommending the planetarium program to others, n=255

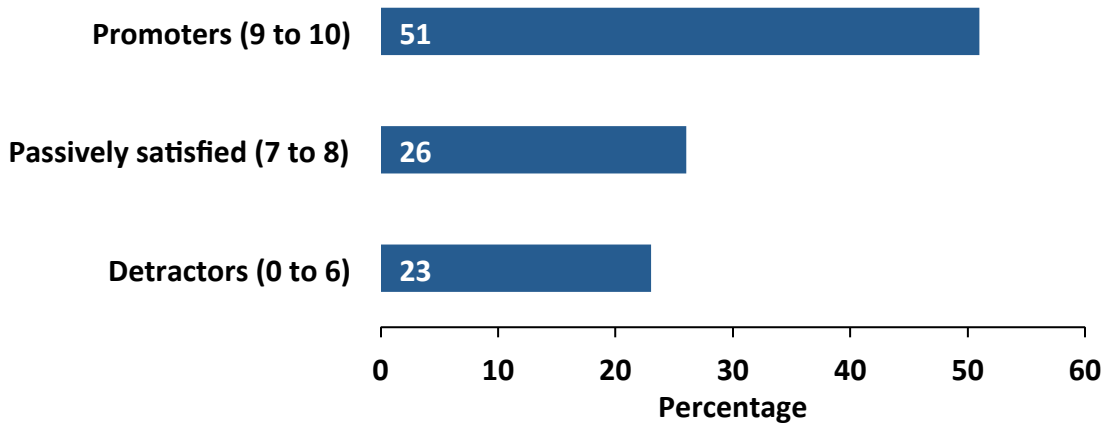
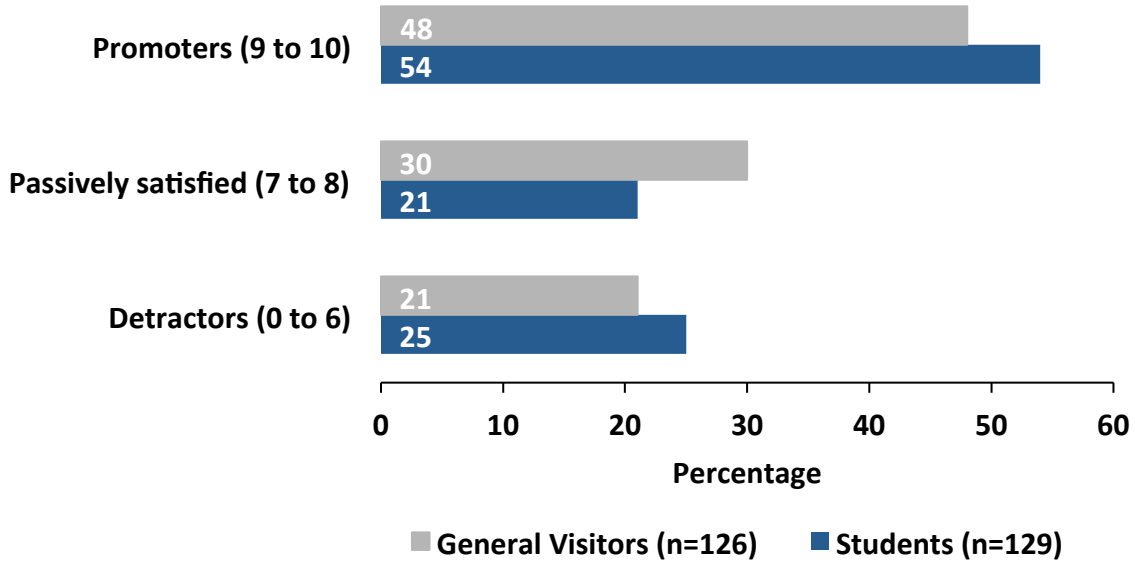


Figure 16. Recommending the planetarium program to others, by audience type



NOTE: The comparison between general visitors and students was not a statistically significant difference. In this figure percentages add to more than 100% due to rounding.

Participants had much praise for the planetarium show (70%), writing they would recommend the planetarium show because they found it fascinating, interesting and generally liked and enjoyed the program (see Table 7). Participants also enjoyed learning through the show (30%), with many finding the program educational. Some participants

wrote that the program showed them challenges faced in engineering, and they learned something new. Finally, participants would recommended the program to others since an audience they had in mind would enjoy the program (13%), either others in general, children, those interested in engineering or space science, or to a person visiting the museum. Roughly 80 participants (36%) had a negative comment about the planetarium program. The negative comments varied from having suggested changes to the show (13%), different audiences would not enjoy the show (12%), general negative feelings about the show (10%), and negative experiences resulting from the dome projection (5%).

Table 7. Why Participants Would Recommend the Planetarium Program, All Participants, n=220

MetaCategory	MicroCategory	Frequency	Percent
General Praise		**153**	**70%**
	Fascinating/Interesting	40	26%
	I liked it/I enjoyed it	37	24%
	Entertaining	24	16%
	Fun	18	12%
	It was great or good	12	8%
	Cool	7	5%
	Engaging	3	2%
	General praise, misc.	12	8%
Enjoyed Learning Through the Show		**67**	**30%**
	Found it educational	39	58%
	Learning about challenges in engineering	9	13%
	Learning about NASA	6	9%
	I learned new things (not specific)	4	6%
	Easy to understand	4	6%
	I want to learn more	3	4%
	Saw engineering used in real life	2	3%
Positive Recommendation Based on an Audience		**28**	**13%**
	Others would greatly enjoy the show	10	36%
	Good show for children	8	29%
	Personal interest in engineering or space science	7	25%
	Would recommend if person visited MOS	3	11%
Negative, Suggest Changes to Show		**29**	**13%**
	Story needs more content/complexity/detail	9	31%
	Story needs more clarity	7	24%
	Topic needs to be humanized more	4	14%
	Too many computer generated images	4	14%
	Felt like an OMNI show not a planetarium show	3	10%
	Introduction needs work	2	7%

Negative Recommendation Based on an Audience	**26**		**12%**
Wouldn't appeal to everyone		10	38%
I don't like/enjoy engineering		7	27%
I don't usually see this kind of thing		3	12%
I enjoy other types of planetarium shows		3	12%
Not good for kids		2	8%
Don't know who to recommend to		1	4%
General Negative	**21**		**10%**
Boring		7	33%
Did not meet my expectations		3	14%
Not that good		2	10%
Not interactive		1	5%
Scary		1	5%
General negative, misc.		7	33%
Liked the Graphics and Music	**20**		**9%**
Great visuals and graphics		13	65%
Enjoyed the music		4	20%
Like graphics and music, misc.		3	15%
Problems Due to Dome Projection	**10**		**5%**
Hard to see		5	50%
Made me tired/dizzy		5	50%
Miscellaneous	**8**		**4%**

Learning from the Planetarium Program

Participants were asked to complete the sentence, "I never realized that," as a way to measure learning that occurred due to the planetarium program. Over a third of participants learned something new about building spacecraft (36%), particularly the extensive testing and preparation done on spacecraft, and the existence of NASA testing facilities for spacecraft under construction (see Table 8). Almost a quarter of participants wrote they had never realized a fact about Pluto and New Horizons (24%), mostly the existence of the current New Horizons mission to Pluto, the distance and time it will take to reach Pluto, and specifics about the New Horizons spacecraft. A smaller percentage of participants wrote they had learned something new about engineering and engineers (15%), the Hubble and Webb space telescope (12%), space in general (11%), and NASA (6%).

Table 8. I Never Realized That..., All Participants n=217

MetaCategory	Micro Category	Frequency	Percent
Building Spacecraft		**78**	**36%**
	So much testing and preparation is done on spacecraft	20	26%

	Existence of testing facilities for spacecraft		16	21%
	Existence of different spacecraft		9	12%
	Size of spacecraft		8	10%
	Building requires precision/is complex		7	9%
	Speed of spacecraft		7	9%
	Testing chamber conditions		6	8%
	Building spacecraft, misc,		5	6%
Pluto and New Horizons		**52**		**24%**
	Existence of current mission to Pluto		23	44%
	Distance and time to reach Pluto		12	23%
	Learned more about New Horizons spacecraft		12	23%
	Learned more about Pluto		4	8%
	Pluto, misc.		1	2%
Engineering and Engineers		**32**		**15%**
	Engineering is difficult, hard, requires effort		15	47%
	Engineering is interesting or exciting		9	28%
	Engineering is so advanced		3	9%
	Engineering, misc.		5	16%
Hubble and Webb Space Telescope		**26**		**12%**
	Learned more about Hubble and Webb		17	65%
	Learned about the mirrors		5	19%
	Learning about Hubble and Webb was interesting		2	8%
	Pictures available from space		2	8%
Space		**23**		**11%**
	Distances in space are long		13	57%
	Space is interesting		3	13%
	Space is beautiful		2	9%
	Space, misc.		5	22%
NASA		**12**		**6%**
	NASA has many missions planned		4	33%
	NASA missions tell us more about space		2	17%
	Unmanned missions to space		2	17%
	NASA is interesting		1	8%
	NASA, misc.		3	25%
Enjoyed Planetarium		**6**		**3%**
	Planetarium is fun		3	50%
	Planetarium shows movies		1	17%
	Enjoyed planetarium, misc.		2	33%
Miscellaneous		**6**		**3%**
	Nothing/I don't know		4	67%
	Miscellaneous, misc.		2	33%

When comments from school groups and general visitors were looked at separately, differences were seen in the frequencies of the following metacategories: Building Spacecraft, Engineering and Engineers, Space, and the Hubble and Webb Space Telescope (see Table 9). General visitors more often wrote they had learned something new about Building Spacecraft (45%), and the Hubble and Webb Space Telescope (21%). Students, on the other hand, more often wrote they had learned something new about Space (14%), and Engineering and Engineers (22%).

Table 9. I Never Realized That… By Audience Type

	School Group n=105		General Visitors n=112	
MetaCategory	**Frequency**	**Percent**	**Frequency**	**Percent**
Building Spacecraft	28	27%	50	45%
Pluto	25	24%	27	24%
Engineering and Engineers	23	22%	9	8%
Space	15	14%	8	7%
NASA	7	7%	5	4%
Hubble and Webb Space Telescope	3	3%	23	21%
Enjoyed Planetarium	3	3%	3	3%
Miscellaneous	4	4%	2	2%

Impact of Planetarium Program

The team was also interested in understanding the extent to which the planetarium program could have an impact on participants' views of engineering. For the four items that participants rated, they said viewing the program was most likely to make them better appreciate the challenges of spacecraft engineering and making engineering seem more fun (see Figure 17). It also changed how they thought about engineering, and for some students made them more likely to think about becoming an engineer. In comparing general visitors and students, general visitors were more likely than students to say the planetarium program made engineering seem more fun (see Figure 18).

Figure 17. Impact of planetarium program ratings, n=254

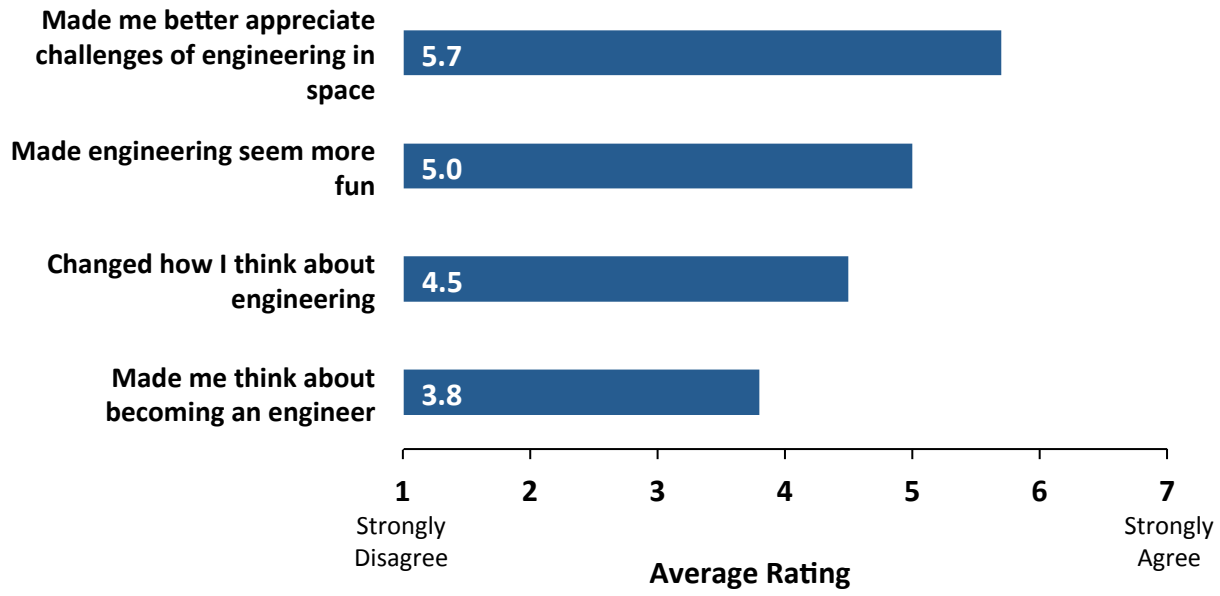
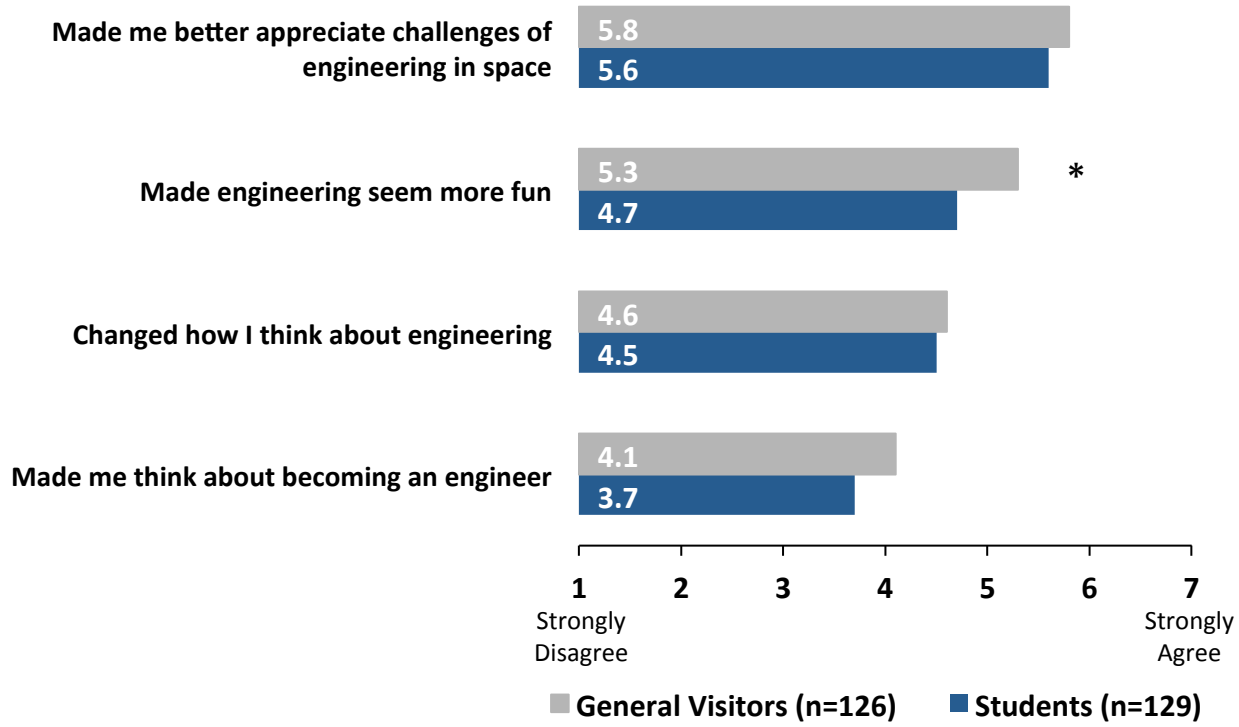


Figure 18. Impact of planetarium program ratings, by audience type



NOTE: An asterisk (*) shows a statistically significant difference.

Multiple Regression Analyses

While the above analyses focused on the differences between general visitors and students, another type of analysis can determine the relative influence of a group of variables. This type of analysis, called multiple regression analysis, is used to see which group of variables is the best set to predict another outcome variable.

How Multiple Regression Works

In the analyses below, there is one main variable that is the focus of the regression – this is called the *dependent variable*. Then one or more variables are entered to see how predictive they are of the main variable – these are called the *independent variables*. In a stepwise regression, the type used in the analyses below, the independent variables are entered one by one in the order of their predictive power. That is, the best predictor of the main variable is entered first, the second best predictor is entered next, and so on; correlations are used as the means for knowing how predictive, or how strong of a relationship there is. However, independent variables will not be entered if they do not have any additional predictive power above and beyond the variable or group of variables already entered into the analysis. That is, if an item does not account for any additional variance above and beyond the group of independent variables already included, it is not included.

