SAINT LOUIS SCIENCE CENTER

Mission: Mars

Bridging Earth and Mars (BEAM)

Summative Evaluation

Conducted for
The Saint Louis Science Center
by
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Executive Summary

The Saint Louis Science Center (SLSC) project Bridging Earth and Mars (BEAM), based upon work supported by NASA under grant award NNX14AD08G, engages the general public and children from schools and community groups. Visitors learn of NASA's exploration of Mars through exhibits simulating control of robotic rovers on the surface of Mars, as well as related educational programming. Two public exhibition galleries opened on November 21, 2015: (1) Mission: Mars Control, located on the second floor of the SLSC Main Building; and (2) Mission: Mars Base, located in the SLSC Planetarium Building across the highway from the Main Building via an enclosed bridge. These two galleries, referred to for simplicity as Control and Base, aim to support NASA's goals to (1) inform, engage, and inspire the public to appreciate NASA's mission by sharing findings and information about NASA's missions to Mars; (2) ignite interest in S-STEM topics and careers for diverse K-8 students; and, (3) encourage students in grades 6-8 to sustain participation in educational experiences along the S-STEM careers pipeline. This summative evaluation focuses on the public exhibition galleries.

Tisdal Consulting conducted the external evaluation for this project. This summative report aims to provide useful information for funders, the project team, and other organizations developing exhibitions on engineering design and Mars exploration. Data for this study were collected between July 5, 2018, and September 5, 2018, using a mixed-method evaluation design. Methods included (1) tracking and timing observations (N = 322), (2) structured exit interviews (N = 58), and (3) focused-observations with brief open-ended interviews (N = 10).

Summary of Findings and Conclusions

The two-gallery design of the Mission: Mars project included innovative ideas such as programming and transmitting Mars rover programs as well as making deep connections to the engineering and scientific collaboration essential for the success NASA's Mars missions. Visitor satisfaction and impact both indicate that challenging project goals have been accomplished. Visitors to the SLSC should benefit from these accomplishments for years to come, and other science center and museums can consider replicating some of the innovative designs including programming and transmission, and watching model rovers perform scientific work on simulated Mars landscapes. The design and test area in Control also appear worthy of replication in other science center and museums. The ease with which visitors understand this design challenge and iterate design and testing cycles makes this set of exhibits worthy of replication and reuse in other institutions.

Visitor Experience

Gallery Use

Indicators of gallery use appeared lower than expected due to crowded gallery conditions during data collection; that is, visitors may have moved on to other experiences in the SLSC since exhibits in this gallery may have been unavailable due to use. Median lengths-of-stay were lower compared to the remedial evaluation study. Serrell's (1998) indicators of gallery use, Sweep Rate Index (SRI) and Percent of Diligent Visitors (%DVI), were low. It appears that many subjects entered both Control and Base and left after a short time due to most of the exhibits being in use. Crowding during data collection may have lowered this measure as traffic increased to the galleries, but visitors found other visitors already engaging at exhibits and left quickly. These findings are due to collecting data for remedial and summative evaluations at different times of the year. This means that data were not directly comparable; however, findings about the implications of crowding are important.

Individual Exhibit Element Attraction and Holding

Control Exhibits Attraction and Holding

In Control, newly designed interactive and renovated exhibits ranked in the top quarter of exhibits in the level of attraction, that is, the percentage of subjects tracked through the gallery who stopped at these exhibits. These

highly attractive exhibits consisted of A5.1 Rover Testing Station, A5.0 Rover Design Station, A2.0 Rover Arm Build, A4.0 Rover Navigation Station, and A2.1 Rover Arm Weight. Also in this upper quarter of attraction was A1.0 Mars Rover Family that had been moved inside the gallery, and appears to provide Control with a major gallery attractor to bring visitors into the exhibit gallery. In terms of holding power, A8.2 Rover Programming Station 2, A8.1 Rover Programming Station 1 ranked number 1 and 2. These two stations provide important experiences connecting the two galleries and linking elements of Mars exploration on Earth and Mars.

Base Exhibits Attraction and Holding
Four exhibits made up the top quarter of attraction rankings: B12.0 Mars Globe, B 0.0 Rover Observation, B9.1 Direct Drive Landscape, and B5.0 Gravity Testing Station. Each of these exhibits moved subjects into and through the gallery space. Four exhibits comprised the top quarter of rankings of holding power: B8.0 Mars Rocket Lander Game, B5.0 Gravity Testing Station, B9 Direct Drive Rover Station, and B2.0 Rock Identification Station.

Pathways
Changes in both Control and Base after the remedial evaluation included signs (large labels) and space dividers that appeared to make both Control and Base more unified spaces. Neither gallery had prime pathways, that is, ways large numbers of subject moved through gallery spaces. Some pathway patterns could be identified in both galleries that improved visitor use of the areas.

Use of Both Gallery Areas
In the remedial evaluation exit interview, findings indicated that only about 25.0% of subjects reported awareness of the other Mission: Mars gallery, but in the summative evaluation, about 40.0% of subjects reported prior visits to the other gallery. This indicates that use of both galleries appears to have grown over time deepening the connection of the two galleries, a major aim of the Mission: Mars project.

Visitor Outcomes and Impacts

Big Ideas and Misperceptions
The galleries appeared successful in communicating the Big Ideas that focused the gallery design and content. In the Control exit survey, a majority of subjects identified at least two of the three the Big Ideas specified by the project team in the logic models for the gallery, and a majority of subjects identified all three Big Ideas in Base. Control focuses on engineering design in Mars exploration, and Base focuses on the scientific missions of Mars exploration. Yet, a majority of both Control and Base exit survey subjects perceived some Big Ideas as common to both galleries. This may indicate that subjects perceived the shared aims and deep connection between the two galleries and their content.

Reactions
Given the comparatively lower gallery attraction and holding indicators, findings related satisfaction levels and Net Promoter Score increase were surprisingly high and positive. The Control gallery satisfaction measures increased from means of 7.4 to 9.1 between the remedial and summative evaluations, and Base measures increased from 8.1 to 8.6. The differences in Control were statistically significant, and those in Base were not. Net Promoter Scores for both galleries increased when remedial and summative score were compared. Control scores show the greatest increase, from 19.4% in the remedial study to 62.1% in the summative study. Base increased substantially also, rising from 30.0% in the remedial evaluation to 53.6% in the summative evaluation.

Best Aspects and Areas for Improvement
During Control and Base summative evaluation exit interviews, data collectors asked subjects about aspects of the galleries they liked best and areas for improvement. Subjects mentioned interactive exhibits, opportunities for hands-on engagement, and appropriateness of the galleries for children as some of the best aspects of both the Control and Base galleries. In Control, the new exhibits in the rover design and test area were mention as favorites. For Base, subjects cited B9.0 Direct Drive Mars Rover as a favorite experience.

In both Control and Base, subjects indicated they wanted more engagement opportunities for younger children. Content in both of these galleries is intentionally targeted to older children and adults, adding appropriate experiences for these two groups to the SLSC experience as a whole. In Control, specific exhibits cited as less accessible for younger children included the Rover Navigation Stations (A8.1, A8.2, and 8.3) and the Rover Arm (A2.0, A2.1, A2.3). A few subjects also said they wanted more room in the gallery, more interactive expertise and wanted to touch a rover model.

Focused Observations

Focused Observations indicated that the newly developed test and design area worked well and was highly effective for both adults and older children. Exhibits in the test and design area consisted of A5.0 Rover Design Station, A5.1 Rover Testing Station, and A5.2 Engineering Design Tips. Subjects appeared to use and absorb information from the long label on the wall behind A5.0 Rover Design Station but other labels appear used less often. Many older children and adults completed multiple design/test iterations, an important part of the engineering design cycle. The areas functioned the most effective during low to high levels of crowding, and the functioned least well when the gallery was nearly empty or very crowded. During the nearly empty conditions, subjects did not immediately perceive the connections between A5.0 Rover Design Station and A5.1 Rover Testing Station, probably due to the lack of opportunity to see other visitors designing and then testing their designs. During very crowded conditions, adults could not sit and help children with engagement and some parts (rover bodies and wing nuts/washers) were scarce. The area worked better for adults and older children who made connections to other gallery content and could easily understand the design testing process. For children slightly younger children (five to seven years old), the design and testing activities were clear, but many in this age group thought they were engaging in a car design and did not connect the activity to other gallery content. Very young children, those under five years old, engaged primarily with A5.1 Rover Testing Station and only with substantial assistance from adults. However, the test and design area was not intended for younger children and the attractiveness at A5.1 Rover Testing Station provided satisfying engagement for younger members of visiting groups while older brothers and sisters complete the entire test and design sequence.

Recommendations and Lessons Learned

This summative evaluation did not focus primarily on identifying changes to the two galleries. However, some lessons learned and a few recommendations for changes can be identified.

- Both gallery areas function better at moderate to high levels of crowding. Some consideration needs to be given to the overall quality of visitor experience during times when the levels are very high. While there are immediate benefits for the institution in terms of earned income, long term impacts in terms of return visitation and institutional reputation may be less positive. There are no easy solutions to this issue but SLSC may want to consider the issue in strategic planning and messaging about visit planning on the website.
- Additional parts are needed at A5.0 Rover Design Station, including two to three rover bodies and wing nuts/washers. Additional storage bins do not appear necessary; subjects often started engagement with artifacts of previous visitor engagement, much as engineers start with the redesign of previous projects.
- Exhibit redesign and prototyping, particularly in the Control gallery, appeared to have paid off in terms of both visitor satisfaction and visitor impact.
- Some consideration could be given to providing additional gallery seating near the back of Control's Engineering Design Lab to encourage visitors to move through this area of the gallery and see A7.0 Landing with Style/Engineering Challenges, A7.1 Entry, Descent, and Landing Infographics, A7.2 Aeroshell Artifact with Label, and A7.3 Seven Minutes of Terror.
- One key visitor experience linking the two galleries, the programming and transmission in Control (A8.1 Rover Programming Station 1, A8.2 Rover Programming Station 2, and A8.3 Program Transmission) and

watching the program execute in Base (B 0.0 Rover Observation and B0.1 Remote Programming Screens) improved substantially between the remedial and summative evaluation studies. Attraction and holding power of exhibits improved.

- Careful repositioning and placement of exhibit elements along with area space dividers appear to have increased the coherence, exhibit visibility, and pathways through both Control and Base. The shape of both gallery areas is challenging as the galleries need to balance directed visitor pathways with safety egress, which can disrupt visitor pathway flow. Yet, careful consideration to these factors, along with the gallery esthetics appears to have increased exhibit visibility and access. Crowding issues hides some these improvements to the galleries.

Introduction

The Saint Louis Science Center (SLSC) project Bridging Earth and Mars (BEAM), funded by the National Aeronautics and Space Administration (NASA), engages the general public and children from schools and community groups. Visitors learn of NASA's exploration of Mars through exhibits simulating control of robotic rovers on the surface of Mars, as well as related educational programming. Two public exhibition galleries opened on November 21, 2015: (1) Mission: Mars Control, located on the second floor the Main Building of the SLSC; and (2) Mission: Mars Base, located in the Planetarium Building of the SLSC across the highway from the Main Building via an enclosed bridge. These two galleries aim to support NASA's goals to (1) inform, engage, and inspire the public to appreciate NASA's mission by sharing findings and information about NASA's missions to Mars; (2) ignite interest in S-STEM topics and careers for diverse K-8 students; and, (3) encourage students in grades 6-8 to sustain participation in educational experiences along the S-STEM careers pipeline. This summative evaluation focuses on the public exhibition galleries. Figure 1 shows the location of the galleries at the SLSC.

Figure 1. Location of Mission: Mars Galleries at the SLSC

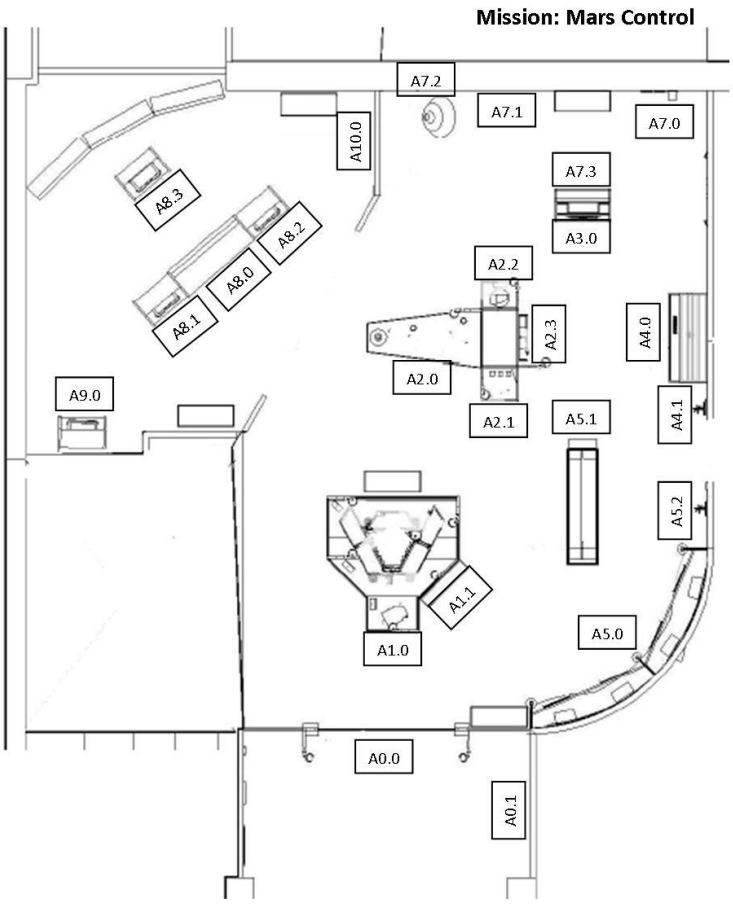
Tisdal Consulting, the external evaluator for this project, conducted the remedial evaluation of the two gallery areas in 2016 (Tisdal & Klein, 2016). The primary audience of the remedial report was the project team. This summative report aims to provide useful information for funders, the project team, and other organizations developing exhibitions on engineering design and Mars exploration. Data for this study were collected between July 5, 2018, and September 5, 2018, using a mixed-method evaluation design. Methods included (1) tracking and timing observations (N = 322), (2) structured exit interviews (N = 58), and (3) focused-observations with brief open-ended interviews (N = 10).

Mission: Mars Control

Mission: Mars Control (referred to in the remainder of this report for simplicity as "Control") focuses on three Big Ideas:

- Scientists and engineers work together to explore Mars -- what scientists want and what engineers can deliver!
- Engineers build, test, and program Mars rovers for science missions, and you can do the same at the Science Center.
- Scientists and engineers working for NASA are diverse in gender, ethnicity, and age.

As shown in Figure 2, this 2,200 square-foot space includes 23 exhibit elements. The Control gallery area features two sections: (1) an Engineering Lab where exhibits focus on engineers' work in creating the tools and technology for Mars exploration; and (2) Mission Control, where exhibit elements focus on programming Mars rovers and sending a program to a rover on Mars.



Mission: Mars Control Exhibits

A0.0	Mission: Mars Control Entrance
A0.1	Mission: Mars Control Entrance Sign
A1.0	Mars Rover Family
A1.1	Generations of Innovation
A2.0	Rover Arm Build
A2.1	Rover Arm Weight
A2.2	Rover Drill Testing
A2.3	Rover Arm vs Human Arm
A3.0	NASA Eyes on Mars
A4.0	Rover Navigation Station
A4.1	Rover Navigation Challenges
A5.0	Rover Design Station
A5.1	Rover Testing Station
A5.2	Engineering Design Tips
A7.0	Landing with Style/Engineering Challenges
A7.1	Entry, Descent, and Landing Infographics
A7.2	Aeroshell Artifact with Label
A7.3	Seven Minutes of Terror Video
A8.0	Bridge Earth + Mars
A8.1	Rover Programming Station 1
A8.2	Rover Programming Station 2
A8.3	Program Transmission Station
A9.0	Mars Trail
A10.0	Meet a Mars Scientist! Video with Label

Figure 2. Control Gallery Map and Exhibit List

Control Renovations made after data collection for the remedial evaluation and prior to the data collection for the summative evaluation included:

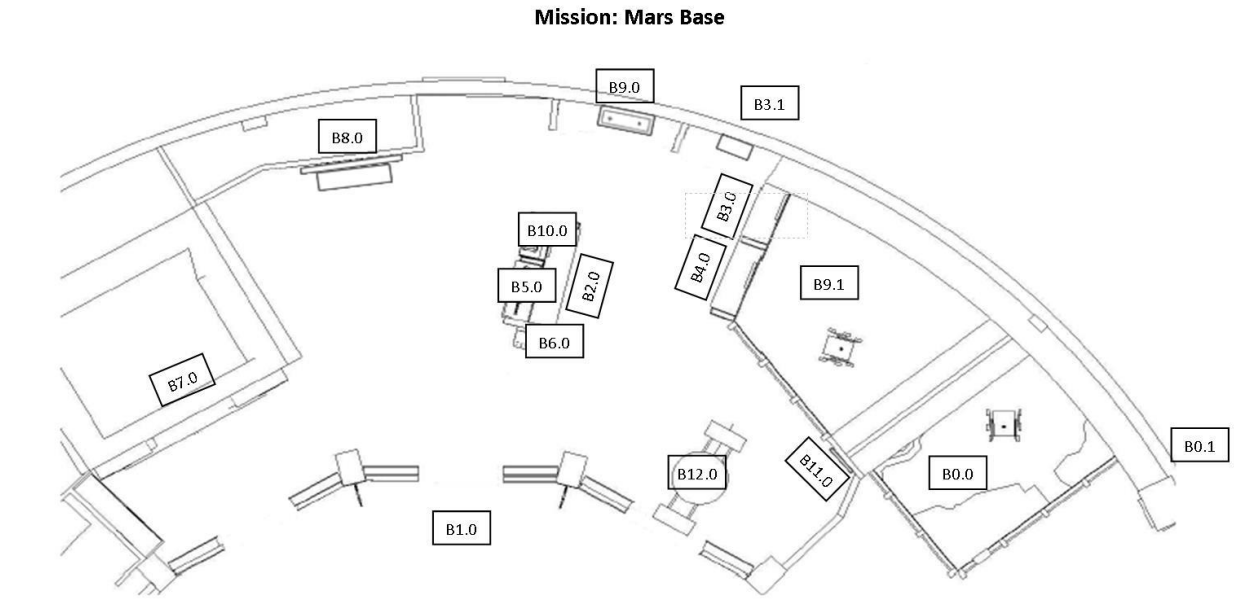
- The gallery entrance was redesigned to allow visitors to view gallery exhibits from the hallway leading past the gallery.
- A large exhibit showing generations of the Mars rover moved from outside the gallery entrance to a central point just inside the gallery entrance to service as a gallery attractor to encourage visitors to enter the main gallery space.
- New exhibits, installed just to the right of the gallery entrance, created an engineering design and testing area.
- The rover weight activity was prototyped and updated to include increased levels of interactivity.
- Spatial separators were installed between the Engineering Lab and Mission Control areas of the gallery.
- Signage and labels throughout the gallery were redesigned and installed.

Mission: Mars Base

Mission: Mars Base (referred to for simplicity as "Base") focuses on three Big Ideas:

- In the future, scientists will be living and doing scientific work on Mars, and you can play that role at the SLSC.
- Scientific exploration of Mars helps us learn about Earth.
- Scientists and engineers work together to explore Mars -- what scientists want and what engineers can deliver!

This 3,324 square-foot gallery features: (1) a remote observation station where programs sent from Control operate rovers conducting scientific research in a simulated Mars landscape; and (2) a futuristic Mars base where scientists carry out scientific research, including directly controlling a rover in a second simulated Mars landscape. Figure 3 shows a map of the Base gallery and a list of exhibit elements.



Mission: Mars—Base			
B0.0	Rover Observation	B6.0	Earth/Mars Comparison
B0.1	Remote Programming Screens	B7.0	Mars Base Airlock
B1.0	Mars Base Welcome	B8.0	Mars Rocket Lander Game
B2.0	Rock Identification Station	B9.0	Direct Drive Rover Station
B3.0	Gas Identification Station	B9.1	Direct Drive Landscape
B3.1	Planetary Observation Station	B10.0	NASA Eyes on the Solar System
B4.0	Rock Analysis Station	B11.0	Martian Meteorite
B5.0	Gravity Testing Station	B12.0	Mars Globe

Figure 3. Map of Base and Listing of Exhibits

Base renovations made after data collection for the remedial evaluation and prior to the time of data collection for the summative evaluation included:

- Spatial dividers were installed to more clearly separate the futuristic Mars Base area of the gallery from central open areas of the second floor of the planetarium building as well as a rover observation area connected to the Control gallery to its south. Spatial dividers were intended to provide a clearer and more coherent grouping of exhibits.
- Additional interactives focusing on scientific instrumentation and research on Mars were installed.
- The Mars Base airlock was redesigned along with additional theming.
- New signs and labels were designed and installed throughout the gallery.
- A new computer interactive, Mars Rocket Lander Game, was included in the gallery.

Logic Models

The project team developed two logic models, one for Control and one for Base. Team members used the Bennett's Hierarchy Logic Model approach (Onka, 2018: Radhakrisna & Bowen, 2018). Bennett specifies four types of short-term learning impacts: knowledge, attitudes, skills, and aspirations. While the first three types of impacts are commonly used, defining aspirations allows the measurement of changes in motivation associated with a learning experience. Appendix A includes copies of these logic models.

Questions Addressed

Based on the logic models, three overarching questions were identified to explore in this summative evaluation. The topical framework that follows shows these three questions and specific questions that explore these areas in more detail.

1. How did visitors use the gallery areas?
2. To what extent were gallery visitor outcomes and impacts accomplished?
3. To what extent and in what ways were the exhibits in the Control rover design area effective with different types of visitors?

Conventions

This report uses several conventions.

- Tables and graphs show the Control gallery in blue (representing Earth) and Base in red (representing Mars).
- Abbreviations and short forms include:
    - Standard deviation (*SD*)
    - Mission: Mars (M:M)
    - Number or counts (*N*)

Methods

Data Collection and Analysis

Mixed methods were used to conduct the summative evaluation. Methods included: tracking and timing, structured exit Interviews, and focused observations. For simplicity, these methods will be referred to in the rest of this report as tracking, exit Interviews, and focused observations. Appendix B includes the summative protocol for tracking and exit interviews provided as instructions to data collectors. When needed to answer a question more clearly, analysis included comparisons between remedial and summative evaluation tracking and exit interview data. Table 1 shows the data sources for both remedial and summative data.

Table 1. Data Sources by Method

Evaluation Study	Protocols	Control N	Base N	Protocol N	Collection Dates	Evaluation Total N
Remedial Evaluation	Exit Interview	46	45	91	May 4–May 28, 2016	
	Tracking	149	139	288	May 4–May 28, 2016	
	Focused Observations	39	28	67	May, 13–May 28, 2016	446
Summative Evaluation	Exit Interview	30	28	58	July 5 -- August 8, 2018	
	Tracking & Timing	159	163	322	July 5 -- August 8, 2018	
	Focused Observations	10	0	10	July 12 -- September 5, 2018	390

Tracking

Tracking captured how subjects moved through the two gallery areas and allowed the calculation of levels of attraction and holding for the gallery as whole and individual exhibit elements. Appendix C includes tracking forms for both Control and Base. The following definitions describe the gallery and exhibit attributes calculated from the data.

- *Gallery Area Holding* is defined as the sample median for total time for each subject's gallery area length-of-stay. For time data, the median is the most stable measure of central tendency. The more familiar mean (or average) is less stable because the distribution is not normal; that is, there are many more short stay times than longer times.
- *Exhibit Attraction* is the percentage of the total sample that stopped at each exhibit element.
- *Exhibit Holding* is the median stop time at each exhibit among those in the sample that stopped for at least one second.

Exit Interviews

Data collectors conducted exit interviews as subjects exited Control and Base. These exit interviews included several identical items to allow comparison between the two galleries. Appendix D consists of a copy of the exit interviews used for Control and Base. Data collectors asked tracking subjects who appeared to be over the age of 18 if they were willing to be interviewed. Children less than 18 years old were not interviewed due to parent/guardian consent requirements.

To measure impact, exit interviews included a retrospective pre-tests/post-test approach (Allen & Nimon, 2007). Interview items asked subjects to rate levels of knowledge, attitudes, skills, and aspirations before and then after visiting the gallery. All items used scales from 0 = low to 10 = high. Each category had five items. Measuring the impact of gallery visits can be challenging for several reasons. First, visitors to museums wanted to spend time with exhibits, family, and friends rather than answering interview questions. Second, formal learning interviews make visitors feel like school children being tested. Finally, subjects frequently overrate existing levels of impact prior to visiting a learning experience (Howard, 1980). This tendency can hide the actual gain associated with a visit.

Three staff members from the Research and Evaluation department of the SLSC collected and entered data. The external evaluator trained data collectors, and they were scheduled and supervised during data collection and data entry by an associate in the department. Figure 4 shows response rates.

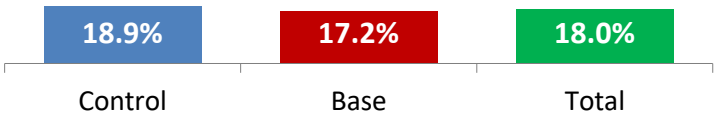


Figure 4. Exit Interview Response rates.

Focused Observation

The external evaluator conducted focused observations using naturalistic methods (Lincoln & Guba, 1985). Naturalistic inquiry uses purposive sampling (Miles & Huberman, 1994), that is, subjects are specifically sampled according to individual characteristics and gallery conditions to provide contrasting subjects and conditions to understand the range of exhibit use better. In this evaluation, contrasting variables included the age of subjects, group types, observed ethnicity, and levels of gallery crowding. Focused observations included one area observation to explore patterns of interaction among members of different types of visiting groups and nine observations of selected individuals. During observations, the data collector unobtrusively observed subjects and took notes including length-of participation, group type, age, observed gender, observed ethnicity, level of gallery crowding, sequential behavior, and engagement with other individuals (including conversation when it could be heard). After observations, brief interviews were conducted. For children under 18 years old, the permission of a parent/guardian was requested prior to the interview, and children were also asked if they were willing to be interviewed. All subjects were asked for their permission to be recorded. Recordings were transcribed. The overall response rate for brief interviews after observations was 100.0% of groups. Interviewees included the focus subject, and in some cases, a parent/guardian engaging with a child in the exhibit area. The findings section includes demographics for each focused observation.

Data Analysis

The external evaluator analyzed tracking and exit interview data using Excel and SPSS. Preparation for data analysis involved the calculation of several variables (e.g., total stops per subjects, gain scores for subjects) and creation of merged tracking data and exit interview files for each gallery. Analysis included the calculation of descriptive statistics including count, percentage, mean, standard deviation (SD), median, and range. Tracking data often contain highly skewed distributions, that is, many very short stay times and exhibit stops and very few longer stay times and numbers of stops. It is not appropriate to use many inferential statistics with highly skewed distributions. Analysis included rankings data from highly skewed distributions. For normal distributions, group comparisons involved Chi-Square tests, Correlation Coefficients, and parametric and non-parametric t-tests to identify significant differences. Specialized types of analysis (i.e., Net Promoter Scores and indicators of

level of gallery use) are included in findings so underlying calculations can be clearly presented with the indicators produced.

Data analysis for focused observations involved the coding of data and comparison of codes among observations. Codes included types of behavior, themes in conversations, and label reading.

Procedures for Confidentiality and Security

A medical/legal transcriptionist, accustomed to maintaining secure records and confidentiality, transcribed audio recordings. Exit interview forms, maps, transcripts, handwritten notes, and debriefing documents are stored securely. Electronic files (transcripts and debriefing documents) are maintained in a secure database at Tisdal Consulting.

Limitations

First, small exit interview sample sizes did not allow more sophisticated analysis (Control *N* = 30 and Base *N* = 28). A regression analysis can explain the relative importance of several independent variables more succinctly requiring fewer charts to present data. The initial targets of 40 exit interviews appeared difficult to reach. The resulting smaller sample sizes did not allow group comparisons within galleries and, and as is the case with any small sample, tended to underrepresent groups making up smaller percentages of the samples, for example, adults visiting without children and minority ethnic groups. This lack of sample diversity also affected the focused observations. The small sample sizes also meant that group comparisons (e.g., gender, visiting group type) could not be made.