The measure of the amount of predictive power is called the *R-squared*. It ranges from .000 to 1.000 and represents the amount of variance (as a percentage) the group of independent variables explains about the dependent variable. The R-squared value represents a range from 0% to 100%. The higher the R-square, the better job the independent variables do of predicting the dependent variable. In the social sciences while it is still a subject of much debate, an R-square of .400 or .500 is considered to be a relatively good predictor. The more related the variables, however, the more you would expect strong correlations and thus higher R-square values.

Regression: Planetarium program made me better appreciate the challenges of engineering in space, BY Main ratings

As can be seen in Table 10 below, two of the three independent variables were included in this regression analysis. In stepwise regression, only variables that contribute predictive power above and beyond those already entered are included in the analysis. The two variables entered (educational experience and overall experience) had a combined R-squared of .275; meaning, about 28% of the variance for the dependent variable was explained. The entertainment experience rating did not account for any additional variance above and beyond the first two being entered. Thus, it was not a strong predictor of participants appreciating the challenges of engineering in space.

Table 10. Multiple Regression, Appreciating the Challenges of Engineering in Space, n=254

Dependent Variable: Appreciating Challenges of Engineering in Space		
Independent Variables Included:	**R-squared**	**R-squared change**
Educational Experience	.246	N/A
Overall Experience	.275	.029
Independent Variables Not Included:		
Entertainment Experience	N/A	N/A

Regression: Planetarium Program Made engineering seem more fun, BY Main ratings

As can be seen in Table 11 below, two of the three independent variables were included in this regression analysis. In stepwise regression, only variables that contribute predictive power above and beyond those already entered are included in the analysis. The two variables entered (overall experience and educational experience) had a combined R-squared of .238; meaning, about 24% of the variance for the dependent variable was explained. The entertainment experience rating did not account for any additional variance above and beyond the first two being entered, which is interesting given that the variable being predicted was about engineering being more fun. Thus, knowing the two variables entered would result in a decent but not overwhelming ability to predict whether participants saw engineering as more fun as a result of seeing the planetarium program.

Table 11. Multiple Regression, Making Engineering Seem More Fun, n=251

Dependent Variable: Making Engineering Seem More Fun	**R-squared**	**R-squared change**
Independent Variables Included:		
Overall Experience	.217	N/A
Educational Experience	.238	.021
Independent Variables Not Included:		
Entertainment Experience	N/A	N/A

Regression: Changed thinking about engineering, BY Main ratings

As can be seen in Table 12 below, two of the three independent variables were included in this regression analysis. In stepwise regression, only variables that contribute predictive power above and beyond those already entered are included in the analysis. The two

variables entered (educational experience and overall experience) had a combined R-squared of .269; meaning, about 27% of the variance for the dependent variable was explained. The entertainment experience rating did not account for any additional variance above and beyond the first two being entered. Knowing ratings of the educational experience and overall experience did an okay job predicting whether participants said the program helped change their thinking about engineering.

Table 12. Multiple Regression, Changing Thinking about Engineering, n=253

Dependent Variable: **Changing thinking about engineering**		
Independent Variables Included:	**R-squared**	**R-squared change**
Educational Experience	.231	N/A
Overall Experience	.269	.035
Independent Variables Not Included:		
Entertainment Experience	N/A	N/A

Regression: Consider becoming an engineer, BY Main ratings

As can be seen in Table 13 below, two of the three independent variables were included in this regression analysis. In stepwise regression, only variables that contribute predictive power above and beyond those already entered are included in the analysis. The two variables entered (overall experience and entertainment experience) had a combined R-squared of .167; meaning, about 17% of the variance for the dependent variable was explained. The educational experience rating did not account for any additional variance above and beyond the first two being entered. Thus, this combination of variables was not a very strong predictor of participants considering becoming an engineer.

Table 13. Multiple Regression, Consider Becoming an Engineer, n=178

Dependent Variable: **Changing thinking about engineering**		
Independent Variables Included:	**R-squared**	**R-squared change**
Overall Experience	.144	N/A
Entertainment Experience	.167	.023
Independent Variables Not Included:		
Educational Experience	N/A	N/A

Regression: Recommend the planetarium program, BY Main ratings

As can be seen in Table 14 below, in this case all three independent variables were included in this regression analysis. In stepwise regression, only variables that contribute predictive power above and beyond those already entered are included in the analysis. The three variables entered (overall experience, educational experience and entertainment experience) had a combined R-squared of .610; meaning, 61% of the variance for the dependent variable was explained. Therefore, ratings of the overall program, as well as knowing the educational and entertainment experience did a good job in predicting whether or not someone would recommend the planetarium program to others.

Table 14. Multiple Regression, Recommend the Planetarium Program, n=254

Dependent Variable:
Recommend the planetarium program

Independent Variables Included:	R-squared	R-squared change
Overall Experience	.548	N/A
Educational Experience	.594	.046
Entertainment Experience	.610	.016

Regression: Recommend the planetarium program, BY Impact ratings

As can be seen in Table 15 below, all three independent variables were included in this regression analysis. In stepwise regression, only variables that contribute predictive power above and beyond those already entered are included in the analysis. The three variables entered (Made engineering seem more fun, Appreciate challenges of engineering in space, Changed how I think about engineering) had a combined R-squared of .297; meaning, about 30% of the variance for the dependent variable was explained. Thus, this combination was a decent predictor of participants being likely to recommend the planetarium program to others.

Table 15. Multiple Regression, Recommend the Planetarium Program, n=249

Dependent Variable:
Recommend the planetarium program

Independent Variables Included:	R-squared	R-squared change
Made Engineering Seem More Fun	.218	N/A
Appreciate Challenges of Engineering in Space	.276	.058
Changed How I Think About Engineering	.297	.021

Regression: Consider becoming an engineer, BY Impact ratings

As can be seen in Table 16 below, two of the three independent variables were included in this regression analysis. In stepwise regression, only variables that contribute predictive power above and beyond those already entered are included in the analysis. The two variables entered (Made engineering seem more fun, Changed how I think about engineering) had a combined R-squared of .402; meaning, about 40% of the variance for the dependent variable was explained. The variable about appreciating the challenges of engineering in space did not account for any additional variance above and beyond the first two being entered. The combination of the two variables (Engineering seeming more fun, Changing how they think about engineering) was a good predictor of students becoming more likely to consider becoming an engineer.

Table 16. Multiple Regression, Consider Becoming an Engineer, n=174

Dependent Variable: Consider becoming an engineer **Independent Variables Included:**	**R-squared**	**R-squared change**
Made Engineering Seem More Fun	.362	N/A
Changed How I Think About Engineering	.402	.040
Independent Variables Not Included:		
Appreciate Challenges of Engineering in Space	N/A	N/A

Conclusions, Planetarium Program

Ratings for the planetarium program were good, with all the main ratings being at least an 8.0 on a 10-point scale: 8.3 for Overall Satisfaction, 8.1 for Entertainment Experience, and 8.0 for Educational Experience. For those who had seen other planetarium programs, 84% rated it as either about the same (27%) or better than other programs (57%). More than half of those who viewed the program would definitely recommend it to other people. When asked why they would recommend it, viewers talked about how interesting it was and how much they liked it, or that they liked learning by watching the program.

In terms of what they learned during the planetarium program, participants talked about how spacecraft are built, especially the extensive testing and preparation in NASA testing facilities. They also talked about the New Horizons mission to Pluto, including the distance and time it takes to reach Pluto and specifics about the spacecraft. Learning about engineers and engineering was also a theme.

A number of items in the planetarium survey looked at the impacts of viewing the planetarium program. Participants were most likely to say viewing the program made them

better appreciate the challenges of engineering in space (5.7 on a 7-point scale), followed by the program making engineering seem more fun (5.0 on a 7-point scale). Participants also said viewing the program changed how they thought about engineering (4.5 on a 7-point scale). When asked if the program made students think about becoming an engineer, the average rating was a 3.8 on a 7-point scale. General visitors were more likely than students to say the program made engineering seem more fun.

Photo courtesy of the Museum of Science, Boston

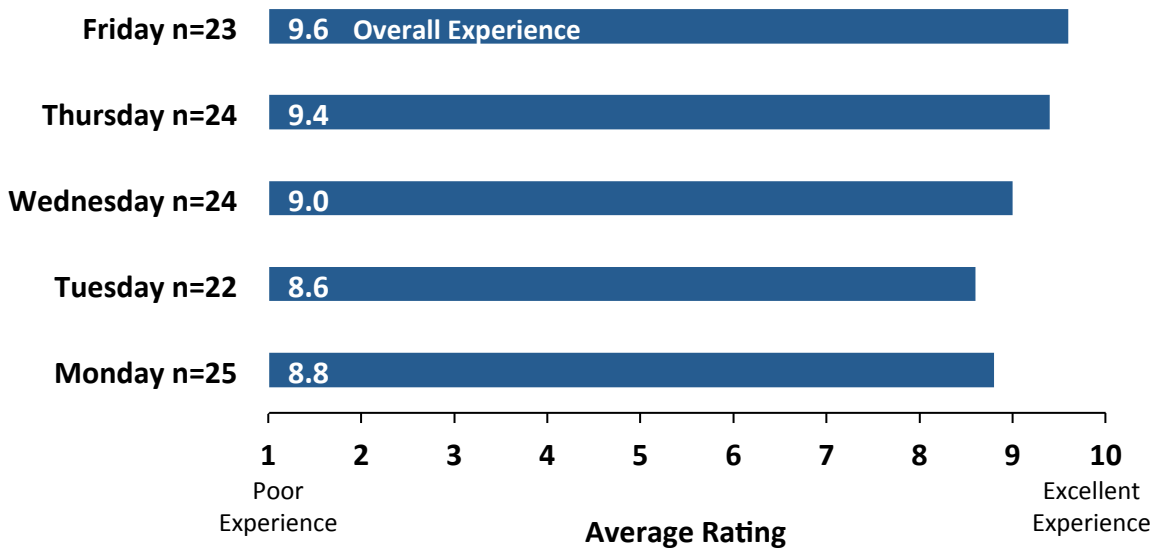
Findings - Teacher Workshop

Teacher Satisfaction with Workshop

(Sources: Daily Survey & Last Day Survey)

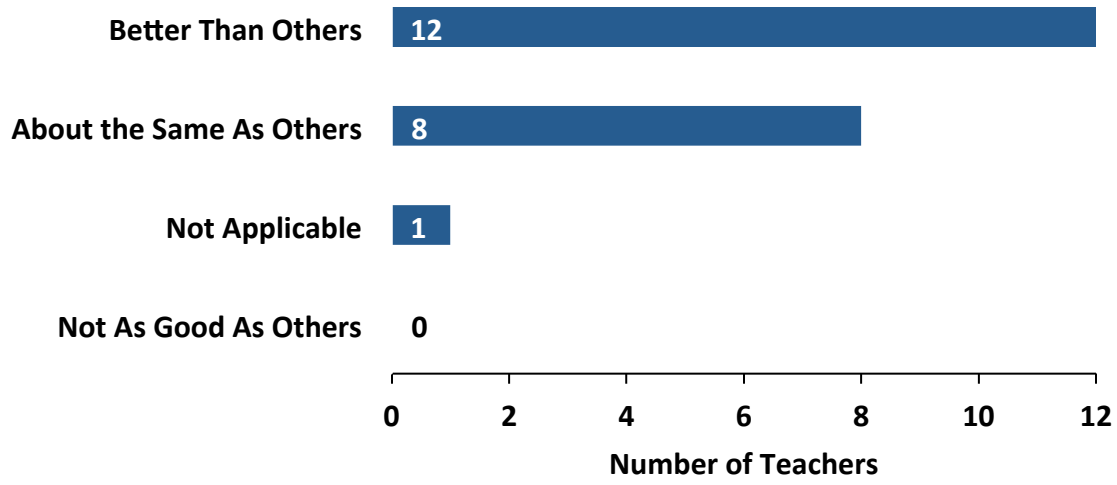
Teacher satisfaction with the workshop experience was high on individual days, and increased over the course of the week. After the first day of the workshop, participants gave their experience an average rating of 8.8, very close to the maximum rating of 10 for and excellent experience. By the end of the workshop, participants gave their overall experience an average rating of a 9.6, showing an almost 1 point increase in their satisfaction ratings (see Figure 19).

Figure 19. Teacher Satisfaction With the Workshop Experience



In accord with their high satisfaction with the workshop, over half of teachers (n=12) felt the workshop held at MOS was better than other similar workshops they had attended in the past (see Figure 20). Another eight teachers felt the workshop was about the same as other workshops, and no teachers thought the workshop was not as good as others they had attended. The one teacher who said the question was not applicable had not attended similar workshops and thus could not make the comparison.

Figure 20. Comparison to Other Teacher Workshops, n=21



When asked what would make the workshop a better experience, teachers had multiple suggestions (see Table 17). Three teachers felt that a greater focus on action plans would have been useful. Two teachers also expressed that starting the workshop with an overview of standards and strands would have been better for them, and well as limiting less structured discussion time.

Table 17. What Would Make the Workshop A Better Experience, n=6

Category	Frequency
Focus More on Action Planning	3
Start Workshop with Standards	2
Less Talking without Structure	2
Praise	1

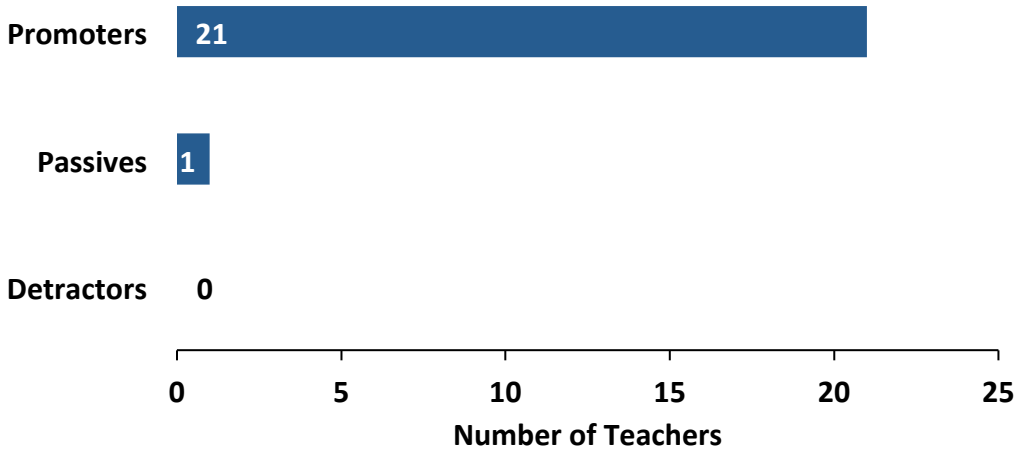
In the words of one teacher, which encapsulates multiple suggestions that teachers had,

> *I loved having the opportunity to explore all of the MOS and NASA resources. I think that taking a good chunk of time to look closely at the new Next Generation Science Standards (or MA DRAFT standards) early in the week (Day One) would have framed the week better. I would have been able to better identify a focus area that correlated to the grade level that I teach. This would have helped me look at all of the resources*

through the lens of that focus area and make better connections to the standards. This might have led to stronger action plans.

As a result of their positive experiences at the MOS teacher workshop, teachers would highly recommend the workshop to other teachers (see Figure 21).

Figure 21. Net Promoter, Teacher Recommendation of the Workshop, n=22



Teachers used words such as inspiring, exciting, fantastic, and engaging to describe their feelings about the workshop. Teachers felt they had learned a multitude of things, and they would encourage colleagues at their schools to attend workshops at MOS.

I gained a wealth of knowledge from this workshop. I would love to see my colleagues gain the resources and knowledge and experiences that I got from this workshop.

I am very excited that I will be able to use what I learned from here this week immediately after the school starts again. I will definitely encourage my colleagues to come to this workshop.

Teachers would recommend the workshop because of the focus on Next Generation Science Standards, and feeling empowered to develop curricula relevant to new standards.

I'd love to have these conversations with the other teachers on my science team. I think it could be a great place to start from when we look at changing what we do now as a school over to what we'll need to do to accommodate NGSS two years from now.

I am ecstatic and feel privileged to be a part of this Institute because I am leaving with multiple engineering and general science resources, especially hands-on and inquiry activities, that will help me to design science curricula for the new draft standards that will reach out to and grab the attention of all types of learners.

At least three teachers wrote the workshop was among the best, if not the top, professional development experience they had.