Second, the analysis time involved exploring some unexpected results. Given the extensive changes to both Control and Base, after the remedial evaluation and prior to the summative evaluation, the project team's expectations included increased length-of-stay (holding power) in galleries and increased numbers of stops at exhibits (overall attraction levels of the galleries). Explaining the decreases or modest increases necessitated reanalyzing remedial data rather than using indicators from the remedial report. The differences in levels of crowding at different timeframes between the remedial evaluation (May prior to the end of K-12 spring semesters) and summative evaluation (July and August during heavy summer attendance) impacted tracking results. Findings about levels of crowding comprise some of the most important parts of the summative report.

Despite these limitations, findings in the summative evaluation provide strong measures of gallery use and impact. These should enable both internal and external audiences to make judgments about the effectiveness of the two galleries developed in the BEAM project.

Characteristics of Subjects

Evaluation reports include descriptions of the characteristics of the subjects to provide information about how representative the samples are in relation the population from which they are drawn. The samples in this summative evaluation should represent the population of people visiting each of the galleries during the data collection period. Appendix E includes graphs and tables for subject characteristics and the visit context for tracking (Control and Base) and the exit interview (Control and Base). A few charts show data from the remedial evaluation used in comparisons in this report.

With a few exceptions, the tracking samples and exit interview samples appear much as expected for summer visitors to the SLSC, with large percentages of adults with children, high percentages of adults between 25 and 44 years old, about 2.5 children in groups with children, about 2.0 adults per group, larger percentages of white subjects, and local residents representing a majority of subjects with a scattering of tourists. The large tracking samples (Control *N* = 159, Base *N* = 163), selected in a way to reduce bias, make these samples more representative. In general, small samples tend to underrepresent smaller segments of the population. This means, in particular, that races other than white may be underrepresented in the exit interview samples (Control *N* = 30, Base *N* = 28).

Figure 5 compares the median length-of-stay for tracking and exit interview subjects. Subjects in the Control tracking sample stayed a median 1.3 minutes compared to a median 1.7 minutes for subjects in the exit interview sample. The Control exit interview appears to represent the overall population. Subjects in the Base tracking sample stayed a median of 1.9 minutes compared to 3.8 minutes in the exit interview sample. The large difference in the Base medians indicates that the exit interview for Base underrepresents visitors with shorter lengths-of-stay.

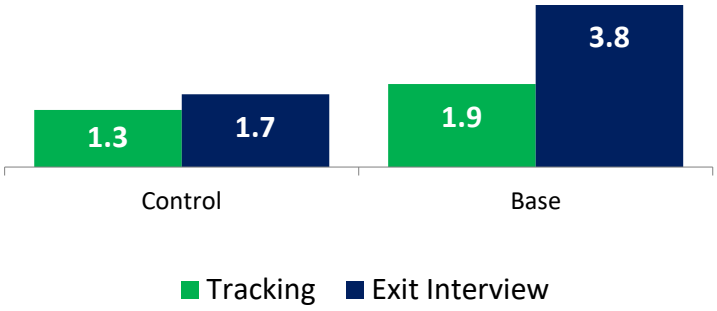


Figure 5. Median Gallery Length-of-Stay in Minutes by Protocol (Control -- Exit N = 30, Tracking N = 159; Base – Tracking N = *163. Exit = 28)*

Discussion of Findings

This section discusses findings related to three broad areas: visitor experience, visitor outcomes, and focused observations. Visitor Experience includes discussions of how subjects used the two gallery areas (*Control* and *Base*). In the Outcomes, we present information about how subjects perceived the experience and how it affected them. Finally, the section on Focused Observations contains findings related to the effectiveness of the rover test and design area in the Control gallery.

Visitor Experience

Gallery Use

Tracking data provide the primary source information for the Gallery Use section. Topics include gallery holding, overall gallery attraction, Serrell's (1998) indicators of gallery use, exhibit attraction, and exhibit holding,

Gallery Area Holding (Length-of-Stay)

The conventional measure of gallery holding is median length-of-stay in the gallery. Figure 6 shows medians for Control and Base in both the summative and remedial evaluations. This comparison indicates a decrease in gallery length-of-stay from the time of remedial evaluation data collection to the time of the summative evaluation data collection. Substantial renovations took place between the time of the remedial and summative data collection. These decreases required further investigation.

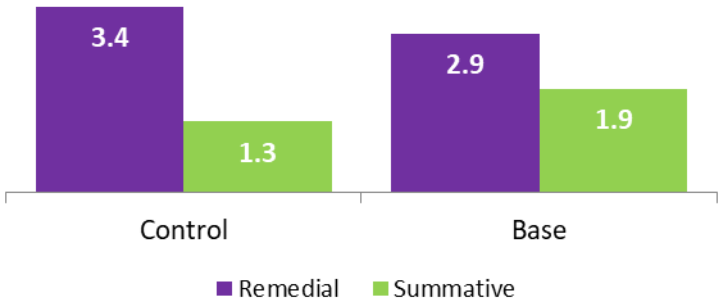


Figure 6. Remedial and Summative Tracking – Median Gallery Length-of-Stay in Minutes (*Control* N = 149, Base N = 139).

An examination of possible factors influencing this decrease focused on levels of crowding. Data collectors determined levels of crowding based on the following definitions included on the tracking form.

- *Nearly empty (1-2 exhibits in use)*
- *Low level (3-5 exhibits in use)*
- *Medium level (1/2 exhibits in use)*
- *Crowded (most exhibits in use)*
- *Very crowded (all exhibits in use)*

Figures 7 and 8[1] show the levels of crowding observed by data collectors for each track they conducted. During the remedial evaluation, 50.0% of data collection in Control took place during conditions when the gallery was nearly empty or there was a low level of crowding, but in the summative evaluation, only about 19.0% of the tracks were conducted in these uncrowded conditions. In the remedial evaluation, 59.5 % of Base tracking took place during these two relatively uncrowded conditions compared to 33.2% in the summative study. In contrast in the summative study, over half of Control tracking occurred during crowded or very crowded periods. Patterns indicate that higher levels of crowding overall during summative data collection than during remedial data collection, and in the summative study crowding levels were higher in Control than in Base. This indicates that crowding levels may have influenced a decreased length-of-stay between the remedial and summative evaluations.

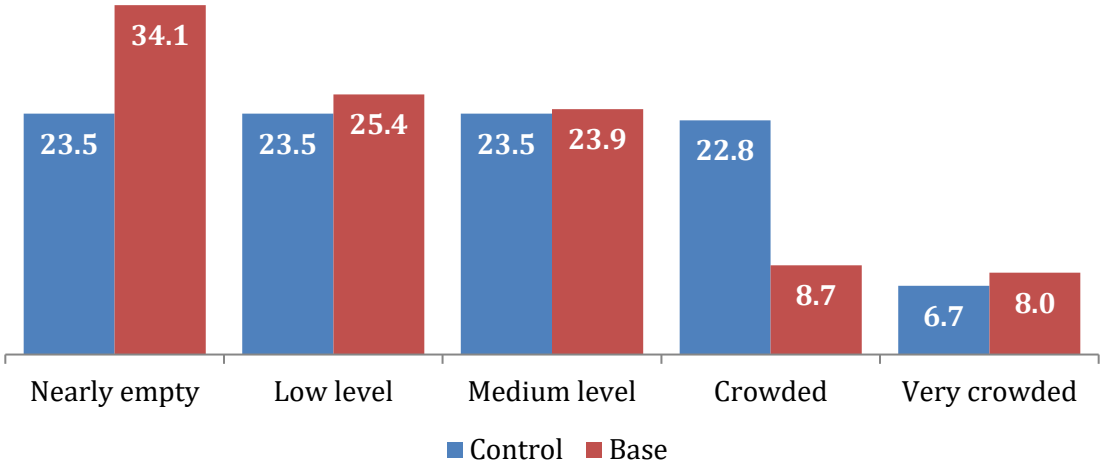
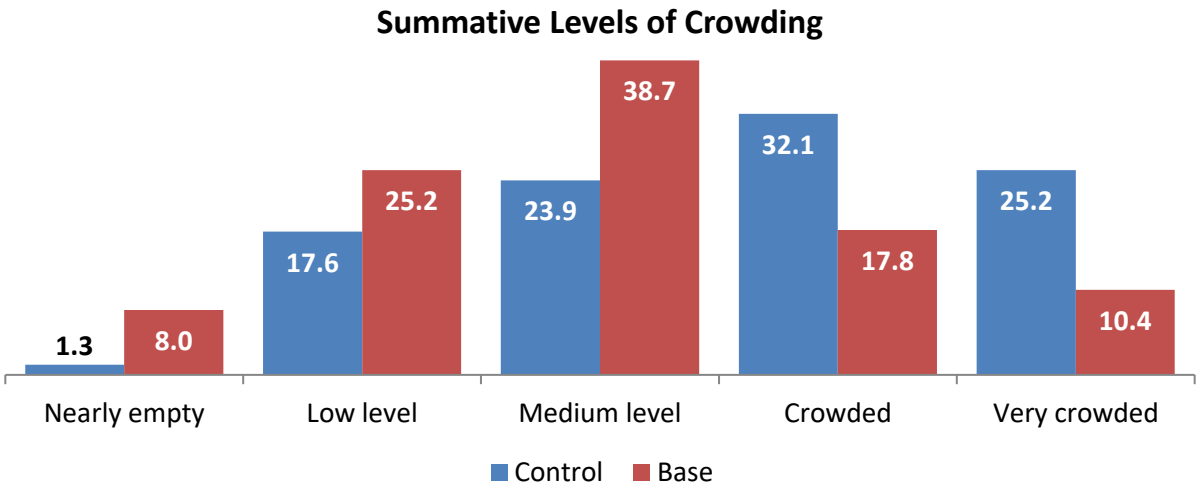


Figure 7. Remedial Tracking -- Levels of Crowding by Gallery in Percent (Control N = *149, Base* N = *138)*



[1] Unlike other graphs, Figures 7 and 8 have headings. These headings are intended to emphasize which of the evaluation studies is represented by the data.

Figure 8. Summative Tracking -- Levels of Crowding by Gallery in Percent (Control N = *159, Base* N = *163)*

Gallery Attraction Level

The number of stops per subject during a gallery visit indicts a gallery's overall level of attraction. The definition used for stop was an instance when a subject placed both feet on the floor for at least one second. Since stops per subject were normally distributed, the means can be calculated as a measure of central tendency and compared using t-tests. In the remedial evaluation, the mean number of stops per subject for Control was 3.6 (*SD =* 2.8) and for Base was 4.0 (*SD =* 2.8). In the summative evaluation, the mean number of stops per subject was 3.3 (*SD* = 2.4) in Control and 3.2 (*SD* =2.3) in Base.

In comparisons between remedial and summative data for each gallery, t-tests showed no significant increase or decrease in the number of stops in either Control or Base. The evaluator expected increased gallery attraction levels in a comparison of remedial and summative evaluation data due to renovations in both galleries between those two points in time. As in the discussion of length-of-stay in the previous section, higher levels of crowding during summative data collection compared to remedial data collection provided a plausible explanation for why there was no increase in attraction levels of the galleries; however, exit survey samples sizes were too small to test this interpretation statistically.

Sweep Rate Index and Percent of Diligent Visitors

Beverly Serrell (1998) proposed two measures that allow for a comparison of gallery use among areas of different sizes. The Sweep Rate Index (SRI) is the average total time visitors spend divided into the exhibition's square footage. The lower the SRI, the more slowly visitors move through a gallery area. Another measure, the percentage of diligent visitors (%DV), is the percentage of visitors who stopped at more than half the exhibits. "The higher the %DV the more thoroughly the exhibition is used" (Serrell, 1998 p. 15). Table 2 shows measures of gallery use for the summative evaluation. Serrell defined a very well-used gallery as one with a %DV of at least 51.0%. In my experience, a well-used gallery will have SRI of 280 square feet a minute for exhibit areas.

Table 2. Measures of Gallery Use

Measures of Gallery Use	***Control***	***Base***
SRI = square footage/average Total Time (square feet per minute)	1,692.3	1,750.0
%DV = percent stopping at more than half of exhibit elements	0.6%	5.5%

The *Control* area has 2,200 square feet, and the *Base* area has 3,325 square feet. Control had an average length-of-stay of 1.3 minutes and Base had an average length-of-stay of 1.9 minutes. One subject stopped at more than half the exhibit elements in Control, and nine subjects stopped in more than half the exhibit elements in Base. Calculations for SRI and %DV are shown below:

- Control SRI = 2,200 square feet/ 1.3 minutes = 1,692.3 square feet per minute
- Base SR1 = 3325 square feet/1.9 minutes = 1,750.0 square feet per minute
- Control %DV = 1 subject stopped at more than half of the exhibits/159 subjects = 0.6%
- Base %DV = 9 subjects stopped at more than half of the exhibits/163 subjects = 5.5%

Individual Exhibit Element Attraction and Holding

Percentage of stops and ranking of stops provide an indicator of the attractiveness of individual exhibits and exhibit elements such as area signage. Median holding time in seconds provides indicators of the holding power

of exhibits. This section includes a discussion of rankings of exhibits in each gallery in terms of attraction and holding.

Control Exhibits

The exhibit list for the Control gallery includes 24 exhibits and exhibit elements. Table 3 provides indicators of the attraction and holding power of exhibits and exhibit elements sorted in rank order of percentage of stops. In the Rank Stops and Median Rank columns, cells shaded green indicated the top quarter of the 24 exhibit elements included on the tracking form. Cells in the same column shaded in pink show the exhibits in the bottom quarter of ranked exhibits.

Table 3. *Control*: Attraction and Holding of Exhibit Elements (*N* = 159)

Control Exhibits	%Stops	Rank Stops	Median in Seconds	Median Rank
A5.1 Rover Testing Station	41.5	1	17.0	13
A2.0 Rover Arm Build	39.6	2	33.0	9
A4.0 Rover Navigation Station	37.1	3	37.0	7
A2.1 Rover Arm Weight	35.2	4	15.0	14
A1.0 Mars Rover Family	22.6	5	6.5	20
A2.2 Rover Drill Testing	22.6	5	8.5	18
A5.0 Rover Design Station	22.6	7	56.5	5
A1.1 Generations of Innovation (label)	18.9	8	14.5	15
A3.0 NASA Eyes on Mars	12.6	9	61.0	4
A8.1 Rover Programming Station 1	11.3	10	116.0	2
A8.3 Program Transmission Station	10.1	11	32.0	10
A9.0 Mars Trail	8.2	12	76.0	3
A2.3 Rover Arm vs Human Arm	7.5	13	8.0	19
A7.3 Seven Minutes of Terror	7.5	13	49.5	6
A5.2 Engineering Design Tips	5.7	15	5.0	21
A8.2 Rover Programming Station 2	5.7	15	256.0	1
A4.1 Rover Navigation Challenges	5.0	17	17.5	12
A8.0 Bridge Earth + Mars	5.0	17	3.5	22
A7.0 Landing with Style/Engineering Challenges	3.8	19	10.5	17
A0.1 Mission: Mars Control Entrance Sign	3.1	20	3.0	23
A7.1 Entry, Descent, and Landing Infographics	2.5	21	30.0	11
A10.0 Meet a Mars Scientist! Video with Label	2.5	22	35.0	8
A0.0 Mission: Mars Control Entrance	1.3	23	2.5	24
A7.2 Aeroshell Artifact with Label	1.3	23	14.0	16

In Control, the six exhibits in the top quarter of attraction power include A5.1 Rover Testing Station, A2.0 Rover Arm Build, A4.0 Rover Navigation Station, A2.1 Rover Arm Weight, A2.2 Rover Drill Testing, and A1.0 Mars Rover Family. As discussed in the Pathways section, most subjects turned right as they entered Control and then stopped at A5.1 Rover Testing Station to check out the rover design and testing area or walked directly into the

gallery and stopped at A1.0 Mars Rover Family. This exhibit appears to be a major gallery attractor as visitors walk down the hallway and see this large display of several generations of Mars rovers. A4.0 Rover Navigation Station appears to capture the attention people passing by the rover design and testing exhibits when they are full of visitors. A2.1 Rover Arm Weight and A2.2 Rover Drill Testing appear to benefit from central placement and visibility as well as the hands-on nature of this group of exhibits. Reorganization of the gallery, providing visibility into Control, and extensive prototyping of two of these exhibits during the gallery update after the remedial evaluation appears to have paid off.

Six exhibits make up the bottom quarter of attraction power. Located along the back wall of the Engineer Lab in an area that few subjects appeared to move through, A7.0 Landing with Style/Engineering Challenges, A7.1 Entry, Descent, and Landing Infographics, and A7.2 Aeroshell Artifact with Label attracted only small percentages of subjects. Similarly, A10.0 Meet a Mars Scientist! Video with Label placed in a corner of the Mission Control area may lack visibility.

The six exhibits ranking in the top quarter of holding power include A8.2 Rover Programming Station 2, A8.1 Rover Programming Station 1, A9.0 Mars Trail, A3.0 NASA Eyes on Mars, A5.0 Rover Design Station, and A7.3 Seven Minutes of Terror. With ranks of numbers one and two, A8.2 Rover Programming Station 2 and A8.1 Rover Programming Station 1 display impressive holding power. Moderate levels of attraction for these two exhibits could be due to these exhibits being in use when some visitors passed by the area.

The six exhibits in Control ranking in the bottom quarter of holding power consist of A2.3 Rover Arm vs. Human Arm, A1.0 Mars Rover Family, A5.2 Engineering Design Tips, A8.0 Bridge Earth + Mars, A0.1 Mission: Mars Control Entrance Sign, and A0.0 Mission: Mars Control Entrance. While these exhibits did not hold subjects for long time periods, exhibit engagement involves looking or reading signs and labels. These types of exhibit elements do not take as long to use as computer interactives, videos, or hands-on interactives.

No exhibits rank in the top quarter of both attraction and holder power, but two exhibits rank in the bottom quarter of both attraction and holding. These are A0.1 Mission: Mars Control Entrance Sign and A0.0 Mission: Mars Control Entrance. These exhibits elements signal entering into a new space on a specific topic. Even if subjects walked by without stopping or stopped for only a few seconds, these exhibits still appear to fill a useful function in the Control gallery.

Base Exhibits Attraction and Holding

The tracking form for Base included 16 exhibits and exhibit elements. Table 4 provides indicators of the attraction and holding power of exhibits and exhibit elements sorted in rank order of percentage of stops. In the Rank Stops and Median Rank columns, cells shaded green indicated the top quarter of the 24 exhibit elements included on the tracking form. Cells in the same column shaded in pink show the exhibits in the bottom quarter of ranked exhibits.

Table 4. *Base:* Attraction and Holding of Exhibit Elements (*N* = 163)

Base Exhibits	%Stops	Stop Rank	Median in Seconds	Median Rank
B12.0 Mars Globe	52.9	1	28.0	5.0
B 0.0 Rover Observation	41.2	2	15.0	11.0
B9.1 Direct Drive Landscape	30.1	3	23.0	8.0
B5.0 Gravity Testing Station	27.5	4	42.0	2.0
B7,0 Mars Base Airlock	26.8	5	24.0	6.0
B2.0 Rock Identification Station	26.1	6	32.5	4.0
B9 Direct Drive Rover Station	22.2	7	39.0	3.0
B3.1 Planetary Observation Station	20.9	8	16.5	10.0
B4.0 Rock Analysis Station	18.3	9	24.0	7.0
B6.0 Earth Mars Comparison	18.3	9	19.0	9.0
B3.0 Gas Identification Station	17.6	11	14.0	12.0
B8.0 Mars Rocket Lander Game	15.7	12	127.0	1.0
B11.0 Martian Meteorite	13.1	13	11.0	13.0
B1.0 Mars Base Welcome	4.6	14	5.0	15.0
B0.1 Remote Programming Screens	1.3	15	8.0	14.0
B10 .0 NASA Eyes on the Solar System[2]	0.0	16	0.0	16.0

In Base, exhibits making up the top quarter of attraction rankings consist of B12.0 Mars Globe, B 0.0 Rover Observation, B9.1 Direct Drive Landscape, and B5.0 Gravity Testing Station. Located outside the enclosed Mars Base, B 0.0 Rover Observation consists of a Mars landscape and provides a place for model Mars rovers to run programs transmitted from the Mission Control area of the Control gallery. B12.0 Mars Globe appears to serve as an attractor for the futuristic Mars base with 52.9% of subjects tracked stopping at this exhibit. With decent median holding time of 28 seconds, changes made to the exhibit appear to have paid off. B9.1 Direct Drive Landscape attracted 30.1% of tracking subjects. B5.0 Gravity Testing Station served as the first stop for many of the subjects entering the Mars base area at B1 Mars Base Welcome. One exhibit, B5.0 Gravity Testing Station, ranked in the top quarter for both attraction and holding.

Exhibits in Base in the bottom quarter of attraction rankings as well as holding times include B11.0 Martian Meteorite, B1.0 Mars Base Welcome, B0.1 Remote Programming Screens, and B10 .0 NASA Eyes on the Solar System. In less crowded conditions, these exhibits may have attracted larger percentages of subjects. Yet, some of these exhibits may function well with their modest holding times.

Exhibits in the top quarter of rankings of holding power include B8.0 Mars Rocket Lander Game, B5.0 Gravity Testing Station, B9 Direct Drive Rover Station, and B2.0 Rock Identification Station. B8.0 Mars Rocket Lander Game had a median holding time of 127 seconds almost three times that of the second rank exhibit. B5.0 Gravity Testing Station and B2.0 Rock Identification Station used hand-on interactives to engage visitors.

[2] B10 .0 NASA Eyes on the Solar System was not installed during the tracking data collection, and this is the reason that no stops for this exhibit were recorded.

Pathways

Pathway analysis provides a way to explain gallery length-of-stay and exhibit attractions beyond specific exhibit design. Changes in both Control and Base after the remedial evaluation included signs (large labels) and space dividers to make each gallery a more unified space. Yet, large percentages of subjects did not move through the gallery in clear, identifiable prime pathways. Crowding levels appeared to encourage very short gallery stay times. In addition, the layout of both Control and Base include immediate options for quick exits. In Control, a doorway into Makerspace leads many visitors to exit quickly into that gallery area. Safety considerations require the Control/Makerspace doorway for emergency egress. In Base, the Mars Base area has three entrances and exits: (1) the north entrance to (to the far left facing the Mars Base area), (2) a central entrance to B1.0 Mars Base Welcome, and (3) a south entrance near B12.0 Mars Globe. During tracking, subjects used all of these entrances with somewhat heavier traffic through the central and south openings.

Some pathway patterns could be identified in both galleries. Unlike tracking patterns in the remedial evaluation, many subjects used the typical right turn into Control. When visitors were engaged at A5.0 Rover Design Station and A51 Rover test station, this area served as a magnet for subjects to turn right and see what was going on. With high or very high crowding levels, subjects stopped to observe at A51 Rover test station and then moved on. Other subjects entered the gallery moving directly toward the large attractive display A1.0 Mars Rover Family and then to the right past A1.1 Generations of Innovation, a label on the side of the display. A1.0 Mars Rover Family, clearly visible through the newly designed entrance, appeared to pull subjects into Control. Notes from the data collectors contained information about the substantial numbers of tracking subjects, with both shorter and longer lengths of stay, who exited Control into Makerspace.

In Control, the attraction level of several exhibits appeared very low due to placement outside of heavily trafficked areas. These exhibits included A7.0 Landing with Style/Engineering Challenges, A7.1 Entry, Descent, and Landing Infographics, and A7.2 Aeroshell Artifact with Label. They are located along the back wall of the Engineering Lab section as along with A9.0 Mars Trail.

In Base, subjects entered and exited the Mars Base area several times during tracking. One pathway pattern identified could be called “The Dive.” Subjects entered Mars Base and moved quickly to an exhibit. After one brief stop subjects would quickly leave the gallery. Influences on this behavior may have been the ages of children in family groups. Parents of younger children may have been scouting the gallery for appropriate activities for their children.

Another pattern in Base can be described as “Looping.” Tracking forms showed subject using an exhibit, exiting the Mars Base area, and then immediately re-entering and heading toward exhibits visible from outside the area. Looping subjects often had longer gallery lengths of stay (five to 10 minutes) and 5 or 6 stops within the Mars Base area.

Finally, some subjects may have used only a few exhibits in both Base and Control because, as discussed in the next section, substantial numbers had previously visited both galleries prior to the day of their visit.

Use of Both Gallery Areas

In the remedial evaluation, about 25.0% of subjects reported that they were unaware of the other M:M gallery. Figure 9 shows the percentage of the summative exit interview sample that had previously visited the other gallery at about 40.0%. These increased levels of familiarity with the galleries help explain the positive gain scores in the next section despite short lengths-of-stay on the day of data collection.

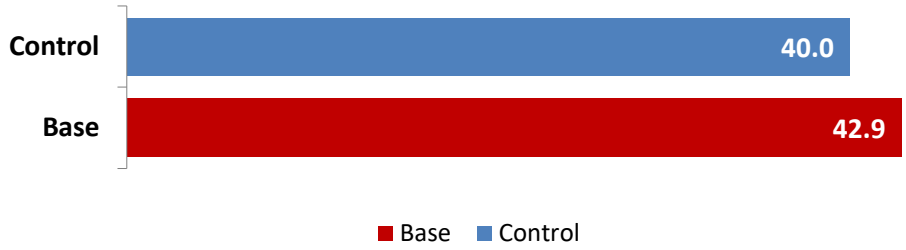


Figure 9. Exit interviews—Percent of Subjects Visiting the "Other" M:M on a Prior Occasion (Control N = *30, Base* N = *28)*

Visitor Outcomes and Impacts

This section contains discussions of Big Ideas and misperceptions, initial visitor reactions to the galleries, and visitor impacts.

Big Ideas and Misperceptions

In her book on exhibit labels, Serrell (1996) discusses the importance of coherent Big Ideas that underlie the exhibition design. Evaluators use Big Ideas to test the extent to which visitors understand the primary messages of an exhibition. Misperceptions are ideas considered false or incorrect by some authoritative source such as scientific experts, teachers, or museum staff.

Both Control and Base exit interviews included the following item using an example from Van Matre (1979):

> *When people design galleries for the Science Center, they want to communicate one or more Big Ideas. For example, the Big Idea of a gallery about photosynthesis could be 'The Sun is the source of energy for all living things.' Which of the following do you think are the Big Ideas for this specific gallery? Choose all that apply.*

The purpose of this item was two-fold: (1) to test whether or not subjects recognized the Big Ideas focusing the content and design of a gallery they had just visited, and (2) to find out to what extent two widely held misperceptions identified in project front-end evaluations (O'Brien, 2015: Tisdal, 2015) persisted after a gallery visit. Figure 10 shows subjects' responses for each gallery in percent. The figure includes parenthetical indications if the option was a primary Big Idea for Control, Base, or both galleries. Two items were misperceptions as indicated. On the items, ** indicates significant difference between the percentages at the $p < .001$ level, and * indicates a significant difference at the $p < .05$ level.

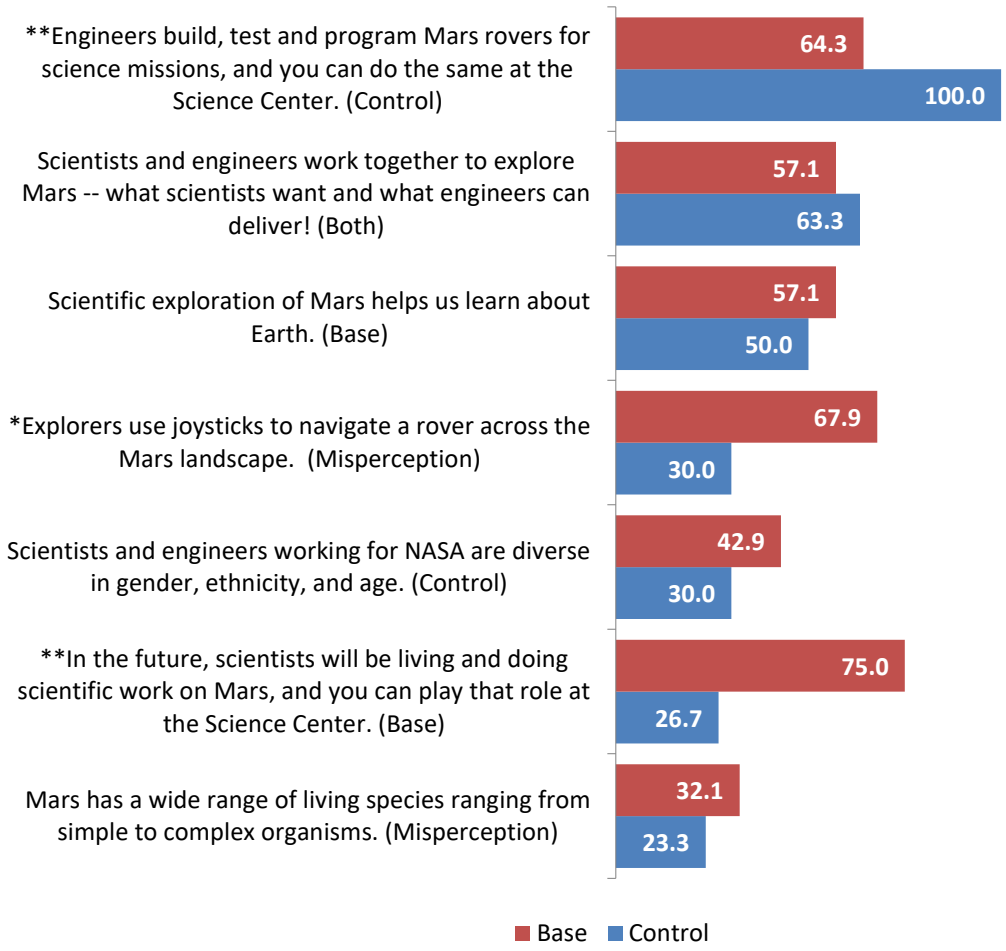


Figure 10. Gallery Big Ideas and Misperceptions in Percent (Control N = *30, Base* N = *28)*

Reactions

The summative exit surveys included items assessing overall satisfaction, how fun each gallery was perceived to be, and how interesting each gallery was to subjects. These items parallel the assessment of immediate reactions recommended by the Bennett's Hierarchy logic model found in Appendix A.