> *This is the best PD [Professional Development] experience that I have ever had!*
>
> *This was one of the best professional developments I have ever taken. You have awoken a new obsession with astronomy for me. I am inspired and had a ton of fun.*
>
> *This is one of the best professional development workshops I have ever attended in my years of teaching. It is relevant and totally applicable that I have something that I can bring right back to my classroom.*

Finally, teachers would recommend the workshop because of the time allotted during the workshop to collaborate and learn from peers, and the time to develop their own action plans for their classrooms.

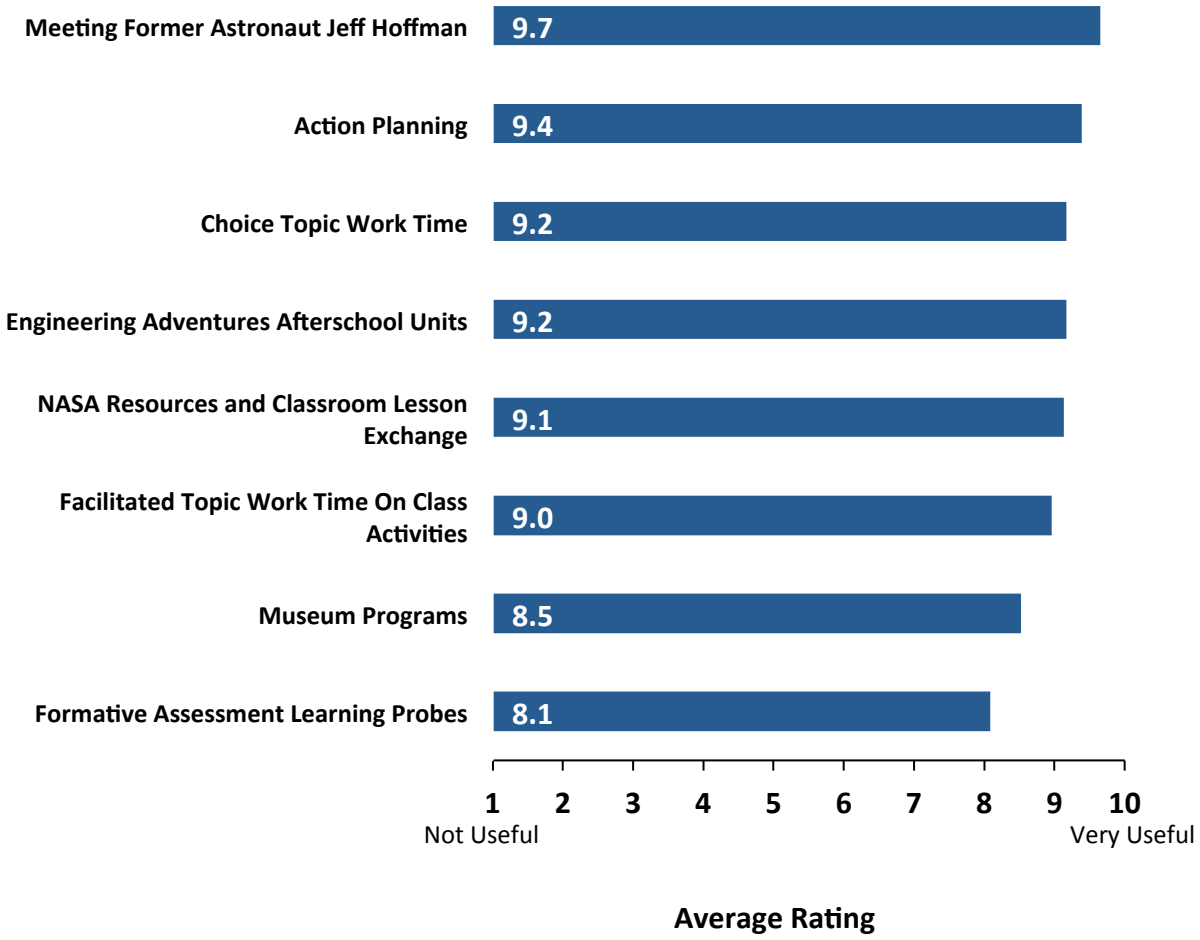
> *We are allowed to think, learn, collaborate and develop units/action plans at our own pace in a kind, fabulous and welcoming setting.*
>
> *It was a great combination of time to work with others and time to work on your own to explore an area of interest.*

Usefulness of Workshops for Teaching Practice

(Sources: Last Day Survey & Group Discussion)

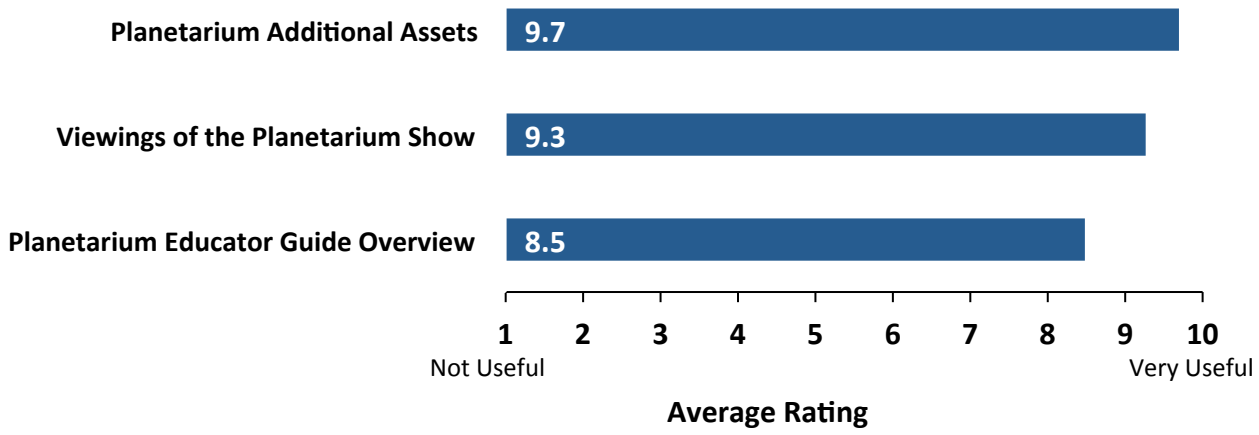
Teachers rated the usefulness of a variety of workshop activities on a scale of 1 (Not Useful) to 10 (Very Useful). The top two most useful activities were meeting former astronaut Jeff Hoffman and action planning (see Figure 22). These were followed by high ratings, all between 9.0 and 9.2, for choice topic work time, Engineering Adventures Afterschool Units, NASA resources and classroom lesson exchange, and facilitated topic work time on class activities. Two workshop activities that ranked as least useful among the group, though still above an 8 on a 10-point scale, were Museum Programs, and formative assessment learning probes.

Figure 22. Usefulness of Workshop Activities, n=23



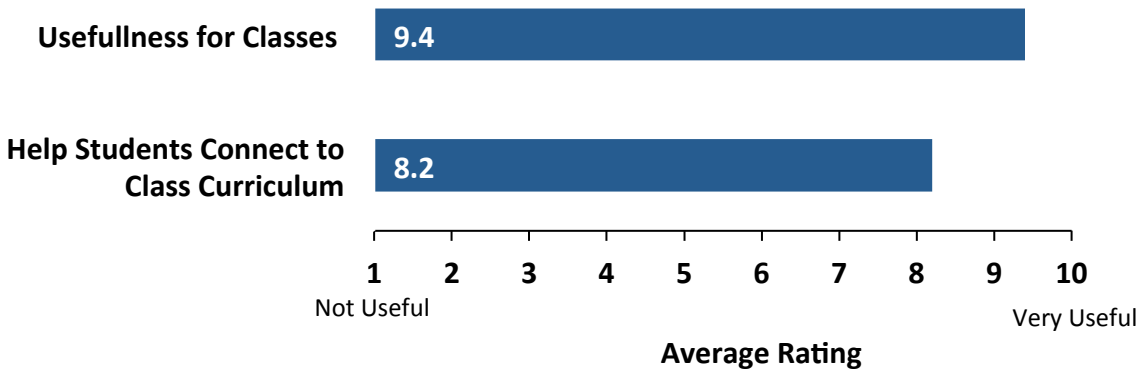
Teachers rated three specific planetarium resources highly, with two rated above a 9 on a 10-point scale. Planetarium additional assets were viewed as the most useful, followed by viewings of the planetarium show, and lastly, the planetarium educator guide overview that was still rated highly (see Figure 23).

Figure 23. Usefulness of Planetarium Resources, n=23



Workshop facilitators were given a description of the planetarium program being developed for this project (see Planetarium Program section in this report). Teachers thought the planetarium show would be very useful for their classes overall. They also thought it would help connect their students to the class curriculum (see Figure 24).

Figure 24. Usefulness of Planetarium Show, n=22



Teachers who gave the planetarium program lower ratings (n=5, a rating of 7 or lower) with respect to how the program would help students connect to class curriculum felt that the planetarium program may not necessarily connect with their current curriculum or their classes in general, because the program did not address the needed science material, or was not at the appropriate level of learning.

> *It will relate more to the 6th grade NGSS performance expectations, and I teach 8th grade.*
>
> *I think the content and the language used in the program are too dense for my students. I believe the content is more suitable for the adult viewers.*

There were a couple of teachers (n=2) who gave a lower rating based on needing time to prepare students for the content presented in the planetarium program.

> *I would have to do a lot of work to connect the two. But I could do it, focusing the kids ahead of time and working with them based on knowledge they would need to gather during the show.*

> *Although the shows were amazing, the age level I teach might have a struggle with the vocabulary present in the show. But being able to review terms and concepts before the show, it would make the viewing of the show that much more exciting for the kids.*

Teachers who gave the highest ratings (n=17, a rating of 8 or higher) thought the program would be positive for students, and that the program aligned well with standards and curriculum, as well as specific topics such as gravity, energy, and the engineering design process.

> *The planetarium would be a great resource to connect to the curriculum. It just adds one more dimension of learning.*

> *The show will cover most of what I am asking the students to model for my action plan.*

> *Planetarium programs are well designed & linked to science standards.*

> *I can't wait to take the students to the planetarium this year. They will able to connect what they are seeing to gravity, energy, force, motion, and the EDP.*

> *The Live Program: Build a Spacecraft and the Hubble Story were both excellent for teaching the Engineering Design Process and connect well to some of the NASA design challenges available on their website. I am very excited to schedule this planetarium program for my students.*

> *The planetarium program will directly relate to and support the gravity and engineering unit that I am incorporating into my new curricula this year.*

The high ratings teachers gave for the usefulness of the workshop activities was further supported by comments in the group discussions held on the last day of the workshop. Teachers strongly felt that the museum and library resources were the most useful aspects of the workshop. Teachers felt they learned an incredible amount, and that the resources had awakened multiple possibilities for their lessons. Teachers found ways to incorporate the engineering design process, planetary science, waves, and gravity into their current classes and thus meet their school's expectations.

> *I am always struggling to find activities for my engineering class, trying to tie it into the science class. This week I was so excited everyday that I actually have this*

planetary science unit that I can tie everything in here, practically copy and paste everything and tweak a little bit. It is a lesson plan for almost a whole term.

I didn't know what to expect, and I think that the planetarium resources are so eye-opening and engaging. I wanted to learn more. Once I got online and explored the NASA resources, I realized it was bottomless, there are so many ways of applying that.

One unanticipated finding from the group discussion was that the time to collaborate with peers was also mentioned as one of the most useful aspects of the workshop. Talking and working with peers created a dynamic environment that the teachers greatly appreciated. They expressed that during the school year they might not have time to talk and to brainstorm with other teachers. Talking with others was also a way to learn about what others have tried in the classroom, and therefore a way to develop activities and lessons that were informed by experience. In the words of one teacher that resulted in many nods of agreement,

When we are in our school year, we don't have the time to dig into topics with our peers, to just have the luxury of bouncing ideas and pouring through activities and hearing from someone else and what they tried. It is just invaluable to have that.

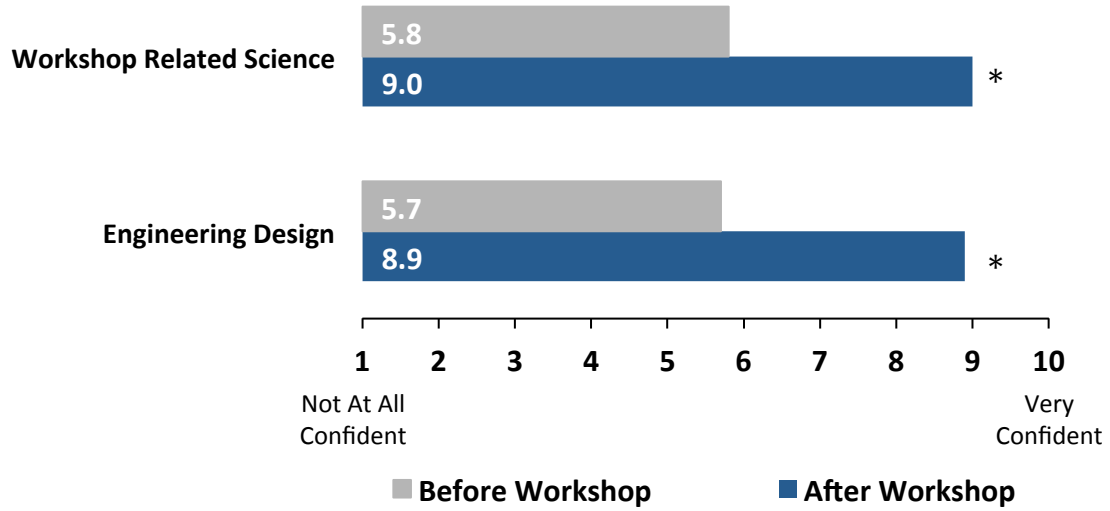
Impact on Confidence & Knowledge of Science & Engineering Design

(Sources: Last Day Survey & Group Discussion)

In a series of retrospective survey questions administered on the last day of the workshop and looking back over the five days, teachers were asked to rate their confidence and knowledge on science and engineering design before and after participating in the workshop. The use of paired t-tests in this section investigated the presence of statistically significant differences between how teachers felt before and after the workshop. Statistical significance was set at the $p<.05$ level, a standard level of confidence used in these types of statistical tests. Any statistically significant differences are reported in the figure by an asterisk (*) and a note about the significance. When an asterisk is not present in the figure, then the difference between how teachers felt before and after the workshop is not statistically significant.

On the whole, the workshop had a very positive impact, leaving teachers feeling more confident and knowledgeable in various areas after the workshop. Teachers felt significantly more confident in their ability to teach the science content covered in the workshop, as well as the engineering design content. Before the workshop, teachers felt somewhat confident, as seen by the average rating of 5.8 for teaching the science content and an average rating of 5.7 for confidence in teaching about engineering design. After the workshop teacher confidence jumped more than three points in these two areas (see Figure 25). Both of these were statistically significant differences.

Figure 25. Teacher Confidence With Teaching Workshop Related Science Content and Engineering Design, n=22



NOTE: A significant difference (*) was found at the p<.05 level using a two-tailed paired sample t-test.

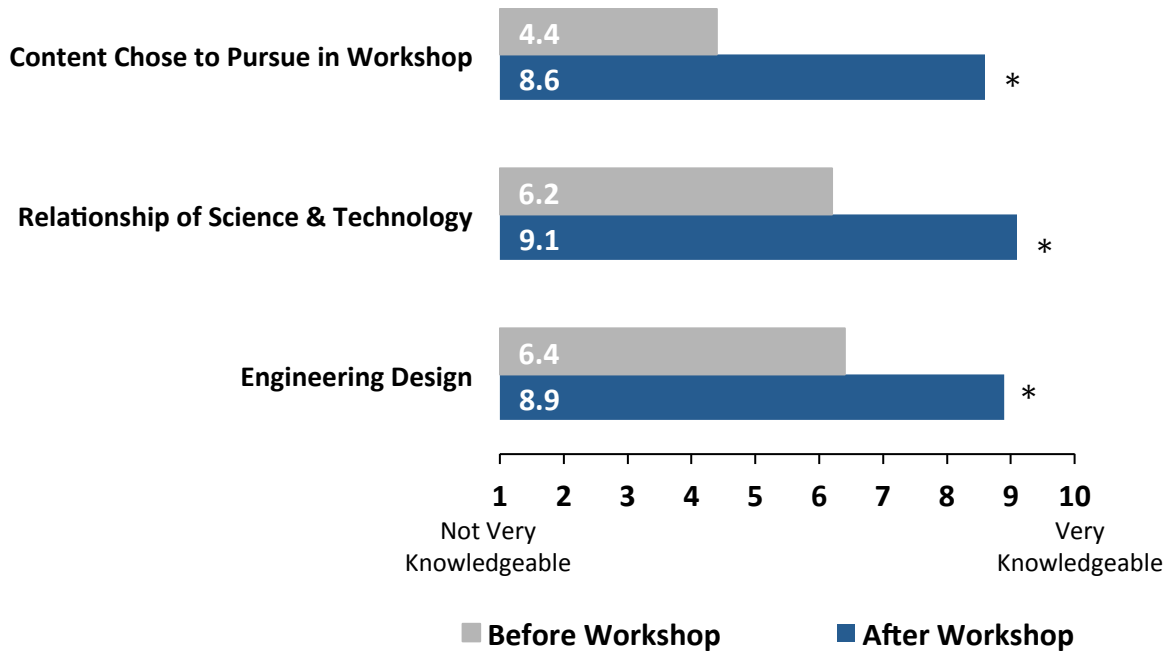
The discussion groups revealed that in the weeklong workshop teachers became more comfortable with the engineering design process and how to present engineering activities to their students in the classroom. The workshop structure and environment provided the needed elements for success, such as "a well-scaffolded program," specific goals, support from museum staff, and time for lesson development. Teachers also said that they thought it was great that the workshop allowed teachers from different subject areas to participate and learn.