Project Team members hoped that gallery satisfaction would increase after substantial gallery renovation. A rating item, commonly used to measure satisfaction, was included on remedial and summative exit interviews. (This is the same item used to calculate Net Promoter scores as explained in the following section.) The item asked, "How likely are you to recommend visiting this specific area of the Science Center to a friend or colleague 0 = very unlikely to 10 = very likely." Figure 11 shows mean comparisons across Control and Base exit interview in both the remedial and summative evaluations. Table 5 shows item descriptive statistics for each sample. Control satisfaction items were significantly different ($p < .001$) between the two studies, but Base satisfaction items were not statistically significant. Satisfaction with the gallery experience appears to have increased in Control but remained about the same in Base before and after gallery renovations.

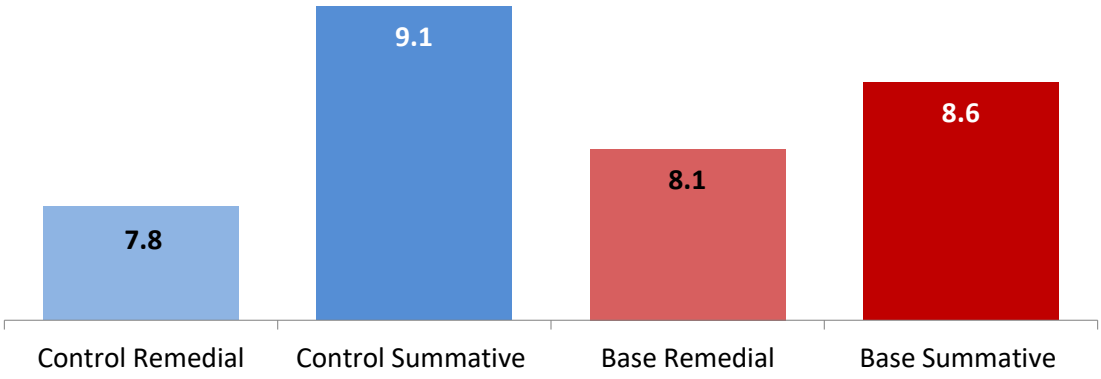


Figure 11. Comparison of Means Satisfaction Item by Galley and Remedial and Summative Evaluations

Table 5. Satisfaction Ratings across Evaluation and Gallery

Gallery and Evaluation	Mean	*N*	*SD*
Control Remedial	7.8	36	1.8
Control Summative	9.1	29	1.3
Base Remedial	8.1	30	1.4
Base Summative	8.6	28	2.1

In two additional reaction items in the summative evaluation, subjects were asked "How interesting was this area compared to other Science Center galleries?" and "How much fun was the area?" Both item ratings ranged from 0 = low to 10 = high. Subjects rated the comparative interest level of Control at 8.5 (N = 28, SD = 1.2) and Base at 8.4 (N = 28, SD = 2.0). In terms of fun, subjects rated Control at 8.5 (N = 28, SD = 1.5) and Base at 8.2 (N = 27, SD = 1.9). Ratings on neither item were significantly different between galleries.[3]

Net Promoter Scores

The SLSC collects data to calculate a Net Promoter Score for the institution as a whole. Using data from the satisfaction item, Net Promoter Scores were calculated for each gallery. In this calculation, Detractors are defined as those responding 0 through 6 on this scale. Passives are subjects selecting ratings 7 and 8. Promoters (of the institution or the gallery area) are defined as those responding 9 or 10. The Net Promoter Score is produced by subtracting the percentage of Detractors from the percentage of Promoters (Satmetrics Systems, Inc., 2016).

Figure 12 shows a comparison of Net Promoter Score across evaluations and galleries. Control scores show the greatest increase from 19.4% in the remedial study to 62.1% in the summative study. Base increased substantially, rising from 30.0% in the remedial evaluation to 53.6% in the summative evaluation.

[3] The "fun" item on the remedial exit survey was not identical to the "fun" item on the summative exit survey. For this reason no direct comparisons were calculated on this characteristic between the two evaluation studies. The remedial exit survey did not have an "interest" item.

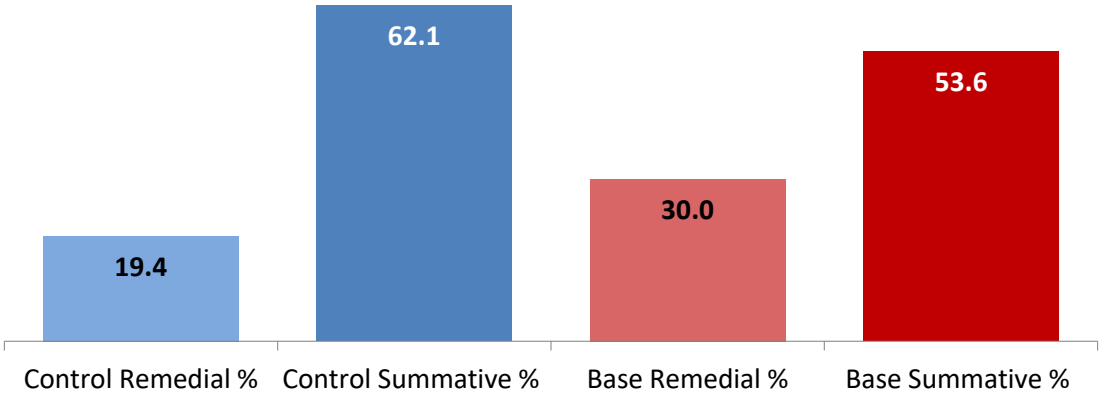


Figure 12. Net Promoter Scores by Evaluation and Gallery

Impacts

Twenty items on summative Control and Base exit surveys assessed impact (short-term outcomes). Items reflected the different impacts that were the focus of each gallery. This study employed gain scores calculated from retrospective pre-test then post-test ratings. Each of the four KASA groups used in Bennett's Hierarchy (Onka, 2018) (Knowledge, Attitudes, Skills, and Aspirations) included five rating items. Figure 13 shows the attitude rating items in the summative Control exit survey. Appendix D includes Control and Base exit surveys.

7. [ATTITUDES] Please rate your perceptions of the following topics BEFORE AND AFTER using exhibits in this area. Ratings range from 0 = a very low level to 10 = a very high level

	BEFORE visiting the gallery	AFTER visiting the gallery
Level of interest in engineering (design, building, and testing) tools and vehicles to explore Mars		
Level of interest in the exploration of Mars		
Level of Interest in NASA missions		
Respect for the work of NASA engineers		
Respect for the work NASA scientists		

Figure 13. Attitude Pre then Post Retrospective ratings for Control, Attitude Items

Calculations of gain scores for each subject on each of the 20 survey items involved subtracting pre-test rating from the post-test rating. Ratings on all 20 items ranged from 0 = a low rating to 10 = a high rating. After calculating individual gain scores for each subject on each item, means (averages for each item) were calculated

using statistical software. Table 6 shows mean Before (Pre-test) ratings, mean After (post-test) ratings, and mean gain scores for each of the 20 Control items from highest to lowest gain.

Table 6. Control Mean Gain Scores for Individual Items (*N* = 30) [4]

Impact	Before	After	Gain
The challenges of exploring Mars (Mars terrain and atmosphere)	5.13	7.37	**2.23**
I want to find out more about NASA Mars rover missions	5.67	7.73	**2.07**
Building a model rover to successfully move across challenging Martian terrain	4.53	6.60	**2.07**
Engineering Design (testing and revising components on Earth)	4.43	6.47	**2.03**
Mars rover missions	4.20	6.20	**2.00**
I want to find about out more Mars	5.83	7.77	**1.93**
Level of interest in engineering tools and vehicles to explore Mars	5.13	7.03	**1.90**
Rover instruments	4.07	5.93	**1.87**
How NASA scientists and engineers work together	5.07	6.90	**1.83**
Building a model rover arm to reach different distances	4.10	5.90	**1.80**
Carrying out a simulation of long-term scientific mission to explore Mars	3.97	5.73	**1.77**
I want to find out more about the scientific exploration of Mars	5.90	7.57	**1.67**
Programming a model rover to explore key locations on Mars	4.30	5.90	**1.60**
Level of interest in the exploration of Mars	6.43	7.90	**1.47**
Respect for the work NASA scientists	6.93	8.27	**1.33**
Completing an engineering design cycle (build, test, rebuild) to accomplish a goal	4.87	6.20	**1.33**
Respect for the work of NASA engineers	7.00	8.30	**1.30**
Level of Interest in NASA missions	6.57	7.60	**1.03**
I can see myself as an engineer	3.50	4.40	**0.90**
I can see myself as a programmer	3.77	4.10	**0.33**

Overall, item scores show modest levels of increase. Gains ranged from a high of 2.23 to a low of 0.33. The higher gain increased attitude scores, that is, increased interest and enjoyment of engaging in exploration engineering design. The two lowest mean gain scores are aspiration items focused on career paths, decisions most of the adults in this sample had already made.

[4] One decimal point is used for most statistics in this report; however, ratings and gain scores are presented with two decimal points. Rounding error at one decimal point obscured some of the ranking relationships among the mean ratings.

Table 7 includes mean gain scores on individual items for Base. Items near the top reflect perceived gains in knowledge. The higher gain scores in this set of data are associated with rather low Before rating scores. Two exceptions are interest related to the two lowest gain score teams. These are for the aspirational items "I can see myself as an astronaut exploring Mars" and "I can see myself as a scientist." Like similar items on the Control exit interview, the many adults in this sample may have seen these items focusing on career decisions that they had already made.

Table 7. Base Mean Gain Scores for Individual Items (*N* = 28)

Impact	Before	After	Gain
Gravity on Mars	2.79	5.64	**2.82**
Geology and types of rocks and minerals of Mars	2.46	5.25	**2.71**
The tools used by scientists to explore Mars	3.21	5.82	**2.57**
How scientists use rovers to study Mars	2.79	5.36	**2.57**
The atmosphere on Mars	3.14	5.21	**2.07**
Using color filters identify different features on Mars	1.68	3.61	**1.93**
Operating a model Mars rover	1.54	3.43	**1.89**
Reading a graph to identify rocks on Mars	2.43	4.43	**1.82**
Level of interest in Mars	4.82	6.61	**1.79**
Using a magnifier to identify rocks using color and texture	2.43	4.07	**1.64**
Level of interest in the scientific exploration of Mars	4.57	6.11	**1.54**
Reading a graph to identify gasses on Mars	1.93	3.43	**1.50**
I want to find about out more Mars	4.86	6.25	**1.29**
Interest in NASA Missions	5.82	7.07	**1.25**
I want to find out more about NASA Mars rover missions	4.93	6.04	**1.11**
Respect for the work of NASA scientists	6.71	7.79	**1.07**
I want to find out more about the scientific exploration of Mars	4.75	5.75	**0.93**
Respect for the ability of scientists to discover new things	7.21	8.07	**0.86**
I can see myself as an astronaut exploring Mars	2.11	2.64	**0.54**
I can see myself as a scientist	3.57	4.11	**0.50**

A total gain score was calculated by adding the gains scores for all 20 items for each subject. These created variables (total gain score) were added to the data set for each gallery in order to calculate means (averages). Means for each gallery were then compared in statistical software where appropriate. Note that means cannot be added to get the total gain score for the survey. Each individual item mean has difference variance, and means are sensitive to extreme (very high or very low) scores.

Figure 14 shows a comparison of total gain score means for each gallery. Mean gain scores were calculated by summing gain scores for each subject across all 20 items. A mean was calculated for each set of scores, that is, an average for Control and an average for Base. The mean gain score for Control was 39.0 (SD =14.7) and for Base 38.2 (*SD* = 16.9). An independent sample t-test comparing these means found no significant difference.

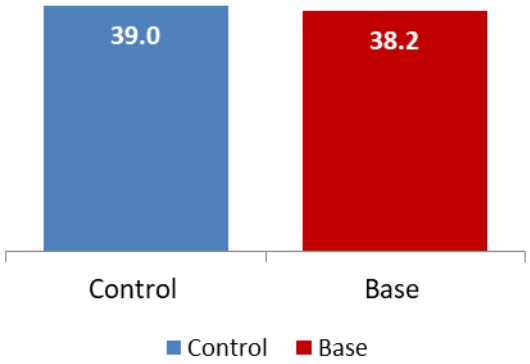


Figure 14. Total Gain Scores by Gallery (Control N = *30, Base* N = *28)*

While means for total scores do not show huge gains, they appear reasonable reflections of an informal learning experience.

Knowledge Checks

Two parallel items on the gallery exit interviews provide a check for the self-assessment of learning in the KASA ratings items.

The Control interview asked, "Which of the following NASA missions to you remember hearing about in this gallery?" Four options consisted of rover missions' subjects that could have been seen or heard about in Control. Two other options (Friendship and New Horizons) were not part of the gallery content. Figure 15 presents a summary of responses in percent. In general, accurate options were recognized by higher percentages of subjects than inaccurate items. Figure 16 shows responses in percent. Inaccurate options are preceded by two asterisks in the graph.