In the discussion groups teachers also expressed their appreciation for learning more about various areas of science, and their increased confidence in being able to teach science and engineering in their classrooms. Teachers were grateful for the abundance of resources they could use to support their own understanding of content, such as waves and gravity, and the resources they could continue to rely on when designing lessons and activities for their students.

As the conversation in the groups developed around the topic of their increased confidence, teachers said that the workshop taught them to see science and engineering as connected and not separate, and to see technology as connected to engineering. The workshop enabled many teachers to see how these three topics (i.e., science, engineering, and technology) "could be combined in a holistic way." Teachers further said that the two staff members made it easy to understand how to use engineering in the classroom, and that it would now be easier to talk about technology in the classroom and much more fun. Teachers, as a whole, felt an increased confidence integrating engineering into the classes they already taught at their schools.

Similar to the increase in confidence, the workshop had a positive and statistically significant impact on teachers feeling more knowledgeable (see Figure 26). Before the workshop teachers felt less than somewhat knowledgeable, a 4.4 on a 10-point scale, about the specific content they chose to pursue in the workshop; such topics included waves and their applications, gravity, engineering design, and heat and energy transfer. After the workshop their self-perceived knowledge in these content areas rose to an average rating of 8.6 on a 10-point scale, an increase of 4.2 points. Teacher knowledge of engineering design, specifically, increased by 2.5 points from a 6.4 average before the workshop to a 8.9 average after the workshop. Understanding the interwoven relationship of science and technology, the idea that sometimes science drives technology and sometimes technology drives science, saw a large increase of almost 3 points from a 6.2 average before the workshop to a 9.1 average after the workshop. All three of these were statistically significant differences.

Figure 26. Teachers & Feeling Knowledgeable About the Content They Chose to Pursue, the Interwoven Relationship of Science & Technology, and Engineering Design, n=22



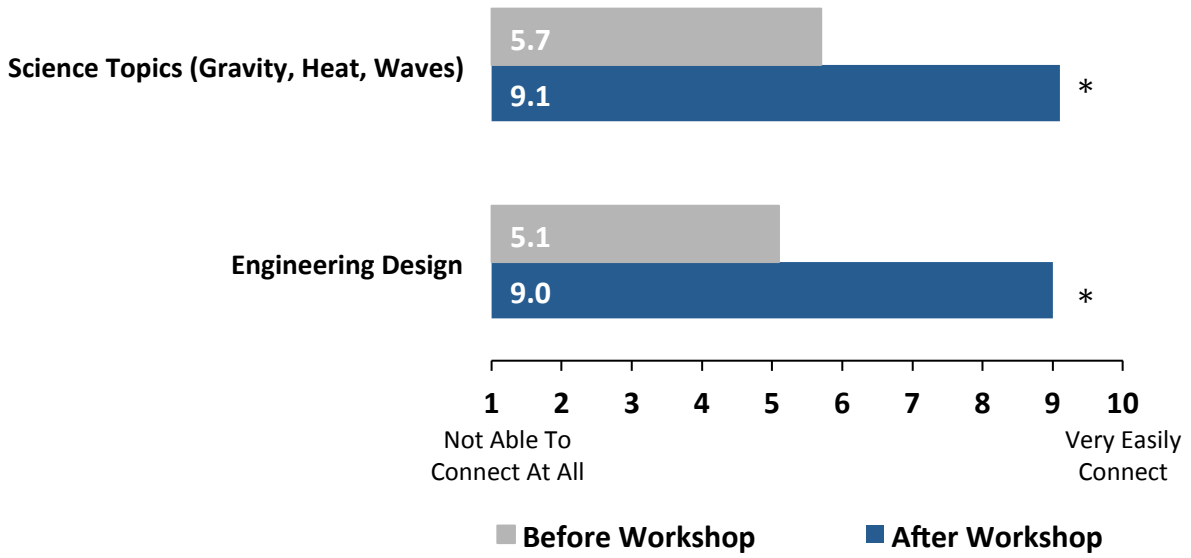
NOTE: A significant difference (*) was found at the p<.05 level using a two-tailed paired sample t-test.

Impact on Teaching Practice & Curricula

(Source: Last Day Survey)

The workshop had a positive and significant impact in teachers' abilities to connect science topics and engineering design to their class curricula (see Figure 27). Prior to the workshop, teachers felt somewhat able to connect the science topics of gravity, heat and waves to their curricula, as evidenced by an average rating of 5.7 on a 10-point scale. At the end of the workshop the rating rose by 3.4 points, resulting in teachers feeling like they were easily able to connect science topics to their class lessons. Likewise, a large increase was seen in finding connections for engineering design to class curricula, an increase of almost 4 points; from 5.1 before the workshop, to 9.0 after the workshop. Both of these were statistically significant differences.

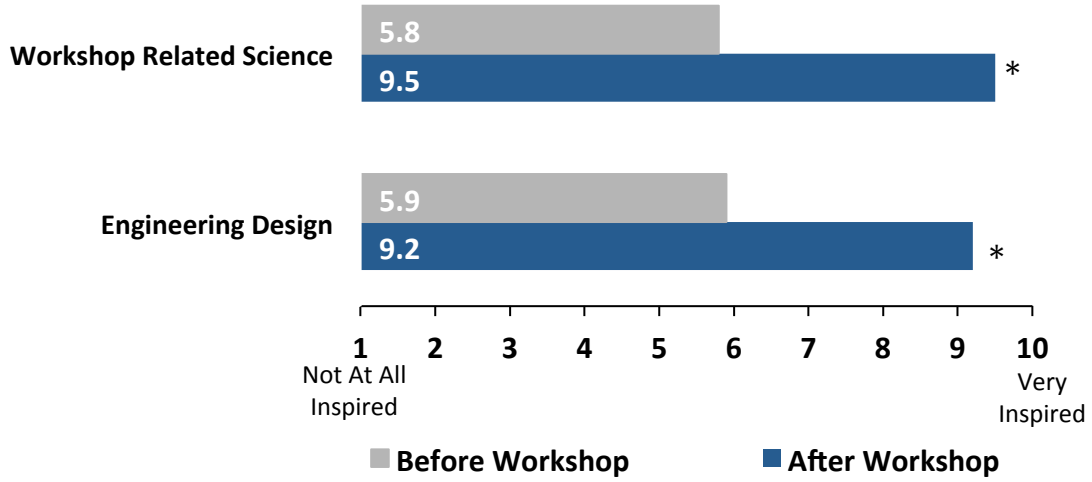
Figure 27. Connecting Engineering Design and Science Topics (Gravity, Heat, Waves) to Their Curricula, n=22



NOTE: A significant difference (*) was found at the p<.05 level using a two-tailed paired sample t-test.

The workshop experience resulted in a large and significant impact in teachers feeling like they were inspired to teach workshop content about science and engineering design. Feeling inspired to teach workshop related science increased by 3.7 points from 5.8 out of a 10-point scale before the workshop, to an average rating of 9.5 after the workshop. Feeling inspired to teach engineering design also saw a large increase of 3.3 points from an average rating of 5.9 out of a 10-point scale before the workshop, to an average rating of 9.2 after the workshop (see Figure 28). Both of these were statistically significant differences.

Figure 28. Feelings of Being Inspired to Teach Workshop Related Science and Engineering Design to Students, n=22



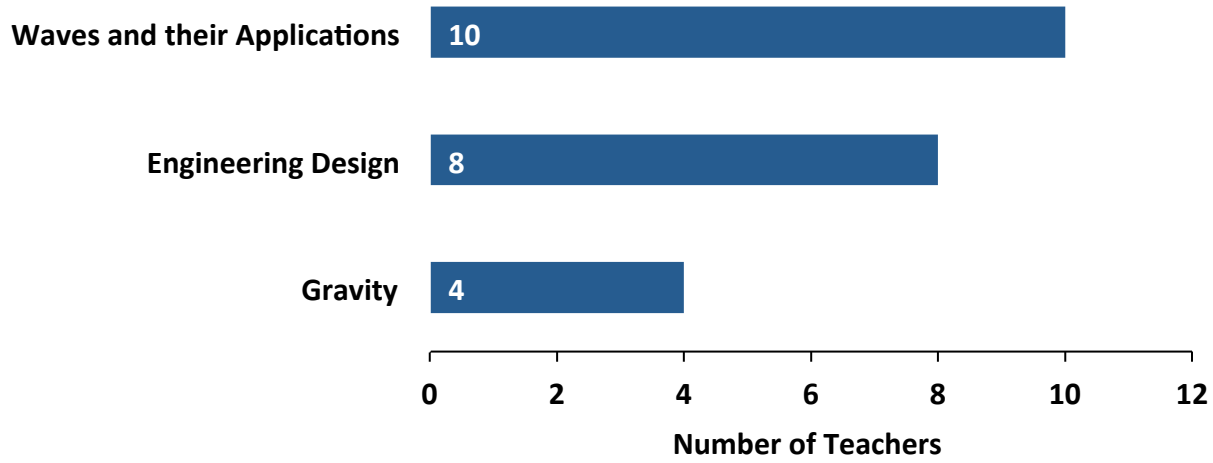
NOTE: A significant difference (*) was found at the p<.05 level using a two-tailed paired sample t-test.

Intentions to Implement Topics and Activities

(Sources: Last Day Survey, Follow up Survey & Group Discussions)

Teachers were asked to choose one of four content areas to focus and work on during the entirety of the workshop: waves and their applications, engineering design, gravity, or heat and energy transfer. To foster growth in their content area, teachers had access to staff, colleagues, and curriculum resources at the library, as well as time to develop an action plan comprised of ideas for lessons and activities. Almost half of teachers (n=10) chose to work on waves and their applications, followed by engineering design (n=8) and gravity (n=4) (see Figure 29). No teachers chose heat and energy transfer to work on during the workshop.

Figure 29. Content Areas Teachers Chose to Work On During the Workshop, n=22



NOTE: No teachers chose to grow and work on the topic of heat and energy transfer.

The main reason teachers chose to work on the topics of waves, engineering design or gravity was seeing a direct connection between learning about that specific content area with science standards and their curricula (n=13). A second reason teachers gave was the feeling of having little knowledge about those areas of science, and a strong desire to learn more (n=8).

Waves and their applications

Out of 10 teachers, 6 felt they knew little about waves and 4 chose the topic because of direct ties to science standards and curricula. The following quote illustrates why some teachers chose the topic of waves.

> *Waves were something so entirely new for me that I hadn't yet even begun to explore. Frankly I was a little intimidated to begin. Second, because I will have to teach it soon! With the change in curriculum accompanying the MA performance expectations, I will be responsible for teaching them in two years. It was nice to have the time to grapple with my own content learning while I was surrounded by resources and had peers to ask questions from and bounce ideas off of.*

Engineering design

Out of the 8 teachers that chose engineering design, 6 did so out of a need to incorporate the topic into their class curricula, and 1 felt weak in the area. One teacher declined to write about their reason for choosing this topic. The following quotes illustrate why some teachers chose the topic of engineering design.

> *I choose engineering design as my focus area because the curricula that I teach do not explicitly address it, and I have been concerned for a long time about the fact that my*

students don't get any exposure. It turns out that they do, I can see it now, but now I can also add in some places to make engineering a more explicit focus, which is cool.

I struggled to teach engineering to my students before I came to the workshop. The lesson plans that I have do not match my science curriculum. This is the main reason why I chose to come to this workshop hoping that I can do something different with my engineering class.

Gravity

For the topic of gravity, 4 teachers saw connections between learning about the topic and their classes, and 1 perceived it as a weak area. The following quote illustrates why some teachers chose the topic of gravity.

The new draft standards emphasize gravity and I wanted to be able to more deeply explain what gravity is and be able to demonstrate/ help kids how to model how gravity works.

In the group discussions teachers were asked about their intentions for what they might change or do different in their classrooms as a result of attending the workshop. Fourteen teachers talked about their intentions to use engineering design in their classrooms, *"Change what I am already doing to incorporate engineering, and to have children do critical thinking."* Teachers expressed that due to the workshop they saw how the engineering could be integrated into the science subjects they already taught in school, and that engineering did not have be unconnected from other content, *"I can do lots of small activities throughout the year that can support my science curriculum instead of having engineering and science separated."* In fact, one teacher said that engineering activities and concepts would strengthen the content taught in their class*, "I will incorporate engineering in my curriculum because it strengthens the content."*

A portion of those teachers said they would use activities from the workshop that would enable students to practice engineering design. One teacher said they would make smaller engineering projects that could fit in a day, and another teacher mentioned their intentions to do a unit on communication and technology, and the intention of using snap circuits with their students.

All teachers, from both discussion groups, agreed that their classroom practice would change because of the workshop and felt that the changes would be carried forward through multiple school years. Teachers thought they would continue to incorporate engineering and what they learned in the workshop this year and in future years. However, 4 teachers felt that incorporating elements from the workshop into their classroom would be difficult in the coming year, for three reasons. The first difficulty was time, since concepts in engineering would take multiple days to teach. The second difficulty was the cost of the materials. The third difficulty was district goals, since curriculum changes would be easier for teachers in districts dedicated to integrating engineering into science.

Topics and Activities Actually Implemented in the Classroom

(Source: Follow up Survey)

Once back in the classroom couple of months later, teachers most often remembered the engineering activities they learned in the workshop (n=8) and the planetarium show (n=7) (see Table 18). They also referenced interacting with the teachers and meeting an astronaut.

Table 18. Most Memorable Aspects of the Workshop, n=15

Category	Frequency
Engineering Activities	8
Planetarium Show	7
Interacting with Teachers	4
Meeting an Astronaut	3
Learning New Content About Engineering	2
Staff Was Helpful	2
Standards Applied to Planetarium Show	1

NOTE: Teachers mentioned multiple aspects, thus the total frequency will be larger than 15 teachers.

Most teachers (n=13 out of 15) thought their students would find activities from the workshop inspiring. Only two activities, the Penguin Lab and the Planetarium Show, were mentioned by more than one teacher (see Table 19). The teachers thought a wide variety of activities would serve to inspire their students.

Table 19. Workshop Activities Inspiring to Students, n=14

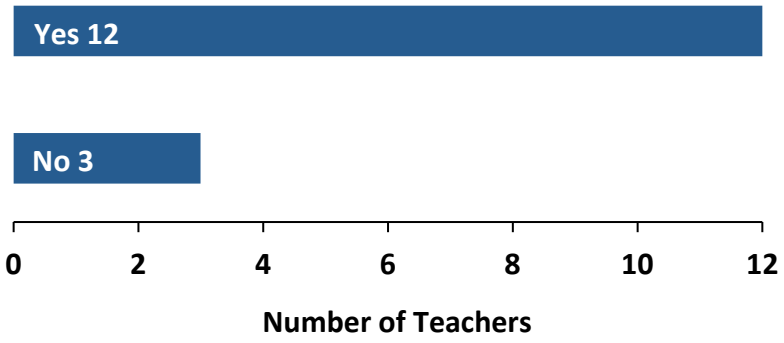
Category	Frequency
Penguin Lab	2
Planetarium Show	2
Rocket Lab	1
Wind Tunnel	1
Gravity Assist	1
NASA Pictures	1
Hubble Space Telescope	1
Jeff Hoffman, astronaut	1
Engineering Activities, unspecified	2

NOTE: Teachers mentioned multiple activities, thus the total frequency will be larger than 14 teachers.