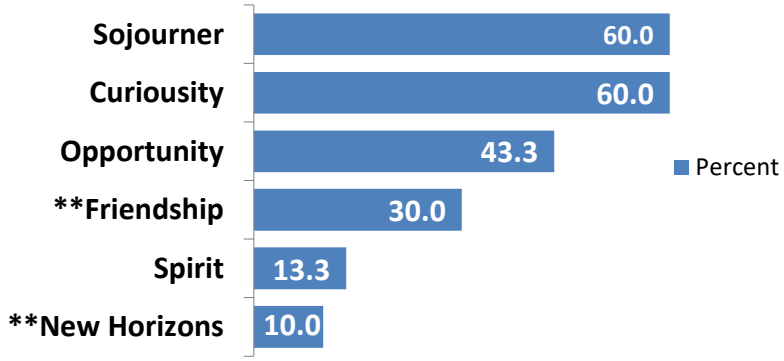


*Figure.15 Control Knowledge Checks (*N = *30)*

Figure 16 includes responses in percent to a similar item asked in the Base exit interview. In this figure, inaccurate items are preceded by an asterisk. The Base exit interview asked subjects: "Scientists use many tools to study Mars, only some of which are featured in the gallery. Which of the following tools (including vehicles) that scientist use to study Mars do you remember seeing in the gallery?" The four accurate items had the four highest percentages. Inaccurate options (Polygraph, Landspeeder, and Dyameter) the lowest percentages. Again, while these responses do not show change over time, they provide support for the subjects' assessment of their own learns in the KASA impact items.

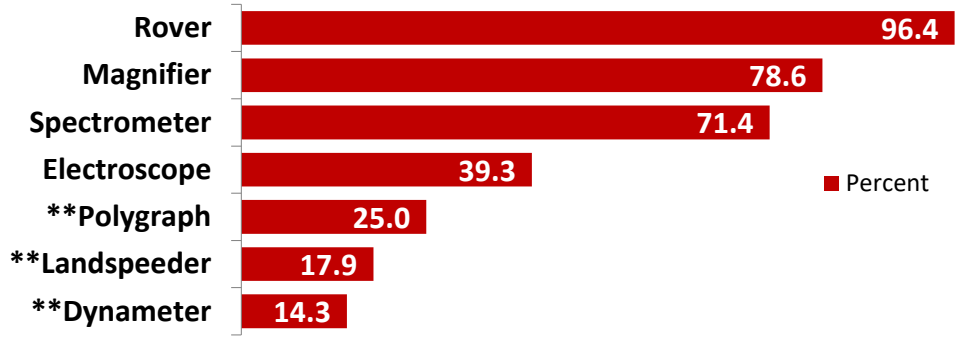


*Figure 16. Base: Knowledge Checks (*N = *28)*

Best Aspects and Areas for Improvement

During Control and Base summative evaluation exit interviews, data collectors asked subjects two open-end questions and wrote down key words from their responses. During exit interviews subjects were asked, "What was the best thing about this gallery?" and "What aspects of the gallery need improvement?" Analysis involved grouping similar responses to develop codes and identifying up to three codes in each response. Codes included gallery characteristic mentions of specific exhibits. Tables include only the categories identified for over 5.0% of the sample.

In developing the codes, subjects tended to make different types of connections to comments about computer interactive experiences and physical interactive experiences. While sometimes it was unclear exactly what type of experience they meant, the term "interactive" tended to be used to describe a characteristic of the entire gallery. "Hands-on" tended to be used to describe physical interactive experiences subjects identified to use with children.

Table 8 includes the best aspects categories for Control. The best-liked aspect of Control was its interactivity (25%). The best-liked aspects commented on by somewhat lower percentages of subjects were A5.0 Building and Testing a Mars Rover, Hands-on, A1.0 Mars Rover Family, and Good/fun for children.

Table 8. Control -- Best Aspects

Control – Best Aspects Comment Topics	% Control
Interactive	25.0
A5 building and testing a Mars rover	15.9
Hands-on	13.6
A1 Mars Rover Family	9.1
Good/fun for children	9.1

Table 9 includes the categories of comments focusing on the best aspects of Base. The two categories with the highest percentages were Hands-on at 18.2% and Interactive at 15.2%.

Table 9. Base -- Best Aspects

Base -- Best Aspects Comment Topics	Base %
Hands-on	18.2
Interactive	15.2
Good/fun for children	12.1
B9 Direct Drive Mars Rover	9.1
Interesting	9.1

Areas for Improvement

Table 10 shows categories for comments focusing on areas of improvement for the Control Gallery. The category with the highest percentage of improvement comments were A8 Rover Programming and Transmission at 28.6% and More for younger children at 21.4%

Table 10. Control – Aspects for Improvement

Control -- Improvements Topics	Control%
A8 Rover Programming and Transmission	28.6
More for younger children	21.4
Not informative	14.3
Mission Control area	7.1
Rover Arm	7.1
More interactive	7.1
More room	7.1
Want to touch a rover	7.1

Table 11 presents categories of comments about improvements for Base. The two highest areas cited as needing improvement were More for younger children at 23.5% and the Elevator 17.6%.

Table 11. Base – Aspects for Improvement

Base – Improvements Topics	Base %
More for younger children	23.5
Elevator	17.6
B.0 Rover Observation	11.8
Too loud	11.8
Too many gadgets	5.9
Not informative	5.9
More on gravity	5.9
More interactive	5.9
Too crowded	5.9

Focused Observations

The set of focused observations included one newly developed exhibit area in Control. Exhibits included A5.0 Rover Design Station, A5.1 Rover Testing Station, and A5.2 Engineering Design Tips. As the project team explained, both Control and Base were designed for older children and adults. Observations indicate that groups with younger children entered Control and some adults adapted these exhibits for younger children in their groups. Figure 17 shows the location of the Test and Design Area near the Entrance to Control. Figures 18 and 19 show A5.0 Rover Design Station and A5.1 Rover Testing Station.

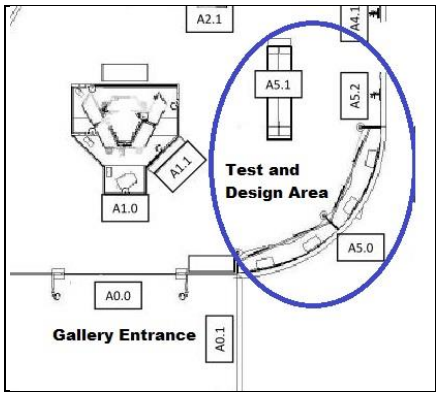


Figure 17. Location of the Test and Design Area in the Control Gallery

Figure 18. A5.1 Rover Testing Station

Figure 19. A5.1 Rover Testing Station

Table 12 shows demographics of cases, number of design/test iterations, and levels of crowding during observations. These cases were purposively sampled based on ages of children and levels of crowding, so they do not reflect a representative sample of the use of these exhibits. (Refer to Table 3 for indicators of use based on a representative sample.) The Gender and Age column shows individual group members; group member preceded by a "^" indicate the individual who was the primary focus of the observation and whose total engagement is shown under the Holding Time column. Holding Time is shown in minutes. Group types followed by "R" were audio recorded. Other interviews were recorded in data collector notes. " N of Iterations" means that a subject built a rover and walked over to the A5.1 Testing and Station and released the rover down the ramp. An interaction was not counted unless the individual both built and tested, but data collector notes and debriefs do not include any instances of building a rover and not testing it. Some subjects did use only the testing station. Building a rover sometimes involved modifying a rover left by a previous visitor or dismantling a rover and starting from scratch. In Table 13, "0" generally indicates that the subject did not build a rover at all. These were often adults with children during crowded periods.

Table 12. Focused Observations – Demographics, Iterations, and Levels of Crowding

Case#	Date	Group Type	Observed Ethnicity	# in Group	Holding Time (Minutes)	Gender and Age	*N* of Iterations	Crowding Level
0	7/12/2018	Adults with children	White	~35	varied	mixed	mixed	Medium
1	8/29/2018	Adults with children -- R	White	5	21	Female--60s Female – 30s ^Male -- 9 Female – 7 Male --5	0 3 4 3 3	Crowded
2	9/2/2018	Adults with children -- N	White	2	2	Male -- 50s ^Male -- 8	0 0	Very crowded
3	9/2/2018	Adults with children -- R	Asian	4	26	Male – 30s Female – 30's ^Male – 12 Male -- 7	1 0 3 1	Very crowded
4	9/2/2018	Adults with children -- N	White	6	2	Male – 30s Female -- 30s ^Female – 10 Male -- 7	0 0 1 0	Very crowded
5	9/5/2018	Adults with children -- R	White	6	34	Female – 30s Female – 30s Male – 30s ^Male – 9 Female – 11 Female -- 10	0 0 0 5 2 2	Very crowded
6	9/5/2018	Adults with children -- R	African American	4	4	Female – 30s ^Female – 30s Female – 2 Female -- < 1	0 0 0 0	Low level of crowding
7	9/5/2018	Adults with children -- R	White	5	3	Male – 50s Female – 50s ^Female – 20s Male – 5 Female -- 2	0 0 0 0 0	Almost empty
8	9/5/2018	Adults with children -- R	White	2	4	^Female -- 20's Male -- 5	0 0	Almost empty
9	9/5/2018	Adults only -- R	White	2	1	Male – 60s ^Female – 60s	0 0	Almost empty

Patterns in Observations

Use of Labels

Cases 0, 1, 2, 3 and 5 included a subject explicitly observed looking up at the long label on the wall behind A5.0 Rover Design Station. The use of the term "hazardous landscapes" in five interviews indicated the label had been read. In addition, adults and children, as well as subjects from different visiting groups, used the names of parts in conversation with each other, particularly when parts were scarce. Some parts were not named (e.g. wingnuts), and this provided variation in the naming of these parts in conversation. In addition, adults and children over seven seemed to have no difficulty understanding how to design their rovers. Figures 20 and 21 show this label.

Figure 20. Label on Wall behind A5.0 Rover Design Station

Figure 21. Close-up of Upper Left of Label on Wall behind A5.0 Rover Design Station

Observations indicated less obvious use of labels on A5.1 Rover Testing Station, but during medium to very high periods of crowding, subjects had no difficulty finding where to go to test their design. Observations did not include instances of any subjects looking at A5.2 Engineering Design Tips. It is likely that the strong attraction to the two interactive elements of this area made this wall label almost invisible.

Design/Test Iterations

Design/test iterations, an important part of an engineering design cycle, ranged from 0 to 6 in the focused observations. This means the number of times the individual designed (or redesigned) and tested their rover. Table 12 shows the number of iterations by subject in the *N* of Interactions column. (An interation included a subject designing or adapting and then testing the rover. During this observation, no subject was observed designing or adapting a rover and then leaving the area. This may have been due to crowding which made space and time at the experience very valuable to subjects.)

Levels of Crowding

Levels of crowding affected use of the area in some unexpected ways. During higher levels of gallery crowding, all the stools were occupied by children under about 12 years old. During very crowded times, parents stood behind their younger children, helping them. As one mother pointed out, adults wanted to sit, too.

> *. . . if they're adults, they want to sit there and there would be no space for kids to play if they want to. But you cannot sit -- adults cannot sit down, right?* (Case 3, female, age 30s)

Crowding also appeared to affect groups splitting up. In the initial observation (Case 0), there were 7 to 8 instances where some members of visiting groups left the area before other members of their group. This did not cause problems because larger groups had more than one parent or grandparent accompanying children. For example in Case 5, two adult females (sisters) left the area with two female children in the group (ages 10 and 11) who completed two design/test iterations in about seven minutes. Right before leaving, one female approached her nine-year-old son, put her hands on both shoulders, and told him,

> *I want you to build quick and share your space.* (Case 3, female, 30s)

After the mom and aunt left, a male in his 30s, the father of the nine-year-old boy, came to the area from Makerspace and waited patiently for his son to complete his engagement. The boy used the design and tests exhibits for 34 minutes and completed five design/test iterations. When interviewed, this father commented.

> *Honestly, I think it's a great exhibit. All the kids love the interactive things. My son is a perfectionist so if it's not exactly what's in his brain oh, he's going to keep trying. That's not a bad thing, but that's probably what made our stay in this exhibit longer than most. He just really wanted to see his vision through.* (Case 5, male, 30s)

Yet, when the gallery was not crowded, several subjects, as confirmed in interviews, did not notice the connection between A5.1 Rover Testing Station and A5.0 Rover Design Station (Cases 7, 8, and 9). Subjects stopped at the testing station immediately as they entered the gallery and turned right, but many did not notice the design station unless they saw other visitors sitting on the stools and building rovers. Some of these cases included groups with younger children where only. One adult couple walked into an empty gallery, stopped, and looked briefly at the testing station and walked on without engaging. When asked, the woman explained, pointing to rover designs left on the testing station by previous visitors saying,

> *It was broken. . . . One of the wheels was laying on its side.* (Case 9, female, 60s)

Parts Availability

During crowded times, some people could not find parts to complete their designs. Rover bodies and washers/ wingnuts (also referred to as butterfly nuts by subjects) were scarce. One boy pointed out,

> *I just could not find washers, because those were apparently really scarce and everybody was using the washers. The wingnuts, actually, because for some reason, everybody just wanted to use the wingnuts.* (Case 3, male, age 12)

A mother commented,

> *I think the supplies are too limited . . . Just give more supplies so kids won't have problems looking for them. And if they finish, they will leave soon.* (Case 3, Female, 30's)

Adult Roles with Children

Some adults with children, whether standing behind children as they designed or sitting with younger children on their laps, appear to give advice and locate parts for children. One mother summed this up commenting,

> *I just give some advice, like if the wheel is too low it won't work. It's just some kind of advice. He can do it by himself. . . . If he couldn't find it I just looked around to see if I could get some for him.* (Case 3, Female, 30's)

Younger Children

Parents and grandparents with younger children appeared to adapt the type of engagement to the ages of children. Children of about seven and above designed and tested rovers on their own. If space was available, parents and grandparents would sit on a stool next to and sometimes with children on their laps, and build a rover with their five and six-year-old children. This happened in Case 1 and Case 2. In other cases, adults with very young children (under five) helped them send rovers others had designed down the test ramp.