Teacher Implementation of Workshop Materials

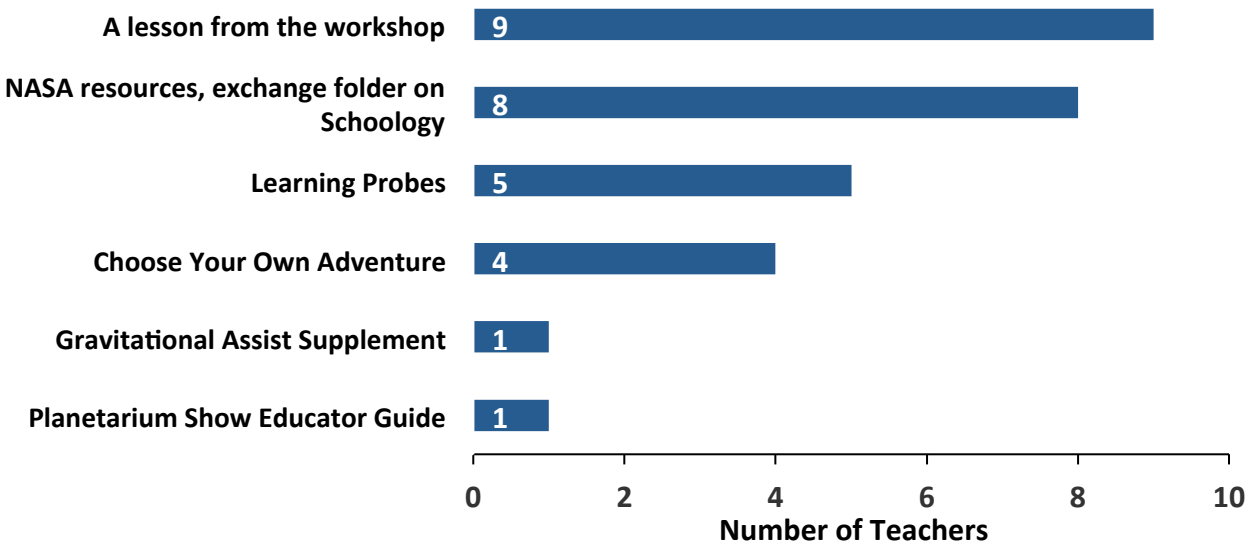
Out of the fifteen teachers that responded to the follow-up survey, twelve had implemented various materials from the workshop in their classrooms (see Figure 30). Teachers specifically wrote about using the following engineering activities: penguin lab (n=3), the frog lift (n=1), the Everest trek (n=1), the rocket launch (n=1), and the wind tunnel (n=1).

Figure 30. Teachers Who Implemented Materials After the Workshop, n=15



Other aspects of the workshop that teachers used in their classrooms were a lesson from the workshop (n=9), the NASA resources and the classroom exchange folder found on Schoology (n=8), the learning probes (n=5), and the Choose Your Own Adventure module (n=4). The gravitational assist supplement and the planetarium show educator guide were only used by one teacher each (see Figure 31).

Figure 31. Aspects of the Workshop Teachers Used in the Classroom, n=12

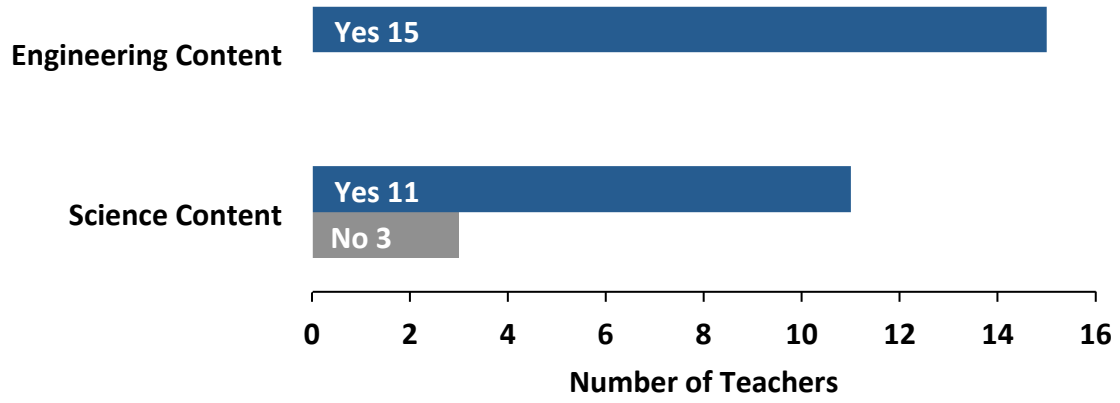


NOTE: Teachers selected multiple options, thus the total frequency will not add to the sample size of 12 teachers.

Implementations in Classroom Around Engineering & Science

After the workshop 15 out of 15 teachers covered, or planned to cover engineering design content in the classroom. A total of 11 teachers covered, or planned to cover workshop related science content in the classroom (see Figure 32).

Figure 32. Teachers Who Have Covered, or Plan to Cover, Engineering Content and Science Content in the Classroom, n=15



Most teachers (n=12) who responded to the web survey said they made changes and were doing something differently with respect to teaching engineering design content as a result of attending the workshop (see Table 20); they felt more comfortable teaching engineering (n=5), and that they had used some workshop activities (n=3). Other teachers wrote that due to the workshop they were planning on covering engineering design sometime in the future (n=2) and were planning on visiting the MOS (n=2).

Table 20. Changes in Teaching Engineering Design Content Resulting From the Workshop, n=15

Category	Frequency
Made Changes	**12**
What changes were made:	
More Comfortable Teaching Engineering	5
Use Workshop Activities	3
Currently Teaching Engineering	2
Plan on Covering Engineering Design in the Future	2
Plan to Visit MOS	2
Started Engineering Student Projects	1
Used the Penguin Lab	1
More Time Planning Engineering Activities	1

NOTE: Teachers mentioned multiple changes, thus the total frequency will be larger than 15 teachers.

For changes in teaching workshop related science content due to the workshop, seven teachers said they had made changes (see Table 21). Teachers found the science content they address in the classroom had changed (n=4), and their approach to teaching content had also changed (n=2). A few teachers (n=2) were addressing more science standards in their curricula as a result of the workshop.

Table 21. Changes in Teaching Workshop Related Science Content Resulting From the Workshop, n=10

Category	Frequency
Made Changes	**7**
What changes were made:	
Changed Science Content in the Classroom	4
Changed Approach to Teaching Content	2
Addressed More Standards in Curricula	2

NOTE: Teachers mentioned multiple changes, thus the total frequency will be larger than 10 teachers. For this question 3 teachers wrote they had not made changes in teaching workshop related science because of the workshop.

In addition to the current changes happening in their classrooms, 14 teachers said they were still planning on applying more of what they had learned from the workshop. Two teachers specifically wrote that they would plan on adding light and waves into their curriculum, one teacher wrote they would address gravity at the end of their school year, and another teacher wrote about piloting "Engineering Fridays" this year. Three separate teachers wrote about wanting to start an afterschool program about engineering design, *"I would love to start an engineering club after school and completely incorporate the engineering lessons from this workshop."*

Teacher Recommended Changes

(Sources: Last Day Survey & Follow up Survey)

On the last day of the workshop, teachers had multiple recommendations for improving the workshop. The top recommendation, mentioned by four teachers, was being able to take home the engineering kits (such as the snap circuits) that teachers used in the workshop. Other recommendations that were mentioned twice each include the following: more time to collaborate with teachers, a larger room for the workshop, to start the workshop with the new standards, more time to view the museum exhibits, and a museum tour. Other recommendations for improvement that are mentioned just once can be seen in Table 22. The full list of suggestions teachers had for how to improve the workshop can be found in Appendix G.

Table 22. Recommended Changes to Make the Workshop More Useful For Teachers, n=21

Categories	Frequency
Take Home Engineering Kits	4
Time to Collaborate More with Teachers	2
A Larger Room	2
Start with New Standards	2
More Time for Museum Exhibits	2
A Museum Tour	2
More Activities	1
More Engineering Activities	1
More Guidance on Resources	1
More Hands-on Activities	1
Offer Workshop to More Teachers	1
Structure Action Planning Time	1
Split Teachers by Grade Level	1
Add Teachers from Varied Disciplines	1
Two Room for Simultaneous Discussions	1
Less Guidance for Planetarium Resources	1
A Library Tour	1
Mix-up Teacher Groups More	1
Nothing	1

NOTE: Teachers mentioned multiple changes, thus the total frequency will be larger than 21 teachers.

Additionally, when asked for any other additional feedback that would help MOS make the workshop a more worthwhile experience for them as a teacher, sixteen teachers responded with praise (n=11), or by expressing the request that the museum offer more workshops for teachers (n=4) (see Table 23). Other teachers offered specific suggestions such as integrating more structure into the workshop (n=2), having days based on a theme (n=1), the option to take home the engineering kits (n=1), having teachers from a variety of

different discipline participate (n=1), offering professional credit (n=1), and holding the workshop in a larger space (n=1).

Table 23. Other Recommendations for the Workshop, n=16

Categories	Frequency
Praise	11
Offer More Workshops	4
More Structured Workshop	2
Engineering/Science Themed Days	1
Take Home Engineering Kits	1
Have Teachers from Different Disciplines	1
Offer College or Teacher Credit	1
Larger Workshop Space	1
Better Food	1

NOTE: Teachers mentioned multiple recommendations, thus numbers will not add to the sample size of 16 teachers.

Once back in the classroom, teachers were again asked if they had wished the MOS workshop instructors had spent more time on any particular thing. While four teachers responded no, another two teachers wished more time had been spent on strands, and two wished they had chosen another topic to work and grow on (teachers did not specify which topic they would have chosen). One teacher wished the workshop had given them materials for the engineering activities since they had a difficult time finding materials for the flying object activity (see Table 24).

Table 24. Recommendations for More Workshop Time, n=10

Categories	Frequency
No	4
More Time on Strands	2
Wish I Chose Another Topic	2
Wish Workshop Provided Materials for Activities	1
More Time Focused on Engineering for Middle School	1

NOTE: Teachers mentioned multiple recommendations, thus the total frequency will be larger than 10 teachers.

Conclusions, Teacher Workshop

Teachers were highly satisfied with the workshop program on individual days, and their satisfaction increased over the course of the week. By the end of the workshop, participants gave their overall experience with the workshop an average rating of a 9.6 on a 10-point scale. Over half of teachers felt the workshop held at MOS was better than similar workshops they had attended in the past, another eight teachers felt the workshop was

about the same as other workshops, while not a single teacher thought the workshop was not as good as others they had attended. Teachers were very satisfied with the workshop as a whole.

Teachers also rated the individual workshop activities and planetarium resources very highly. Many thought the planetarium show would be very useful not only for their classes in general but also for helping them connect classroom lessons to the curriculum. Teachers who gave the planetarium program the highest ratings thought the program would be positive for students, the program aligned well with standards as well as important curricular topics such as gravity, energy, and the engineering design process.

The high ratings for the usefulness of the workshop activities were further supported by comments in the group discussions. Teachers strongly felt that the museum and library resources were the most useful aspects of the workshop. Teachers also reported learning an incredible amount in the workshop, and that the resources had awakened multiple possibilities they would apply to their lessons. By two months after the workshop, the teachers had already found ways to incorporate the engineering design process, planetary science, and waves and gravity into their current classes.

With regard to increasing teacher confidence and knowledge, the workshop had a very positive and statistically significant impact. Teachers left the workshop feeling more confident to teach science content and engineering design to their students. They reported becoming more comfortable with the engineering design process and how to present engineering activities in the classroom.

Similar to the increase in confidence, the workshop also had a positive and statistically significant impact on teachers feeling more knowledgeable about the content. Before the workshop teachers felt less than somewhat knowledgeable about such topics like waves and their applications, gravity, and engineering design. After the workshop their self-perceived knowledge had risen greatly. Prior to the workshop, teachers felt somewhat able to connect specific science topics and engineering design to their class curricula. By the end of the workshop teachers felt extremely confident about connecting this content to their class lessons.

The workshop program had a large and significant impact in energizing teachers for the classroom, resulting in greater feelings of inspiration to create curricula. This inspiration to teach the workshop topics and engineering design was not there at the beginning of the workshop. At the end of the workshop, teachers were asked what they might change or do differently in the classroom as a result of attending the workshop. Many teachers talked about their intentions to use engineering design in their classrooms, and all the teachers agreed that their classroom practice would change in some way as a result of participating in the workshop.

Teachers have used words such as inspiring, exciting, fantastic, and engaging to describe their feelings about the workshop. As a result of their positive experiences, teachers would highly recommend the workshop to other teachers. The key reasons for their strong recommendation were the focus on Next Generation Science Standards, feeling empowered

to develop curricula relevant to new standards, the time to collaborate and learn from peers, and the time to develop their own action plans for their classrooms.

Teacher implementation of workshop activities and resources were documented in a follow up survey administered eight weeks after the end of the summer workshop. Since starting the academic year, teachers had used lessons from the workshop, the NASA resources and the classroom exchange folder found on Schoology, the learning probes, and the Choose Your Own Adventure module. Out of the fifteen teachers who replied to the follow up survey, all fifteen had covered, or planned to cover engineering design content, and eleven covered, or planned to cover science content from the workshop in the classroom.

Findings – Out-of-School Time Units

NOTE: In the findings section below, some responses are separated to include quotes in different categories, while additional quotes were not included if they were superfluous or did not add to the response category. Quotes are included in the section so the reader can have a full sense for teacher responses.

Most Memorable Moments in the Units

Educators were asked what they found most memorable in teaching the unit, and responses covered a variety of topics and areas. The main themes that emerged were the content and its delivery, the reaction of the students, specific activities, and the hands-on or interactive nature of the activities.

Many educators talked about the **content and how it was delivered**.

> *It worked out great for me because we were very much trying to do STEM related summer camps. The curriculum was right on the money for that. I have actual elementary teachers who teach in my summer camp. They were able to jump in and do it, and it was valuable to get feedback from the kids as well.*

I suppose...I taught at an army installation and our coast specializes in helicopter training. The kids are especially interested in flight. They enjoyed it because it was related to that.

Everything was very unique in the STL [Sky's the Limit] lesson. Each week they were trying out a new technology, something they hadn't done before. It was new each week. It had them engaged immediately. All the different materials that we used over the course of the unit helped with engagement for sure.

For me, I feel that the children learning rockets, how they function as opposed to just playing with the pump, they learn the different types of ways things move, the velocity and all that stuff that was involved in the pilot.

I think it was a nice addition. It was for our after school science club. It was more open ended than the other things we've been doing. I liked that it carried a theme through the whole unit.

I liked the challenge of the different difficulty levels. It was challenging, but they were very focused to reach the goal that they had.

We used it as an add-on to an aeronautical camp we do every summer. It's a camp for students just entering middle school. We are a small STEM school. We do a lot with aeronautics. What impressed me was how they took the simplicity of the things they did, that the kids learned so much from it. You could easily replicate that unit without having to go out and buy many materials, or expensive materials. That's always a big deal. Schools don't get money. If you can find good quality lessons on a school string or a small budget, that's always really good.

Many of the educators focused on the **reaction of the students**, mentioning how excited or enthusiastic students were about the activities.

I guess just always that the kids liked it. That was the 3rd one that I had piloted and I did it in a summer school setting. 8 days from 7:30 to 12:00. I really liked it, I really thought it a high success rate in a way.

I was very excited that the kids actually got to construct their parachutes. They actually got to create different types of parachutes that they could drop. It was very fun and exciting for the kids. They were very creative. We didn't have time for the activities, I had to add more time because they were so into it and wanted time to think about how to do it and redo it to make it better.

It's an outside of school activity and what sticks out for me is that the kids that did it are asking whether we're going to have another one. They wanted to do it. They liked the engineering part of it - create, try, create again, and try again.

Most memorable was the engagement with the students.

The way the kids reacted to it. How they were excited knowing they built it and they could do it.

I definitely think that the most memorable part was how excited the kids were. Anything where we're making objects fly in the air is exciting. Overall a fun unit for them to do. They learned a lot. It was able to engage kids that don't normally do things like that. If the topic is interesting enough it will always draw a crowd. That's always great.

Quite a few educators mentioned **specific activities** they participated in, including some that mentioned the positive qualities the activities encouraged.

They enjoyed doing the copters and wind tunnel.

As far as specific Sky's the Limit, the kids really enjoyed working with the wind tunnel. We did a lot with that. With the dropcopters and those frisbee things.

We just did the stomp rocket, use the wooden [unintelligible] and make a rocket that launches. I liked the fact that there was the rover too, that addition to it.

I really enjoyed the content for including the planets and the moon. The moon specifically.

I think a few memorable moments were we did dropcopters and there was a lot of creativity and enthusiasm about that project and the kids just loved the activity. It led to a lot of great brainstorming and teamwork and a lot of new designs. That's a memory that sticks out most.

Other educators mentioned the **hands-on or interactive nature** of the activities.

Building the little rovers. They were able to cut it out and build it and see how it would be if they were to do it in real life.

What I really liked about that was we worked with elementary school aged children. We were able to do STEM activities with our older elementary students. I thought it was really interactive. I liked the variety of different materials. It shows the kids that they can use ordinary every day items to engineer.

The hands-on portion of it. They enjoyed being able to create the activities. Then there was the inquisitiveness of it. Having to figure out what materials to use. That was most memorable - about how well it was put together so the kids could be engaged.