As one mother of a two-year-old who helped her son at A5.1 Rover Testing Station explained,

> *For him, I don't know if he [understands it's a rover,] but he likes it because it has wheels on it, and it's like a car. He's into cars. . . . He was trying to push it up backward so [I helped] him understand it's got to go down in order to move.* [Pointing at A5.0 Rover Design Station*] he probably wouldn't understand this part until he's a little older but this part, I think is great because this is already set up* [pointing to a car designed by another visitor and left at the testing station] *. . . He likes the interaction with pushing it up and down the slope. (Case 6, female, 30s)*

A grandfather, accompanying a two and a five-year-old, commented on the A5.1 Rover Testing Station:

> *. . . probably not for their age. It was too hard for them to push it. I don't think they were successful at pushing it by themselves. We had to help them. (Case 7, male, 60s)*

Yet, the mother of a child of the same age saw ways to use the exhibit with her child. She commented,

> *It's a cool way for them to build things and to test them out, try to see what's wrong, and what they can change and everything.* (Case 8, female, 20s)

Another mother, who helped her five-year-old son complete three iterations of design and testing, appeared to have done a great deal of thinking about their design.

> *I tried modifying and making the wheel stand higher up . . . the rubber wheels against the rubber wheels were bouncing, and they were having friction so they wouldn't continue.* (Case 1, female, 30s)

Understanding of Design Challenge and Connections to Previous Knowledge and Experience

Most children over about nine years of age could use the exhibit independently and most made connections to Mars rovers.

> *It was a rover and I tried to make it as realistic as possible and to adapt to the terrain. . . . I just kind of saw how it was they built that one* [pointed to A1.0 Mars Rover Family] *and saw the cargo has to be quite a few inches above-the-ground to adapt to the terrain.* (Case 3, male, age 12)

> *I was thinking about how to get it over the uneven landscape. . . . [It is] a Mars Rover. . . . I know that they go to Mars and they collect samples of rocks, and they learn more about rocks on Mars and they can just explore Mars.* (Case 1, male, age 9)

Children from about five to eight could build and test independently, but most children in this age group identified what they were building as a car.

I tried doing different things to see if they would go together and if they would work. . . . To see if it would go on the uneven ones and over the sharp rocks. . . . Mine looks more like a racecar. . . . A lot of times I build a lot of things. We have a couple thousand Legos so I build lots of cars out of Legos a lot for [younger brother]. (Case 1, female, age 7)

Ratings

On a scale of 0 = poor to 10 = excellent, ratings from children fell between 7 and 9, generally with lower ratings association with not being able to find parts. Adults tended to rate the area somewhat higher, ranging from 8.5 to 10. Adults noted that their children were immediately attracted to the exhibits and liked the hands-on design challenge.

Summary

For children seven and older, the actual physical design and testing appeared to be doable. Many of the subjects who completed a design used the label on the wall behind A5.0 Rover Design Station. Not surprisingly, since Control was designed for older children and adults, children under seven needed help from adults to use the design station, and very young children only used A5.1 Rover Testing Station. Adults helped adapt the experience to the ages of children in their groups. Levels of gallery crowding appeared to affect how the exhibits in this area were used. During higher levels, adults stood behind children as they sat on stools to design their rovers. During less crowded times, adults sometimes sat with children on their laps and designed rovers with five and six-year-olds. When the gallery had low levels of crowding, most subjects did not make a direct connection between A5.0 Rover Design Station, A5.1 Rover Testing Station and stopped at only the testing station.

There was some scarcity of parts during crowded times with a shortage of rover bodies and wingnuts/washers. Adults supported the engagement of both older and younger children by giving advice and by looking for parts. While children seven years old and older understood the design challenge, only those over about nine years made connections to Mars rovers and NASA. Younger children sometimes perceived their designs as cars. A few older children saw the rovers in A1.0 Mars Rover Family and used them as models for their design. Ratings of the exhibit were fairly high with a few slightly lower ratings associated with scarcity of parts.

Conclusions and Recommendations

This section includes (1) conclusions; (2) recommendations and lessons learned; and (3) final thoughts. Conclusions consist of three broad areas: visitor experience, visitor outcomes, and focused observations. Recommendations and lessons learned consider some changes to gallery areas that can be considered in future gallery updates. Final thoughts provide an overall summary of the benefits of the project innovations to SLSC visitors and replicability at other institutions.

Conclusions

Visitor Experience

Gallery Use

Indicators of gallery use appeared lower than expected due to crowded gallery conditions during data collection. Median lengths-of-stay were lower compared to the remedial evaluation study. Overall, gallery attraction level was not significantly different compared to the remedial evaluation study. Serrell's (1998) indicators of gallery use, Sweep Rate Index (SRI) and Percent of Diligent Visitors (%DVI), were low. It appears that many subjects entered both Control and Base and left quickly due to most of the exhibits being in use. Crowding during data collection may have lowered this measure as traffic increased to the galleries but visitors found other visitors already engaging at exhibits and left quickly.

Individual Exhibit Element Attraction and Holding

Control Exhibits Attraction and Holding

In Control, newly designed interactive and renovated exhibits ranked in the top quarter of exhibits in the level of attraction, that is, the percentage of subjects tracked through the gallery who stopped at these exhibits. These highly attractive exhibits consisted of A5.1 Rover Testing Station, A5.0 Rover Design Station, A2.0 Rover Arm Build, A4.0 Rover Navigation Station, and A2.1 Rover Arm Weight. Also in this upper quarter of attraction was A1.0 Mars Rover Family that had been moved inside the gallery and appears to provide Control with a major gallery attractor to bring visitors into the exhibit gallery. In terms of holding power, A8.2 Rover Programming Station 2, A8.1 Rover Programming Station 1 ranked number 1 and 2. These two stations provide important experiences connecting the two galleries and linking elements of Mars exploration on Earth and Mars.

Base Exhibits Attraction and Holding

Four exhibits made up the top quarter of attraction rankings in Base: B12.0 Mars Globe, B 0.0 Rover Observation, B9.1 Direct Drive Landscape, and B5.0 Gravity Testing Station. Each of these exhibits moved subjects into and through the gallery spaces. Four exhibits comprised the top quarter of rankings of holding power: B8.0 Mars Rocket Lander Game, B5.0 Gravity Testing Station, B9 Direct Drive Rover Station, and B2.0 Rock Identification Station.

Pathways

Changes in both Control and Base after the remedial evaluation included signs (large labels) and space dividers that appeared to make both Control and Base more unified spaces. Neither gallery had prime pathways, that is, ways large numbers of subjects moved through gallery spaces. Some pathway patterns could be identified in both galleries. Unlike tracking patterns in the remedial evaluation, many subjects used the typical right turn into Control. When subjects noticed A5.0 Rover Design Station and A51 Rover test station, the design and testing area served as a magnet for subjects. Other subjects entered moving directly toward the large attractive display A1.0 Mars Rover Family clearly visible through the newly designed entrance. The entrance design appeared to pull subjects into the gallery. In Base, subjects entered and exited the Mars Base area several time. A productive pathway pattern in Base can be described as looping. Subjects appeared to exit the Mars Base area several

times and then immediately re-enter heading toward exhibits visible from outside the area. Looping subjects often had longer gallery lengths of stay (five to 10 minutes) and 5 or 6 stops within the Mars Base area.

Use of Both Gallery Areas
In the remedial evaluation exit interview, findings indicated that only about 25.0% of subjects reported an awareness of the other M:M gallery, but in the summative evaluation, about 40.0 of subjects reported prior visits to the other gallery. This indicates that use of both galleries appears to have grown over time, deepening the connection of the two galleries, a major aim of the M:M project.

Visitor Outcomes and Impacts

Big Ideas and Misperceptions
The galleries appeared successful in communicating the Big Ideas that focused the gallery design and content. In the Control exit survey, a majority of subjects identified at least two of the three the Big Ideas specified by the project team in the logic models for the gallery, and a majority of subjects identified all three Big Ideas in Base. Control focuses on engineering design in Mars exploration, and Base focuses on the scientific missions of Mars exploration. Yet, a majority of both Control and Base exit survey subjects perceived some Big Ideas as common to both galleries. This may indicate that subjects perceived the shared aims and deep connection between the two galleries and their content.

Reactions
Given the comparatively lower gallery attraction and holding indicators, findings related to satisfaction levels and Net Promoter Score increase were surprisingly high and positive. The Control gallery satisfaction measures increased from means of 7.4 to 9.1 between the remedial and summative evaluations, and Base measures increased from 8.1 to 8.6. The differences in Control were statistically significant, and those in Base were not. Net Promoter Scores for both galleries increased when remedial and summative score were compared. Control scores show the greatest increase, from 19.4% in the remedial study to 62.1% in the summative study. Base increase substantially, rising from 30.0% in the remedial evaluation to 53.6% in the summative evaluation.

Impacts
Gain scores calculated from retrospective pretest then posttest ratings showed gains in both galleries. In both Control and Base, the two gains were higher for knowledge and attitude visitor impacts and lower for aspiration impacts. This may have been due to important visitor aspiration impacts focusing on career areas, decisions that adult subjects had already made in their lives. Gains in all areas provided positive indicators of how visitors think and perceive the engineering and science underlying NASA's exploration of Mars.

About one-third of some important misperceptions appeared to remain, even after gallery visits. The misperception "Explorers use joysticks to navigate a rover across the Mars landscape" may be due to the type of screen controls on the programming screen in both Control and Base. This misperception was higher in Base where joysticks are used as the visitor interface. The other misperception, "Mars has a wide range of living species ranging from simple to complex organisms," could be addressed with some very explicit messages and could be considered at B2.0 Rock Identification Station and B4.0 Rock Analysis Station in Base. These are attractive exhibits with good holding times and the connection between the search for water that could sustain life and geology could be stressed.

Best Aspects and Areas for Improvement
During Control and Base summative evaluation exit interviews, data collectors asked subjects about aspects of the galleries they liked best and areas for improvement. Subjects mentioned interactive exhibits, opportunities for hands-on engagement, and appropriateness of the galleries for children as some of the best aspects of both

the Control and Base galleries. In Control, the new exhibits in the rover design and test area were mentioned as favorites. For Base, subjects cited B9.0 Direct Drive Mars Rover as a favorite experience.

In both Control and Base, subjects indicated they wanted more engagement opportunities for younger children. Content in both of these galleries is intentionally targeted to older children and adults, adding appropriate experiences for these two groups to the SLSC experience as a whole. In Control, specific exhibits cited as needing improvement included the Rover Navigation Stations and the Rover Arm. A few subjects also said they wanted more room in the gallery, more interactive expertise, and wanted to touch a rover model.

Focused Observations

Focused Observations indicated that the newly developed test and design area worked well and were highly effective for both adults and older children. Exhibits in the test and design area consisted of A5.0 Rover Design Station, A5.1 Rover Testing Station, and A5.2 Engineering Design Tips. Subjects appeared to use and absorb information from the long label on the wall behind A5.0 Rover Design Station but other labels appear used less often. Many older children and adults completed multiple design/test iterations, an important part of the engineering design cycle. The areas functioned the most effectively during low to high levels of crowding, and the area functioned least well when the gallery was nearly empty and very crowded. During the nearly empty conditions, subjects did not immediately perceive the connections between A5.0 Rover Design Station and A5.1 Rover Testing Station, probably due to the lack of opportunity to see other visitors designing and then testing their designs. During very crowded conditions, adults could not sit and help children with engagement and some parts (rover bodies and wingnuts/washers) were scarce. The area worked better for adults and older children who made connections to other gallery content and could easily understand the design testing process. For slightly younger children (five to seven years old), the design and testing activities were clear, but many in this age group thought they were engaging in car design, and they did not connect the activity to other gallery content. Very young children, those under five years old, engaged primarily with A5.1 Rover Testing Station and only with substantial assistance from adults. However, the test and design area was not intended for younger children and the attractiveness at A5.1 Rover Testing Station provided satisfying engagement for younger members of visiting groups while older brothers and sisters complete the entire test and design sequence.

Recommendations and Lessons Learned

This summative evaluation did not focus primarily on identifying changes to the two galleries. However, some lessons learned and a few recommendations for changes can be identified.

- Both gallery areas function better at moderate to high levels of crowding. Some consideration needs to be given to the overall quality of visitor experience during times when the levels are very high. While there are immediate benefits for the institution in terms of earned income, long term impacts in terms of return visitation and institutional reputation may be less positive. There are no easy solutions to this issue but SLSC may want to consider the issue in strategic planning and messaging about visit planning on the website.
- Additional parts are needed at A5.0 Rover Design Station including two to three rover bodies and wing nuts/washers. Additional storage bins do not appear necessary; subjects often started engagement with artifacts of previous visitor engagement, much as engineers start with the redesign of previous projects.
- Exhibit redesign prototyping, particularly in the Control gallery appeared to have paid off in terms of both visitor satisfaction and visitor impact.
- Some consideration could be given to providing additional gallery seating near the back of Control's Engineering Design Lab to encourage visitors to move through this area of the gallery and see A7.0 Landing with Style/Engineering Challenges, A7.1 Entry, Descent, and Landing Infographics, A7.2 Aeroshell Artifact with Label, and A7.3 Seven Minutes of Terror.

- One key visitor experience linking the two galleries, the programming and transmission in Control (A8.1 Rover Programming Station 1, A8.2 Rover Programming Station 2, and A8.3 Program Transmission) and watching the program execute in Base (B 0.0 Rover Observation and B0.1 Remote Programming Screens) improved substantially between the remedial and summative evaluation studies. Attraction and holding power of exhibits improved.
- Careful repositioning and placement of exhibit elements along with area space dividers appear to have increased the coherence, exhibit visibility, and pathways through both Control and Base. The shape of both gallery areas is challenging as the galleries need to balance directed visitor pathways with safety egress, which can disrupt visitor pathway flow. Yet, careful consideration to these factors, along with the gallery esthetics appears to have increased exhibit visibility and access. Crowding issues hides some these improvements to the galleries.

Final Thoughts

The two-gallery design of the Mission: Mars project included innovative ideas such as programming and transmitting Mars rover programs as well as making deep connections to the engineering and scientific collaboration essential for the success NASA's Mars missions. Visitor satisfaction and impact both indicate that challenging project goals have been accomplished. Visitors to the SLSC should benefit from these accomplishments for years to come, and other science center and museums can consider replicating some of the innovative designs including the programming and transmission, and watching model rovers perform scientific work on simulated Mars landscapes. The design and test area in Control also appears worthy of replication in other science center and museums. The ease with which subjects understand this design challenge and iterative design and testing cycle makes this set of exhibits worthy of replication and reuse in other institutions.