I think what is most memorable is the fact the kids had actual hands on activities to do. The supplies that were sent to us, that was amazing. We usually don't get things sent to us. Having the supplies as well as the hands on was very very good for the children.

OST Educators Applying Content Knowledge

Educators were asked if they had applied any of the content knowledge around space or flying since participating in the unit. Of the 18 educators, 7 of them had used the content knowledge while 11 had not. Those who had applied the knowledge were educators who reported teaching the content in classrooms, in camps, or after-school programs where the content being covered matched what was in the activities. Quite a few of those who had not applied the content knowledge said that they had considered it, but not gotten around to it, while some said they were not teaching classes that included the content in the curriculum.

Yes – Have Applied the Content Knowledge

Oh, yeah. We do clubs, I'm in an after school program. We've done one that was a paper airplane, I helped with some of their concepts like aerodynamics and how they test things. We didn't do vertical wind, but we did a horizontal thing. I've always liked stuff like that, some of it was easier for me to do.

I teach 4th grade in a public school setting. I teach all the subjects. Part of my curriculum is the solar system, so yes I have.

Yes, probably because I teach a NASA lab. We try to be more creative, versus telling the steps they need to do. Think more outside the box. As teachers, we've never really had time to go back and modify design. Having STL [Sky's the Limit] in the summer, I had that time to go back and redesign. I now try to incorporate that into my classroom. Building the tower, I try to still do that. As a team building, out of the box activity. I did use spaghetti noodles to make it little more difficult.

There was a moon rover the kids built and we use that now...we wrote it into our summer camp curriculum. The kids liked that very much.

Yeah, we have a little science club and they take out the rockets and measure the distance of how far they go. We don't have the funds for the materials, but what we have leftover we use for that.

Yes! I actually created my own program where we learn a lot about space - the astronomy part of it and also the aerospace engineering part of it. I've used some things from the Liftoff unit in my own program and expanded on it as well.

My role has changed since then but we did put the materials...I went from a teacher to an administrative role...they're being used by our 3rd-5th after school program. So they are still a resource for teachers.

No - Have Not Applied the Content Knowledge

We have several of the engineering kits at my school and our students are very familiar with the EDP [Engineering Design Process]. So, generally speaking, we've used the EDP. I've used it in my classroom. As far as specifically the Sky's the Limit, no.

The group of students...we didn't specifically continue with that unit. We didn't continue building on it. Those students were in 4th grade and now they're in 5th grade. The EDP is something we continue to work on with all of our students.

We haven't had another unit like that. We've done geology and environment. Next year we'll be doing more Earth Sciences. We're on a rotation at our school. Next year I will probably dig out the binder and use some of those items.

We have not really...past that unit. We thought about possibly doing the unit again with some of our newer kids this semester, but we haven't gotten to it. Sometimes we hear from students...they'll talk about some of the concepts that they learned. Every now and again they relate back to the concepts from back in the spring.

Unfortunately no. It was only during a summer school time period. If I had access to the kit during the school year, I would. It was different than the science standards for the grade level I'm in, so I don't have access to those materials during the year.

We're a self-contained week long summer camp. I would have no way of knowing what the kids did with the information after that week.

We've been using the EIE [Engineering is Elementary] principles as far as how to teach the EDP [Engineering Design Process]. We've been doing it at our school because we're considered an engineering school. We're planning to use it again the last semester of our after school program. We're going to try to do the exact same one.

I actually retired in August and now I'm working part time at school as a retired call back position. I have not added on anything. Two social studies teachers worked with me on that summer camp and I'm not sure if they have or not.

No we have not.

I have not. I teach 5th grade during the day and I have not implemented anything.

You know, it's an after school club. I don't have the kids in the classroom. I'm not sure if they're using it to be honest.

OST Educators Applying Teaching Strategies

Educators were also asked if they had applied any of the teaching strategies since participating in the unit. Of the 18 educators, 14 of them said they had used the teaching strategies while 4 had not. Those who had applied the teaching strategies talked about using the Engineering Design Process (EDP), employing specific hand-on strategies, or using specific teaching strategies. Those who had not employed teaching strategies gave very general reasons as to why they had not.

Yes – Have Applied the Teaching Strategies

Some educators talked about using the **Engineering Design Process (EDP)** from the activities.

> *Yes, I have been able to go back and do redesign. The EDP - the verbiage and things that were taught in the lesson.*
>
> *We have definitely continued the EDP and to use the prep lessons, yes.*
>
> *Everything we do we use the EDP. When we filter water, a STEM activity tied directly to that English Language Arts project. We use the EDP - they have to design, test, redesign, that whole process.*

Other educators talked about **employing specific hands-on activities**, like journaling or other hands-on activities.

> *I do teach science. I'm a 6th grade science teacher. I try to incorporate a lot of hands-on. With the idea of journaling, I like the idea of having a journal. So, encouraging the kids to write in science class. Similar to how they wrote in their journals in the out of school time program.*
>
> *Yes. The hands-on units. Connecting technology with it. Yes. And more of a question based, starting off with a main question for the kids to think about.*

Other educators talked about **employing specific teaching strategies** like using a manual, having open-ended activities, or using different types of media.

> *[Speaks of someone else who runs the science club] - I know he uses the manual when he does the rockets outside during that club.*
>
> *What I really liked about the unit is it's very self-explanatory. Not all of our curriculum is like that so I was really appreciative of that. I think that definitely the staff that did work with that unit - it gave them more confidence in teaching STEM activities just because it was laid out so clearly.*
>
> *We've continued to have science club this year and I'm making the curriculum much more open ended, more in the style of the unit.*
>
> *Yes and no. I took some little ideas...it helped me get more prepared for stuff. I try to make sure I have all my stuff laid out. It's nice that they have everything, they say to do this, this and this. I'm always trying to have every thing laid out...it makes me get more prepared.*
>
> *Speaking in general to all the different curriculum, the fact that the curriculum is built well for our classroom - that's very useful. I think using different types of media and lots of different materials are something we try to integrate - regardless if it's STEM or something we've created ourselves.*

The strategies align really well to what we do. We're project based. I liked the fact they are taught that way. I do use those strategies. I hope in schools where they don't use those strategies it's a good introduction to them.

Some educators mentioned **general ways** of employing the teaching strategies.

Oh yeah. All of them. We want to do the whole thing, the same way we did it.

Definitely. It's kind of an odd time to be having this conversation, because our Boys and Girls Club is being renovated; so I haven't been able to do much of that this year due to space and time. For the most part, I haven't done anything like it since.

Yes, but...none of them are really that new to me. I have been incorporating those strategies since before - inquiry based, working in groups. I really like the program, so I'll say yes.

No – Have Not Applied the Teaching Strategies

We haven't got to because we're so busy with homework and getting ready for Christmas. The kids asked if we could go back through some of it again, so after Christmas we'll do it again. I still have the books.

No, I don't think I have.

I'm still in the classroom a little bit. I don't think it applies in the way that it could. Maybe I'll say no, or not applicable.

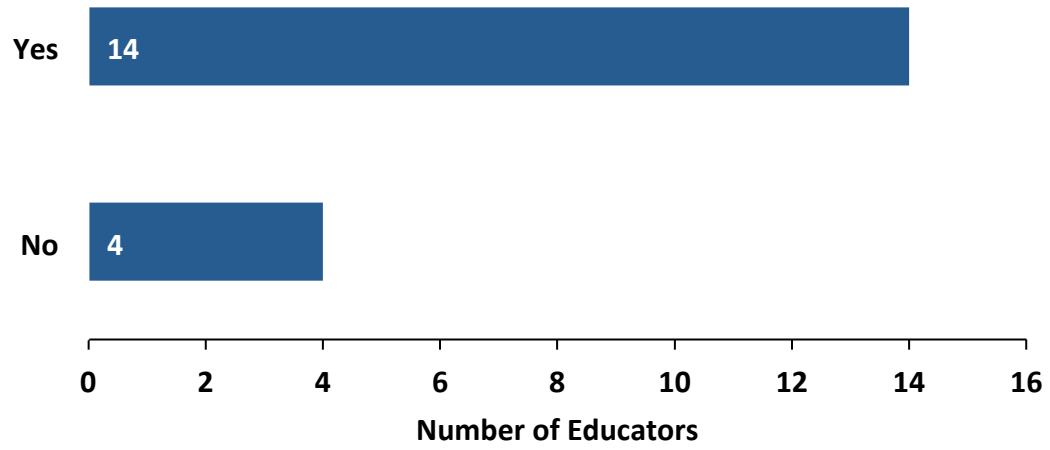
I certainly have not because I was not the teacher. I would not be surprised if my teachers still use them. I'm not in touch with them so I wouldn't know.

OST Educator Observations about Student Changes

One of the main purposes of this evaluation was to determine to what extent students were being impacted by the out-of-school time units. While quantitative analysis of the students collected by the Museum of Science provides evidence for this question, this study looked at educators' perceptions of the extent to which their students were impacted.

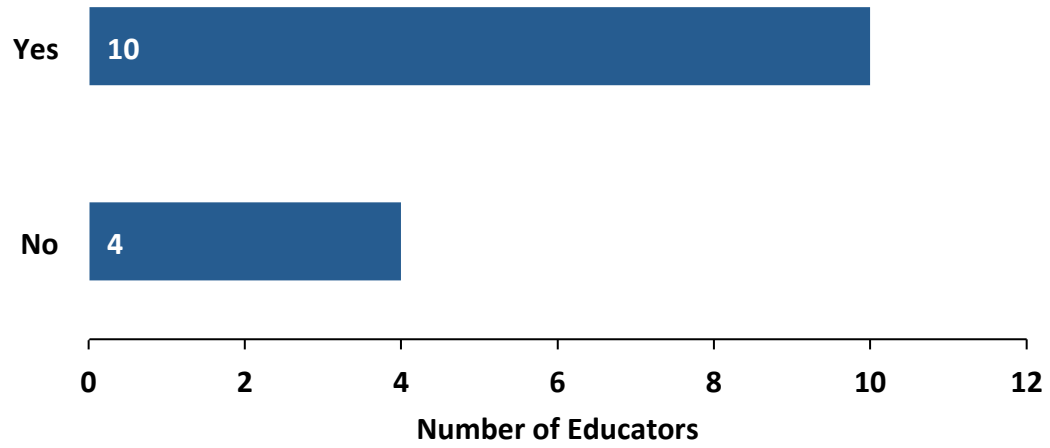
Of those interviewed, 14 of the 18 educators were still working with youth from the programs, and thus were able to answer questions about the impact of the program on youth (see Figure 33).

Figure 33. Educators still working with youths from the program, n=18



Of these 14 educators, 10 said they saw some evidence of students having been influenced by their participation in the OST unit (see Figure 34).

Figure 34. Students Influenced by Participation in Units, n=14



Change in Students' Attitudes Towards Failure

Educators were asked if they had seen any evidence of changes in student attitude towards failure, since that was one of the main messages of the OST units. 10 of the 14 educators were able to give examples of where they had noticed a change in student attitudes towards failure. Educators mentioned that earlier in the unit students had a different

attitude towards failure, while later students became more persistent and willing to try different ways in order to succeed. The specific examples below convey when students showed more persistence and were less likely to give up.

> *Yes, definitely. They're more apt to take chances. Not give up so easily. Learn that it's ok to fail the first time, learn from mistakes and grow from that. First they wanted to work with a partner because they didn't think they could do it. Many still like working with a partner or a group, I give them the option. Some kids like to work alone for various reasons.*
>
> *Absolutely. The fact that they have the motivation to continue. Understanding the EDP [Engineering Design Process] and understanding that failure doesn't stop you. You just go to the drawing board and start again. So absolutely.*
>
> *Yes. This is just one of the units, we've done lots. Some that are yours and some that are others. We talk about that with our kids. It's its hard to tell if it's a product of this unit specifically. When we began doing these types of activities the kids did struggle when they couldn't come up with a solution. And it would end there. We've continued to talk about and utilize from the units failure as part of the process, and it doesn't shut them down in the same way as it has in the past.*
>
> *We always talk about failures and first attempt in learning. I found I needed more supplies because they went through everything. They're interested in tearing things apart, trying, learning from what others are doing.*
>
> *At the beginning of the unit, one of the first units they had to make a watch tower of different materials like index cards...the goal was that it had to be a certain height and hold a certain weight. We noticed when the kids would come across obstacles, such as their creation didn't meet the qualifications. I saw that the kids got easily frustrated. Even at the beginning we had kids that said "I'm not doing this anymore." So it was tough at the beginning. We were just trying to be patient with them and show them you can't just give up. You have to use what you learned to make it better. In other units they'd have to build something that could hold toy soldiers. They could push through, whereas a few weeks before they wanted to give up. Their attitude towards failure really changed and they learned that's ok and it's part of the process.*
>
> *Yes, they are more likely to accept that they can fail and then they just have to try again. They're less likely to start giving up now.*
>
> *I think it has improved. I think they don't give up. They have the confidence to continue trying. And quite honestly, I think the wind tunnel activity helped them with that.*
>
> *Yes, I think they're more comfortable with failing and partly because - not just because it was built into the unit - but also because it was open ended and they knew they could work on it another day and that it was ok. They knew they would get a chance to remake.*

At our school we have a motto, "Engineers don't fail, they learn from their mistakes." (Speaking of water filtration activity) Some kids thought if they used less materials [sic] the water would filter better. They were thinking of absorbent diapers and things like that. So they put hardly anything in it. They thought it was a huge fail. I said no, no, no, what's our motto? In your second design what will you do? We remember that motto, and the kids really believe it.

Yeah, I have. Not necessarily in their school work. We do some Lego brick labs and I hear some of them talk about "oh wait, we've got to test this", "now we've got to go all the way back to the beginning." I've heard some of them mention that during the Legos thing.

Change in Using the Engineering Design Process

Educators were also asked if they had seen any evidence of students applying the Engineering Design Process (EDP). In this case, 11 of the 14 educators were able to give examples of when they noticed a student's application of EDP, and their responses show students were applying these principles in multiple types of classes. Student application of EDP sometimes had to do with testing different approaches, drawing or planning before trying something, redoing parts of a project, and being more deliberate.

I think they understand the idea of the cycle. That it's not linear. I think they've used that in other things.

I would say yes. Again, in that they are not giving up and doing different activities. Whether it's a science activity or different activity, they 're looking for ways to find the answer. And I think the engineering activities helped with that.

Yeah, I have. Not necessarily in their school work. We do some Lego brick labs and I hear some of them talk about "oh wait, we've got to test this," "now we've got to go all the way back to the beginning." I've heard some of them mention that during the Legos thing.

I would have to say yes in my classroom. I can't speak for their math and reading classrooms. Some of the kids I have on my after school Legos league, I'm seeing them thinking, doing the drawing first before they actually started with the building. I see a lot of that designing in that aspect - and in my classroom.

Yes, absolutely. We are a science center so we have a lot of hands on exhibits. We see them using that to engage in those exhibits.

Yeah, they do. We do different experiments. They had gone back and redone their rockets and done different things. We've done different projects and they know to go back and redo something when needed.

I see it when they are doing their homework, when they're doing science homework. Also I feel like, because the engineering steps go through prediction, planning and stuff like that, it goes across other subjects too, not just science. When we do other activities they're being more deliberate about how they approach activities instead of just diving head in.

It's probably true that they do.

Yeah, sometimes. They take a step back and they look and say, "How could we do this to where it will work?" They make a plan. They're building right now. They have a bunch of old sticks and they're building small forts for bugs and stuff.

For this year, that's the only one (water filtration). All of our teachers should be using it. We've had professional development at our school and were shown the overlap, or the sameness, of the writing process to the EDP - the math solving process and scientific method. Line them all up and they're almost all the same. As you are teaching, also tie in the EDP as well.

Yes, I guess so. Other projects and the fact that they're involved - not engineering specific or completely educationally specific. You can tell there's a thought process. You can see in a couple kids that they take time to plan things out more than they used to. I don't know if that's directly related to Engineering Adventures or not.

Three educators either said no, or they were not sure if they had seen evidence of students using EDP after participating in the unit.

No.

We do use it in science. I don't know if I've seen them extend it anywhere else. I only have them for math and science. So, not that I've seen.

I haven't been doing a science curriculum with them. That question might make more sense in that setting. Especially I'm thinking of the kids who were involved in this project. They are generally pretty analytical kids, it comes naturally to them. I feel like it impacted the way they thought about technologies and engineering. It helped them develop that mindset, that way of processing.

Change in Student Interest Towards Pursuing Engineering

Educators were also asked if they had seen any evidence of the students becoming more interested in engineering. For this question, all 14 of the 14 educators gave responses suggesting that there was typically some level of increased interest, although the degree of the increase varied. Some thought the students participating were already predisposed towards an interest in engineering, while others clearly saw an increased interest in groups and individuals. A couple of educators noted differences between boys and girls.

Four of the educators mentioned that many of their students have an **already predisposed interest in engineering**.

> *I think engineering comes so naturally to those students who come here. They're already predisposed to engineering. We've piloted a couple of them and the kids seem to look forward to being able to do them.*
>
> *I think that's what drove a few - the two kids I have - of the kids. They already have an interest and that's why they chose to come. The summer program is optional. There were kids who could sign up specifically for Sky's the Limit. One of those kids I have now. Our school has also incorporated a robotics rotation once a week. We are a STEM school. There's so much they can do with that.*
>
> *I would say they're interested. They're hands-on kids. They're interested in that kind of stuff. Growing up engineering was a scary word for me; I don't think they feel that way about it.*
>
> *They are a pretty solid science group. Our program is based on choice. The kids who want to be in science activities sign up. Those interests are still very strong among those kids.*

Three educators mentioned a **general increased interest** in engineering.

> *Yes, definitely. There are some kids from that group that have really shown strength and interest there.*
>
> *I definitely see more of an interest. Sometimes when people think of the word engineering it's slightly intimidating. For them to be able to see that it is an everyday process and that it could be done by anybody, we've definitely seen more interest in wanting to create things and being more interested in science in general.*
>
> *Definitely more interest. I think maybe they didn't understand what engineering was before that.*

A few educators specifically mentioned seeing **girls** having an increased level of interest when they talked about increased levels of interest. One teacher mentioned that the girls did not seem as interested as the boys.

> *There was some interest in terms of both boys and girls. How things work. How they were able to make certain things work. Some of them even started asking why. "Why is this happening? Why is this working when what I tried before didn't work?" I think it gave them a little more persistence.*
>
> *I had one girl tell me yesterday that if she could build something, she could become an engineer. She could learn to be an engineer and learn how to build buildings. That one stuck out, that was just yesterday. I was like, "Oh! Cool.*

I see a little bit. The girls not so much. The boys are more interested in it. They're the ones who say "Miss Tarah, what are those steps again?" They're the ones building and stepping back to look it over. They're pretty intrigued with it.

A couple of educators mentioned that the students **looked forward to doing additional units**.

Oh yeah they all want me to do another camp. They're all excited.

There's definitely interest. A lot of asking, "When are we going to do our next unit?

A couple of educators talked about **other issues around student interest in engineering**.

We always try to have a career connection when we do things with the kids. For instance, I had a powerpoint (kind of a boring way to present, about 5-6 minutes) about the importance of water. Being stewards of water and keeping the system clean. In it we said what [profession] you would be [depending on each part of the activity]... During 7th grade early in the fall they go to Cobble Mountain, which provides all the water for Springfield. We bring those two field trips and connect it to careers. Additional [Interviewer: And does it excite them, do they seem interested in those careers?] Oh yeah, they think about it. They either love it or think they couldn't ever do it. Never be cooped up in an office. We have a minute or two discussion about it before moving onto the next activity. We do also participate in Dijits (for about five years now), it sends representatives from a STEM job and they come and talk to 6th graders every year about jobs in the STEM field. We've had engineers and people that have been in environmental engineering jobs. We also do a trip that is half in a museum learning about the history of flight and half learning about careers in flight.

We have a lot of different activities and they're always wanting to build certain structures. This is not the only Engineering Adventures guide that we've done. We've done 3 others. They always refer back to what they did in that club.

Anecdotes Shared by OST Educators

At the end of the telephone interview, educators were asked to share any anecdotes about teaching the OST unit. The anecdotes covered a variety of topics. Many educators talked about how engaged the students were, and that they were engaged in a way that they didn't normally see; this included quieter students and those with English as a second language. They also talked about specific activities in the units, mentioning rockets, the wind tunnel, rover and parachute, among others. In general, the anecdotes were very positive and reflected an enthusiasm by both the educators and the students.

I just think that all the activities were very engaging. The students that come to us come from like 25 different elementary schools and most of them don't know each other. So, when they come they're a little shy, timid. The activities are so engaging that they really jumped right into them. The vertical wind tunnel was one of the most favorite activities. They had to do teamwork right away...it's very engaging. We do a

lot of NASA activities, build rockets, they build and launch large hot air balloons (about three feet tall). We made these gliders from "A World in Motion." We tie a lot into it - it's a very active camp [speaking about camp mentioned in Q1]. The unit fits into it very nicely. I like the MOS [Museum of Science] units, we used a lot of them. We used Stick in the Mud for 6th graders. In our Engineering lab we used the wind one. The filtering one, "Water Water Everywhere." That's what we use for the water filtration activity, part of it. We did a family activity with the wind one, that was very well received by families. They have a good product.

The most memorable for me - I know engineering is cool, I'm a believer in it. Our school is pretty far along on that. I'm used to the first couple times, the kids saying "Oh, that's so cool!" It really gets me when a new group of kids who have never been exposed to engineering in the school system - how much they love it, how much they grow from it. They want to take my class again each year, because they think I do a lot of engineering. That always really hits me. I'm a huge believer in the EiE units [Engineering is Elementary]. What I continue to love about the units is that they are so multicultural, they're very accessible, they're very easy and the materials are easy. There's a lot of ooh-ing and ahh-ing. I continue to be frustrated that there isn't more technology either purposefully included or connections. Not just "record this" but do research based, presentation based, use different technologies. That option should be included. I also think there should be more purposeful inclusion of writing. Writing in science is a big thing. There could be more. I do it, but it's not specifically stated within the unit. Those are my two frustrations. I add that in there...there are so many good things. Those two would be relatively easy to include.

Not off the top of my head, I'm sorry.

We loved it - it was a very positive experience. I'll end by saying that.

It's so hard because I don't have it in front of me right now...I really couldn't tell you one right now. We had a great time because we had a party and they flew their dropcopters. They all had a great time decorating them and naming them. That's what I can remember the most out of them [the kids]. I will say the children brought a lot of knowledge with them, since it is an army base school and a lot of their parents are helicopter pilots. Some obviously knew and some didn't. [Interviewer: Did the ones that didn't have preexisting knowledge still enjoy it?] They did, they had to make changes to their designs. There was a division between those that could and couldn't. But that's just part of the EDP [Engineering Design Process].

They were pretty amazed when we did the wind tunnel. They could get the cup to stay on the plate in both. I didn't feel like the fans we were sent were powerful enough. They didn't have the speed, the force, levels 1-3...I even got the hair dryer out. It would have been nice to have had a more powerful fan. Some of the items wouldn't even lift. They could have watched that all day long. They really got a kick out of that. The timing aspect, having to think about the weight...using the little space people hanging on their parachutes...

I would say that probably we took it to another level and added another activity where the kids made moon sand. So the kids could run their rover through it. That was really great. We just extended that activity and made moon sand and they got to play with their rovers in it.

One thing that was memorable was early on in the wind tunnel activity where they're throwing all these things in, one kid in particular took that information he was experiencing and created a parachute. Before the activity had really even started. The kid took the information he was experiencing and could immediately apply it to the design. This was the very first activity. The staff were really excited to see that.

Interestingly, the kids that were doing well...I worked with them before and they were more interested and engaged in the engineering activities than they would be in the classroom. Whereas in the regular classroom they're not as involved and not as interested in learning.

I feel like there's a lot of different things we saw that we were surprised about. For example, when the parents came to pick kids up early there was a lot of fuss about going home. They wanted to stay and finish their activity. Parents want to see that. Some of the other things we saw was the teamwork that the kids displayed in doing different projects. There are certain kids that always play with the same kids, but when they're doing these projects, the kids that normally didn't talk to each other were working together and discussing their design and that was pretty cool. Also, at our community center, most of the kids are low income and most are Asian students from an immigrant background. One other thing I want to say is some kids struggle with their English language; they shy away from academics because of low confidence. They like these...for students with English language capabilities that are not very high there was more engagement. Kids that are already struggling with school step into these activities and don't really hold back in participating. They didn't really need to know clearly what was going on language-wise. They were experimenting and could see the types of flying machines they were making, what was working.

It would be...the last one that they made, the one where they got the fans out and they had to build their dropcopters. We did adults versus the kids. The kids' [dropcopters] would not fly and the adults' would, but the kids had more fun with it. They didn't like that they lost, but they were excited to do it.

I guess I would have to go back to them enjoying the hands on. Being able to take the plastic around the fans and make the door to the wind tunnel and see which objects were able to fly or float and which ones sunk down. That was their most favorite, learning about wind tunnels. Some were looking at wind tunnels on YouTube afterward. It piqued their interest. That was the most memorable for me, that it actually started piquing their interest.

I can't think of anything off the top of my head. I've done probably eight Engineering Adventures units over the past several years and this was probably the most exciting

one for them. Just the nature of the topic in general and the hands on process to create the things that they made.

You know the one thing, I don't know if it was good or bad... At the end when they had to create a flying machine and pick a mission to do, every single kid chose the one mission that had the fewest number of restrictions. That was kind of funny, after the whole unit was about working with restrictions. [Interviewer: Is there anything else you'd like to share?] I really do appreciate the opportunity to have free curriculum like this. We're in a very rural area in NM so we don't have money for things like this. It's very much appreciated.

I know they really liked the wind tunnel. They really got into taking stuff and putting it in the wind tunnel. One kid even had a marble, but smaller, and he was trying to make it go up and down and climb in the wind tunnel. You could see that he was discouraged...by the time we got it built we didn't have much time to put stuff in it. We only did it on Wednesdays. He was really excited every Wednesday to get back to that. Then we moved onto another unit, but I would let him do it again. It didn't work exactly the way he wanted it to, but he was trying to make a remote control type thing.

We had the two hours for this so I was able to extend the activity and, again, using the wind tunnel, there were a lot of NASA videos. It was right after the soccer...World Cup. It was a soccer ball in a wind tunnel. They got to see what different soccer balls did in the wind tunnel. The kids were really excited about that - the current events sort of thing. We had an old aerial photo of our school. We used a lot - the kids were able to see our school. I didn't tell them it was our school at first, just clues with the tennis courts and parking lot. We used an aerial view of our school to talk about the quarter, the desert. We'll be getting more aerial photos that connect to Sky's the Limit.

I just think that they like the final outcome once they built it how they wanted it to go. The final outcome is what made it all worthwhile. Being able to create something and test it out would be the most memorable outcome for us.

Sure. I would say a couple come to mind. The kids had a great team mentality and adopted the stuffed animal as their mascot. They made it clothing and a throne, it was very much loved.

Conclusions, Out-of-School Time

What educators found most memorable in teaching the Out-of-School (OST) units was the content and its delivery, specific activities, the hands-on or interactive nature of the activities, and the enthusiasm seen in their students. Quite a few educators talked about how students were excited about the activities, and some mentioned how students who might not normally be engaged were participating in very positive ways.

While less than half of the educators contacted about the OST units had applied the content knowledge in classrooms, camps, or after-school programs, applying the content knowledge seemed to be dependent on whether the content knowledge matched the current classroom curriculum and activities. Quite a few of those who had not applied the content said they had considered it but not gotten around to it, while others said their classes did not include the type of content covered in the curriculum.

With regard to the teaching strategies in OST, 14 out of the 18 educators contacted had employed something from the units, including the Engineering Design Process (EDP), specific hands-on strategies or activity components such as journaling, open-ended activities, or different types of media. Educators used a variety of approaches that were covered in the units.

A main focus of the study was the potential impact the program could have on student attitudes towards failure, the Engineering Design Process (EDP), and potential interest in engineering. Of the educators contacted after participating in the units, 14 were still working with youth from the program and 10 of those educators reported seeing some evidence of students having been influenced by their participation in the unit. The educators noted that a good number of the students seemed to have changed their attitudes towards failure, had become more persistent, were willing to try different ways in order to succeed, and were less likely to give up. With respect to EDP, educators also saw changes in student behavior. In the interviews, educators gave examples of noticing their students applying the EDP, and they saw their students applying these principles in more than one class. Examples included students testing different approaches, drawing or planning before trying something, redoing parts of a project, and being more deliberate. Educators also noted some increased level of interest in engineering, though the level of interest was seen most in those already predisposed towards and interested in engineering.

Overall, educators saw a high level of engagement in their students, including those who would not normally be as engaged; they credited the hands-on activities and approach of the OST units. The educators' anecdotes about the program revealed very positive feelings, positive reactions, and enthusiasm from both the educators and their students towards the activities and content in the OST units.

Appendix A: Planetarium Program Survey

We would like to get some feedback about the planetarium program you just watched to help us make sure we met our goals to educate and inspire audiences. The survey is anonymous so please answer as honestly as possible.

1) How would you rate the planetarium program as an <u>overall</u> experience?

0 1 2 3 4 5 6 7 8 9 10
Poor Excellent

2) How would you rate the planetarium program as an <u>educational</u> experience?

0 1 2 3 4 5 6 7 8 9 10
Not at all Educational Extremely Educational

3) How would you rate the planetarium program as an <u>entertainment</u> experience?

0 1 2 3 4 5 6 7 8 9 10
Not at all Entertaining Extremely Entertaining

4) To what extent do you agree with the following statements? Viewing the program…

4a. Changed how I think about engineering.

1 2 3 4 5 6 7
Strongly Disagree Strongly Agree

4b. Made me better appreciate the challenges of engineering in space.

1 2 3 4 5 6 7
Strongly Disagree Strongly Agree

4c. Made engineering seem more fun.

1 2 3 4 5 6 7
Strongly Disagree Strongly Agree

5) How likely is it that you would recommend this planetarium program to other people who might come to the museum?

0 1 2 3 4 5 6 7 8 9 10
Not at all likely Very Likely

5a. Why did you give the rating you did?

6) Please complete the following sentence about the program: "I never realized that…."

7) Are you currently a full time student? □ Yes □ No

7a. If Yes, in which grade/level?

- ☐ K - 2nd
- ☐ 3rd -5th
- ☐ 6th – 8th
- ☐ 9th – 12th
- ☐ College/University

7b. If Yes, How much do you agree with the following statement: "Seeing the program made me more likely to think about becoming an engineer."

1	2	3	4	5	6	7
Strongly Disagree						Strongly Agree

8) How would you rate this planetarium program compared to other ones you have seen, either here at the museum or other places? Would you say it was better than, not as good as, or about the same as other planetarium programs you have seen?

- ☐ Better than other programs
- ☐ Not as good as other programs
- ☐ About the same as other programs
- ☐ Not applicable (I haven't seen other programs)

9) Is this your first visit to the Museum of Science? □ Yes □ No

10) Is this your first time seeing a planetarium program at the Museum of Science? □ Yes □ No

11) What is your gender? □ Male □ Female

12) How old are you? _____

13) **If you would like to be entered into a drawing for the iPad mini, please write your email address clearly below. We will not use your email for any other reason than contacting the winner, and the winner will be contacted within seven days after participating. (please write legibly)**

_____

Thank you very much for your time and feedback, it is much appreciated!

Appendix B: Teacher Workshop Calendar

Teacher Enrichment Programs

Engineering MISSION Teacher Institute August 11-15, 2014

Monday	Tuesday	Wednesday	Thursday	Friday
9:00 Welcome	Warm Up	Warm Up	Warm Up	Warm Up
9:30 1st Viewing of **Planetarium Show** A 10:30 Learning Probes LR 11:15 Content Exploration Learning Centers	9:30 Exploring gravitational forces in Planetarium. A 10:15 Modeling gravitational assist & orbits LR 10:45 **Jeff Hoffman** presentation focus on interplay of engineering & science LK	9:30 Viewing additional Planetarium assets A 10:30 Topic Work Time	9:30 2nd Viewing of **Planetarium Show** A 10:30 Code a Scoreboard EtF 4.1 **LK** Communication Systems EtF 4.3 **LK** 11:30 Build a Radio **LK** Or Topic Work Time	9:30 Standards Review **LK** 10:15 Action Planning ‘ Written Action Plan Briefs
12:00 Lunch	Lunch	Lunch	Lunch	Lunch – Presentations Start
12:30 Engineering Adventure *Sky's The Limit: Flying Technologies* O 2:00 Design Challenges LK	12:30 Digital Imaging or Penguin Enclosure LR 1:45 NASA resources and Classroom Lesson Exchange **LR** 2:30 Super Cold Science LK	12:30 Educator Guide Overview A 1:30 Engineering Adventure *Liftoff: Rockets and Rovers* T	Topic Work Time NASA Resources and Classroom Lesson Exchange **LR**	Presentation of Action Plans 2:00 Post Survey & Evaluation Focus Groups
3:00 Reflection	Reflection	Reflection	Reflection	Reflective Review

Appendix C: Teacher Workshop Daily Survey

(Administered at the end of the first four days of the workshop.)

We'd like to know how the workshop is going so far. This will help us not only improve the workshop for future teachers, but also the remaining days of this workshop. The survey is anonymous so please answer as candidly as possible.

1) On a scale from 1 to 10, where 1 is Poor and 10 is Excellent, how would you rate TODAY's workshop.

    1a. If you rated it a 9 or lower, what would make it a "10?"

2) Thinking about how you might use these workshop experiences in the classroom, what was the most useful thing for you in today's workshop, and why?

3) What are you most looking forward to in tomorrow's workshop?

    3a. What can we do to make sure we meet or exceed your expectations?

4) What other feedback do you have about the workshop, anything at all, that would help us make the remaining days a more worthwhile experience for you as a teacher?

Thank you very much for your time and feedback, it is much appreciated!

Appendix D: Teacher Workshop Last Day Survey

(Administered on the last day of the workshop)

We'd like to know how the workshop has gone. This will help us improve the workshop for future teachers. The survey is anonymous so please answer as candidly as possible.

1) How would you rate your overall experience with the five-day workshop? Please use a scale from 1 to 10, where 1 is Poor and 10 is Excellent, [rating from 1 to 10]

    1a. If you rated it a 9 or lower, what would make it a "10?" [open-ended]

2) We are interested in finding out how useful the various activities are for teachers who take the workshop. Please rate each of the following activities for how useful you think they will be for you as a teacher, using a scale 1 to 10, where 1 is not at all useful and 10 is very useful:

    2a. Viewings of the Planetarium Show.
    2b. Formative Assessment Learning Probes
    2c. Engineering Adventures afterschool units
    2d. Meeting former astronaut, Jeff Hoffman
    2e. Facilitated topic work time: Modeling Orbits/Penguins/Digital Images/Code a Scoreboard
    2f. Choice Topic work time
    2g. Museum Programs including: Soaring Satellite Design Challenge/Super Cold Science/Exhibits
    2h. Planetarium Educator guide overview
    2i. Planetarium Additional Assets: Gravitational Assist/Jeff Hoffman Video/Choose Your Own Adventure
    2j. NASA Resources and Classroom Lesson Exchange
    2k. Action Planning

3) We realize that participation in museum programs depends a lot on time and money. Putting those aside, how useful do you think it would be to bring your class(es) to experience the planetarium show? Please use a scale from 1 to 10, where 1 is Not at all useful and 10 is Very useful. [rating from 1 to 10]

    3a. In your opinion, what are main barriers to taking a field trip and participating in museum programs?

4) Which specific content area did you choose to "grow and work on" during the workshop? [select one option; Gravity, Heat and Energy Transfer, Waves and Their Applications, Engineering Design]

    4a. Why did you pick that particular one to work on?

5) Please compete the following sentence: "The one thing that could be changed about the workshop to make it even more useful for teachers would be…." [open-ended]

6) We are interested in finding out what kinds of impacts the workshop may have had across a variety of areas. Please rate each item below, both how you felt before the workshop and then after the workshop. [rating from 1 to 10, 2 items for each option below]. Use a scale of 1 to 10 where generally, 1= not at all, 10 = a lot.

    6a. Connecting engineering design to your curriculum 1= not at all, 10 = a lot
    6b. Connecting science topics (gravity/heat/waves/engineering) to your curriculum 1= not at all, 10 = a lot
    6c. Knowledge of engineering design 1= not at all, 10 = a lot
    6d. Knowledge of workshop related science content 1= not at all, 10 = a lot
    6e. Feeling inspired to teach engineering design to students
    6f. Feeling inspired to teach workshop related science to students
    6g. Confidence teaching engineering design
    6h. Confidence teaching workshop related science content
    6i. Knowledge of the specific content area you chose to pursue

7) How useful do you think the planetarium program will be in helping students connect with the curriculum you cover in your class(es)? Please use a scale from 1 to 10, where 1 is Not at all useful and 10 is Very useful, [rating from 1 to 10]

    7a. Why did you give the rating you did? [open-ended]

8) One of the more challenging concepts in the workshop is the idea that science and technology are interwoven, so sometimes the science drives technology and sometimes the technology drives science. To what extent were you familiar with or knowledgeable about this relationship <u>before</u> and <u>after</u> the workshop? [retrospective pre-post]

9) How likely is it that you would recommend attending this workshop to another teacher? [rating from 1 to 10, from not at all likely to very likely]

    9a. Why did you give the rating you did?

10) How would you rate this teacher workshop, compared to other ones you have taken? Would you say it was better than, not as good as, or about the same as the others?

11) Do you have any formal training or background in engineering? [Yes/No]

11a. If Yes, please explain.

12) Do you have any formal training or background in space science? [Yes/No]

12a. If Yes, please explain.

13) Which of the following statements best describes how frequently you and your students visit the museum? [Multiple choices, one option only]

- I have visited the Museum with students in the past year
- I have visited the Museum with students at least once in the past three years
- It has been over three years since I visited the Museum with students
- I have never visited the Museum with students

14) Have you ever brought a class to a planetarium program at the Museum of Science?

- I have seen a planetarium program at the Museum with students in the past year
- I have seen a planetarium program at the Museum with students at least once in the past three years
- It has been over three years since I seen a planetarium program at the Museum with students
- I have never seen a planetarium program at the Museum with students

15) What other feedback do you have about the workshop, anything at all, that would help us make it a more worthwhile experience for you as a teacher?

Thank you very much for your time and feedback, it is much appreciated!

Appendix E: Teacher Workshop Group Discussion Form

What part or aspect of the workshop was most useful for you as a teacher, and why?

1. Let's go around the room and say what you felt was the one most useful part of the workshop for you. Then we can go back and talk more about your thoughts.

2. What, if anything, do you think you might do differently in the classroom as a result of attending the workshop?

3. Please say, in one sentence, something you would change. What is the one thing you would change? Then we'll come back to everyone and you will get a chance to explain it in a bit.

4. One of the goals of the workshop is to help teachers be more comfortable teaching about engineering and/or science. To what extent do you think a workshop like this can achieve that goal?

5. How realistic does it feel that you will change your practice in the classroom based on what you did today? Does it feel like you might incorporate what you learned in the workshop for just this coming school year? Or do you see using what you learned for many school years?

Appendix F: Teacher Workshop Follow up Survey

(Administered 8 weeks after the workshop.)

We are interested in finding out your impressions of the workshop, now that you are back in the classroom. The survey is anonymous so please answer as candidly as possible.

1) What was most memorable for you about the workshop? What sticks out a few weeks after attending? [open-ended]

2) Where there any instances where you applied something from the workshop in the classroom? [yes/no] [If No, skip to Q4]

    2a. If Yes, please explain. [open-ended]

3) Which of the following resources from the workshop have you used since it ended? [multiple selections possible]

    - NASA resources/classroom exchange folder on Schoology
    - Planetarium Show Educator Guide
    - Choose your Own Adventure
    - Gravitational Assist Supplement
    - Jeff Hoffman Video)
    - A lesson from the workshop
    - Learning Probes

4) Is there any content or are there any activities from the workshop that you expect your students to be particularly inspired by? [yes/no]

    4a. If Yes, please explain. [open-ended]

5) Now that you're back in the classroom, is there anything in the workshop that you wish the instructors had spent more time on or went into more detail about? [open-ended]

6) Have you covered or do you plan to cover any engineering design content in the classroom since the workshop? [yes/no]

    6a. Did you find yourself doing anything differently, or do you expect to do differently, in covering engineering design content, as a result of attending the workshop?

7) Have you covered, or do you plan to cover, any workshop related science content in the classroom since the workshop? [yes/no]

    7a. Is there anything you are doing differently, or expect to do differently, in class when teaching the science content covered in the workshop?

8) In the future, how might you apply what you learned in the workshop? Are there things that you are planning on doing? [open-ended]

9) Is there anything else you wanted to share about the benefits or challenges of applying what you learned in the workshop?

Appendix G: Teacher Workshop Recommendations to Make the Workshop More Useful For Teachers

Last Day Survey: Please compete the following sentence, "The one thing that could be changed about the workshop to make it even more useful for teachers would be…."

Recommended Changes to Make the Workshop More Useful For Teachers, n=21
Seriously, nothing! I've enjoyed all of it and learned more than I expected to learn in a fun, interdisciplinary way!
Maybe having teachers sit together in grade levels for some of the activities. This group was very cliquey and sat with the same people, most coming from their schools. It would have been nice for them to be broken up so we could share things.
That one is really hard. The day that we had two conversation-based activities going on at the same time could have been separated into two independent spaces, though I understand that it was done this way because there wasn't one available at the time. Otherwise... Personally, I didn't really need to have the Resource Guides for the planetarium spoon-fed to me, it would have been fine to have a 5 minute version (this is the kind of information we have in the guides and here's where you find it) rather than a whole page-by-page walk through. Amanda was great, though, so even that I didn't mind so much, because the conversations she generated were always interesting.
More Time at the exhibits.
More engineering experiences.
A better tour of the library and its resources. How do you check books out here? Do you mail resources? Can I mail resources back to you?
More guidance through the wealth of resources the museum offers. This week opened my eyes SO MUCH to things that I can use in my classroom and hadn't thought to ask for. I had never been to a planetarium show before, and the one we saw and got to talk about was a major WOW factor. I think I could have benefited from a guided tour of the exhibit halls - even just a really brief "this is what's in that wing over there" to introduce me to what I could start looking for. I really liked the EiE curriculum, and I am so grateful and excited I had never heard of it before! But it would have been cool to see displays or pictures of all the different projects I could pick and choose from for my specific classroom. Either from EiE or other curricula that incorporates design challenges.
An early focus on the new standards to frame our learning.
To have it in a bigger space we could spread out, collaborate, have conversations, and not be disturbed or disturb others. Add teachers from other disciplines like art and computer science to enrich the point of view of us science teachers.
If the workshop could provide the teachers with the equipment or materials that we use from this workshop that definitely will be more useful for us. For example, the "electricity kits" or the rocket launcher will help us just to get started.
A little more guidance through the museum offerings? This is not a fault of the museum staff involved, but perhaps a little more time spent thinking about what questions were inevitable and accessibility to the exact exhibit and staff who could answer them.
Look at the strand chart and standards on day one.
To have the ability to discuss more ideas with the teachers that are attending. Maybe do an icebreaker to have a more friendly and inviting environment at the very beginning of the week.
Sample kits with lesson plans to bring back/borrow from the program
Giving them kits/materials to conduct investigations
To do more moving around on some of the days. I needed to break away from sitting down for a period of time.
To give us a action plan "challenge". Perhaps it is to create an engineering activity around our specific content area. I felt like the action plan and researching was too open-ended and could have been more structured to give us a focus.
To bring in a few more hands on lessons (like the rocket or penguin lesson) on the last two days of class to break up all the time sitting. It was good to have time to work on the action plan, but it would have been better to have an option of doing a mini lesson for those interested, or those done with the action plan. The

first few days were very exciting and the last few more sedentary.
Maybe provide one hour for mixer activities or team building activities so we can make professional connections that last beyond this week.
Really, the only negative experience I had was the lack of space that I need in order to create effectively. I feel that this workshop should be ongoing and offered to many other educators in order to reach as many students as possible.
Giving us one kit to try with students.

Last Day Survey: What other feedback do you have about the workshop, anything at all, that would help us make it a more worthwhile experience for you as a teacher?

Other Recommendations for the Workshop, n=16
Thank you for letting me be part of this dynamic learning experience!
This workshop as with all the others presented by the Teacher Resource center is of the highest quality. Lesley and her staff are by far my best teacher resources. If they don't have what I need, they either can get it, or point me in the right direction to find it.
Thank you so much for your candor and flexibility, and for the safe learning environment that you created here. I really respect how each one of us was enabled to start fro where we were and progress at our own pace and in our own way toward our own destination. This is how we are supposed to be teaching our students, but it is very seldom modeled for us in our own trainings, and I've never seen it done as well as it was here. Thank you all for an incredible week!
I loved the experience to be able to actually meet an astronaut and hear his story. That opened up a whole new world for me. I loved this workshop. It was a wonderful experience. Please offer more space workshops like this in the future. I would really enjoy taking more of them.
I would like more structure and organization. I would like a wave day, a gravity day, a energy transfer day. Then that day could include the resources, an engineering challenge, maybe an interview with a live expert or a visit to the exhibit, everything you want to show about that topic.
All of the facilitators and guest speakers were excellent! You made us feel welcome and introduced us to a wealth of resources. I felt comfortable asking questions. I appreciated the freedom for self-directed learning. However, I do feel like a little more scaffolding might have led to even deeper content learning and stronger action plans.
Thank you! Vary the food a bit. It's was good, but basically the same thing every day. (but awesome that it was provided). Any possibility of offering college credit?
I strongly recommend that teachers are provided with the equipment and materials for their classroom use after the workshop.
Please figure out ways to do more of this. I will bring more people down. Thank you. Also, get someone from Google involved.
Thanks for another wonderful experience. I feel invigorated, respected and ready to teach!
I hope that a follow-up Institute program will occur next year, or maybe even those that allow us to focus in on different Engineering standard concepts/themes.
Nothing:) I loved that we had choice in our learning. The education powers that be preach about differentiation yet when they run professional development it's never differentiated!!
I think by having the Schoology website is an excellent resource for me and it is a great place to share with other colleagues. I think many teachers need more professional development in the engineering design process like this workshop. I would love to see more workshops like this in the future for teachers to participate in.
Thanks again for all your hard work! It was a wonderful experience!
Talk about the integrating possibilities with other teachers. Working with an art or music person may not be possible in all schools, but when it is, it can be really fantastic. The engineering aspect overlaps with specialties in many ways. Bring in the visual aspect of NASA. They have such wonderful pictures and connections to art and design on their websites. There is no reason why teachers can't add art into their programs. It isn't a hidden quality that they need to know all kinds of art history to talk about. Or bring in the maker idea, and focus on using Design in their engineering or adding aesthetics to their designs....
I would only suggest more work space or fewer participants, otherwise this workshop has really impacted my desire to get back to work in order to, hopefully, inspire my students to study and grow to love science.

Appendix H: Out-of-School Time Instrument

Opening Statement: Thank you for taking the time to speak with me about your experiences teaching the Engineering Adventures [**insert unit name: 1) Liftoff: Engineering Rockets and Rovers, or 2) The Sky's the Limit: Engineering Flying Technologies**] unit. We are conducting these interviews so that the curriculum developers at the Museum of Science can better understand how these units perform in the field. Your feedback will be anonymous and will help our team continue to craft teacher resources that use engineering to pique the interests and curiosities of youth. Feedback from these interviews will also be presented to NASA, our funder, to give them an indication of how impactful these units are in the Out-of-School Time setting.

This interview should only take us about 15-20 minutes. Before we get started, do you have any questions for me?

1) Now that some time has passed since you taught [**insert unit name**], what sticks out for you, what is most memorable?

2) Since finishing the unit, have you:
   - Continued to apply any of the content knowledge related to space or flying that you learned? If so, how?
   - Continued to apply any of the teaching strategies incorporated in the unit? If so, how?

3) We are also interested in the youths who participated, and the potential impact of the unit on them. Are you still working with some or all of the youths in the same group that participated in the [**insert unit name**]?
   - If yes, ask: Have you noticed anything in the youths that might have been influenced by their participation in the unit?
   - If no, continue on to question 7.

4) The unit is designed so that youths might encounter failure in their engineering. Have you noticed any changes in their attitudes toward failure?

5) In the unit that you taught, youths learned how to use the steps of the Engineering Design Process to solve problems. Have you seen anything that suggests they have been applying these same steps elsewhere?

6) Have you seen any changes in interest in engineering among the youths who participated in the unit?

7) Since finishing the [**insert unit name**] have you participated in any other engineering activities or units with youth?
   - If yes, ask: Can you please describe them?

8) Lastly, are there any memorable anecdotes or stories you can share with me about your experiences teaching the [**insert unit name**]?

Appendix I: Out-of-School Time Emails

Email sent from MOS notifying participants that AVC will email

Subject: Engineering Adventures feedback

Hello,

Thank you for participating in the [Name of unit] Engineering Adventures program, and we hope you found it engaging and useful. We are contacting you to let you know that Audience Viewpoints Consulting, an evaluation firm the museum is working with, will be emailing you in the very near future to gather feedback about the program. We hope that you will be able to share your thoughts with them, as it is extremely important to us that we get feedback in an effort to improve the program.

Thank you in advance,

[MOS staff member]

Email sent from AVC to participants

Subject: Engineering Adventures feedback opportunity

Hello,

You should have received an email recently explaining that we are gathering feedback on behalf of the Museum of Science, in order to better understand how the Engineering Adventures program is working. We will be talking to teachers on the phone in the next week or so, and the interview is fewer than 10 questions and takes less than 10 minutes. We know as a teacher you are extremely busy, so want to make this as easy as possible.

We hope that you will click on the following link to let us know when you would be able to talk with us:

You are part of a small group of teachers we are contacting about this, so we certainly hope you are able to help out the museum.

Thank you in advance for your participation,

[AVC staff member]