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Appendix A. Logic Models

Control Logic Model—page 1

Name of Exhibit or Exhibition Mission: Mars Control **Your Name:** Paul Freiling and Kelly Staab **Organization:** Saint Louis Science Center **Date** Updated June 7, 2018

Process Evaluation			Outcome Evaluation			
Inputs	**Activities (Exhibit or Exhibition)**	**Participation**	**Reactions**	**KASA**	**Practice Change**	**Impact (SEEC)**
Financial Resources: • NASA Grant • SLSC Capital Budget **Project Core Team:** Project Leads: • Project Manager • Product Manager Exhibit Designer: • Red Box Studios (contracted) Content Team: • Education Staff Member • Science Staff Member • Research and Evaluation Staff Member Graphic Designer: • SLSC Graphic Design Department Exhibit Staff: • Production Staff Members • Electronics Staff Members • Video Staff Member • Digital Experience Designer (contracted) **Project Advisory Team:** • Washington University • NASA JPL • NASA JSC	**Overarching Big Idea**: (1) Scientists and engineers work together to explore Mars. (What Scientists want and What Engineers can deliver.) (2) Engineers test and create rovers that need to travel to and land on Mars for purposes of scientific discovery. • **Mission: Mars Control**: Step into the shoes of an engineer to build, test, and program a Mars rover for a science mission. (I am an engineer!) **Themes and topics** • **Mission: Mars Control:** NASA Engineering Lab theme with Mission Control **Description**: Free; permanent exhibit located in two parts of the building. Control is on the second floor of the Main building. **Organization and pathways:** **Mission: Mars Control:** Organized by the story of a NASA Engineering Lab. In the lab, visitors will be able to take on the role of an engineer designing, building, and testing key engineering elements of the	**Primary Audience:** General Public, Families **Primary Audience Goal:** Inform, engage and inspire the public to appreciate NASA's missions by sharing findings and information about NASA's missions to Mars. **Nature of Participation:** • Group Participation • Using interactives (Adults and Children) • Engaging in group discussion about content • Looking at signage and landscape **Secondary Audience:** Children, Grades K-8 **Secondary Audience Goal:** Ignite interest in space science topics and careers for diverse K-8 students. Encourage students in grades K-8 to sustain participation	Visitors will find the exhibition satisfying, fun, and informative. Recognize the Big Ideas of the Areas: Visitors will feel like they took on the role of an engineer.	**Knowledge** (Awareness) Increased knowledge of: • Mars (Terrain, Atmosphere) • Mars Rover Missions (Sojourner, Spirit/Opportunity, Curiosity) • Challenges for exploring Mars (Terrain, Atmosphere – Landing on Mars, Communication, and Weight Science Instruments and Length of Rover Arm) • Rover Components (Arm, Body, Wheels, Motors, Science Instruments, Landing System) • Engineering Design Process (Testing and Refining Components on Earth, Working with Scientists) **Attitudes** • Increased interest in Mars exploration and engineering • Increased positive attitudes towards NASA • Increased positive	• Seek out additional information and resources on Mars, Mars Rover Missions, NASA and scientific exploration. • Share knowledge of Mars and Mars exploration with peers, family, etc. • Advocate for NASA funding • Advocate for continued space exploration.	• Greater knowledge of Mars Rover Missions, and the importance of engineers in exploration of Mars. • Spark or sustain interest in Mars Rover Missions, NASA, space exploration or engineering/programmi ng. • Visitors feel like they are or can be an engineer/programmer. This broader impact still needs to be updated. It needs to address Specifically: **s**ocial, **e**conomic, or **e**nvironmental **c**onditions (SEEC) changes

Control Logic Model—page 2

Name of Exhibit or Exhibition Mission: Mars Control **Your Name:** Paul Freiling and Kelly Staab **Organization:** Saint Louis Science Center **Date** Updated June 7, 2018

Process Evaluation			Outcome Evaluation			
Inputs	**Activities (Exhibit or Exhibition)**	**Participation**	**Reactions**	**KASA**	**Practice Change**	**Impact (SEEC)**
	rover. The story of the lab is divided into six key engineering areas (Rover Family, Rover Mobility, Rover Arm, Rover Navigation, Rover Landing (EDL), Mission Control), There is no defined path, but it is intended to visitors to be attracted into the gallery and to see the rover models first. Categories Both Galleries Collections items Physical interactives Computer interactives Video (2) Diorama (of rovers	in educational experience **Nature of participation:** Immersion and opportunities to role-play		attitude toward Mars exploration • Increased positive attitudes towards engineering and engineers/programmers **Skills** Demonstrate an ability to: • Complete a design iteration (build, test, re-build) • Build a rover to successfully move across challenging Martian terrain. • Build a rover arm to reach different distances. • Program a rover to explore key locations on Mars. • Execute a long-term science mission. **Aspirations**: • See themselves as an engineer/programmer. • Want to seek out additional information and resources on Mars, Mars Rover Missions, NASA and scientific exploration.		

Name of Exhibit or Exhibition Mission: Mars Base **Your Name:** Paul Freiling and Kelley Staab **Organization:** Saint Louis Science Center **Date** Updated June 7, 2018

Process Evaluation			Outcome Evaluation			
Inputs	**Activities (Exhibit or Exhibition)**	**Participation**	**Reactions**	**KASA**	**Practice Change**	**Impact (SEEC)**
Financial Resources: • NASA Grant • SLSC Capital Budget **Project Core Team:** Project Leads: • Project Manager • Product Manager Exhibit Designer: • Red Box Studios (contracted) Content Team: • Education Staff Member • Science Staff Member • Research and Evaluation Staff Member Graphic Designer: • SLSC Graphic Design Department Exhibit Staff: • Production Staff Members • Electronics Staff Members • Video Staff Member • Digital Experience Designer (contracted) **Project Advisory Team:** • Washington University • NASA JPL • NASA JSC	**Overarching Big Idea**: Scientists and engineers work together to explore Mars. (What Scientists want and What Engineers can deliver.) • **Mission: Mars Base**: Step into the shoes of a scientist living and working on Mars in the future. (I am a Scientist!) • **Scientific exploration of Mars helps us learn about the Earth** **Themes and topics** • **Mission: Mars Base:** Futuristic Mars Base theme **Description**: Free; permanent exhibit located in two parts of the building. **Organization and pathways**: **Mission: Mars Base:** Organized by the story of a futuristic Mars Base Simulation. On the base, visitors will be able to take on the role of scientist identifying, analyzing, and exploring key elements of Mars. The story of the base is divided into three key areas with no defined pathway: 1. Entry Experiences: Airlock (Exploring Mars – ground level), Earth-Mars	**Primary Audience:** General Public, Families **Primary Audience Goal:** Inform, engage and inspire the public to appreciate NASA's missions by sharing findings and information about NASA's missions to Mars. **Nature of Participation:** • Group Participation • Using interactives • Engagign in group discussion about content • Looking at signage and landscape **Secondary Audience:** Children, Grades K-8 **Secondary Audience Goal:** Ignite interest in space science topics and careers for diverse K-8 students. Encourage students in grades K-8 to sustain participation in educational	Visitors will find the exhibition satisfying, fun, and informative. Recognize the Big Ideas Visitors will feel like they took on the role of a scientist/explorer. Exploring Mars helps us learn about the Earth	**Knowledge** (Awareness) Increased knowledge of: • Mars (Key Features, Atmosphere, Weather, Size, Location in Solar System, Length of Year, Gravity) • Geology and identifying types of rocks and minerals • Tools used by scientists to explore Mars (Rovers, Spectrometers, Magnifiers) **Attitudes** • Increased interest in Mars scientific exploration • Increased positive attitudes towards NASA • Increased positive attitudes toward and Mars exploration • Increased positive attitudes towards science and scientists **Skills** Demonstrate an ability to: • Drive a Mars rover • Land a spacecraft on Mars • Read a graph to identify	• Seek out additional information and resources on Mars, Earth, NASA and scientific exploration • Share knowledge of Mars and Mars exploration with peers, family, etc. • Advocate for NASA funding • Advocate for continued space exploration • Consider scientific and engineering career options	• Greater knowledge of Mars, and understanding of the importance of scientific exploration of Mars. • Spark or sustain interest in Mars, NASA, space exploration or planetary science. • Visitors feel like they are or can be scientist. This broader impact still needs to be updated. It needs to address Specifically: **s**ocial, **e**conomic, or **e**nvironmental **c**onditions (SEEC) changes

Base Logic Model—page 2

Name of Exhibit or Exhibition Mission: Mars Base **Your Name:** Paul Freiling and Kelley Staab **Organization:** Saint Louis Science Center **Date** Updated June 7, 2018

Process Evaluation			Outcome Evaluation			
Inputs	**Activities (Exhibit or Exhibition)**	**Participation**	**Reactions**	**KASA**	**Practice Change**	**Impact (SEEC)**
	Comparison (Comparing your new home to your old home), and Mars Globe (Exploring Mars Globally) 2. Exploration Experiences: Mars Lander, NASA Eyes on the Solar System, and Mars Direct Drive Rover. 3. Scientific Lab Experiences: Gas Identification Station, and Rock Analysis Station.	experience **Nature of participation:** Immersion and opportunities to role-play		gases and rocks on Mars • Use a magnifier to identify rocks found on Mars using color and texture **Aspirations**: • See themselves as a scientist/explorer and consider career possibilities • Want to seek out additional information and resources on Mars, Earth, NASA and scientific exploration		

Appendix B: Summative Evaluation Control and Base Tracking Protocol

Instruments

All instruments will be stored the Research & Evaluation office area. Be certain that you have the instruments for the buildings to which you are assigned for the data collection period.

- MISSION MARS CONTROL SUMMATIVE TRACKING FORM
- MISSION MARS CONTROL EXIT SUMMATIVE SURVEY

- MISSION MARS BASE SUMMATIVE TRACKING FORM
- MISSION MARS BASE SUMMATIVE EXIT INTERVIEW

Numbering

Each data collector is assigned range CASE number ranges in groups of 100. Write the CASE number at the appropriate place on the Tracking Form. Tracks and Exit Interviews for the same person must have the same CASE number.

100 to 199 X
200 to 299 Y
300 to 399 Z
400 to 499 J
500 to 599 K

Legibility

Use a ballpoint pen and write legibly. Make certain that someone else will be able to read your tracks and identify the same data that you will have entered.

Tracking

Selecting Subjects:

Eligible subjects—group your tracks in threes: Tracks 1 and 2 should be of adults over 18, and Track 3 should be of a child between 7 and 17. Find an unobtrusive spot near the entrance to the exhibit. Count the third eligible person crossing the line on the floor running across the front of the area (see map).

- DO NOT intercept children between 7 and 17 for an Exit Interview.
- All tracked individuals over 18 who stopped at least one exhibit and spent at least 1.5 minutes in the gallery should be intercepted and asked for an interview.

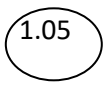
Starting the track

- When the subject enters the exhibition area, turn on your timer. (The phone app Stopwatch is free and has a large readable screen, and there are other apps.)
- Write a unique Case number from your assigned range on the tracking form. You do not have to use them sequentially.
- Write your first name on the tracking form
- Record the start time on the tracking form.
- Also, record the date of the track.
- Record the observed demographic items which appear at the bottom or on the back of the tracking form.

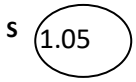
Drawing the Track
Draw a line showing the pathway taken through the gallery. Mark the line with arrows to show direction.

Recording Stop Times
A stop is defined at any point the subject places both feet on the floor for more than 1 second. At each stop, draw a small circle on the map. Record (in minutes and seconds) how long they stop. If using the exhibit requires the subject to walk to other positions around the exhibit, then continue timing the entire engagement.

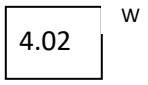
•If the person is simply stopped, perhaps talking to another visitors, but clearly not paying attention to any exhibit at all, draw the circle and record the time. Place a small "x" near the right of the circle.



•If the person is **ENGAGING WITH A STAFF MEMBER,** draw a small "s" near the top left of the circle.



Waiting in Line
If the subject is waiting in line, do NOT record multiple stops. Draw a square at the point they join the line. Time the entire wait, even if they move further up in the line. Record the time in the square. Write a small "w" at the top right-hand corner of the square. Be sure your square is clearly a square.



Broken Exhibits:
Place a "B" in the exhibit list column next to each exhibit you notice is broken or not working during the track.

Multiple Stops at the Same Exhibit
If a subject stops more than one time at the same exhibit, draw circles for each stop and record more than one stop time. You will total the time and record that total for the exhibit when you enter data.

Multiple Gallery Entrances and Exits
If subjects leave and then reenter a gallery, stop the gallery timer when (1) Control: they move into the Makerspace gallery or exit back into the hallway, and (2) Base: walk onto the terrazzo area. Continue timing if they reenter the gallery. Wait 30 seconds if they have do not begin to leave the general area (i.e. appear to be moving on the another gallery and clearly exiting). If they do not reenter after 30 seconds, end the track.

In Control, the Programming and Transmission exhibit in the Mission Control space should be timed as separate exhibit elements NOT as one experience.

Observer Notes:
Note any interesting or unusual occurrences that might explain the pathway.

Ending the track:
Each time the subject exits the exhibition, STOP your timer. Wait for 30 seconds to see if they re-enter. If they re-enter, START the timer again. If after 30 seconds they do not re-enter, record the STOP time. Do this as many times as they exit and re-enter the gallery area. If they are over 18 years old, approach and request an Exit Interview. Do not ask for an interview of anyone you tracked who appears to be under 18 years old.

Exit Interviews

Selection Criteria--Only approach individuals over age 18 for an interview.

Approach--After the exit, approach the person and ask for an interview:
"Hi. My name is _____ and I and work for the Science Center. We would like to learn about your experience in the Mission: Mars area. Would you be willing to answer a few questions? It should take about 5-10 minutes."
(If you are not certain that the subject is over 18, ask "Are you at least 18 years old? I am only supposed to interview people 18 and over so I am just checking.")

Tips for a Successful Approach & Request

- The attitude to aim for is confident, but not pushy. Think positive thoughts--"This person will want to HELP the Science Center learn about this exhibit!"
- You have every right to ask. They have every right to say "no." Thank people who say "no" and say, "Have a great time today!"
- Remember you are the face of the Science Center--not yourself as an individual--be professional, stand up straight, smile.
- Eye-contact is key to a successful approach.
- Be prepared to make the approach and request while walking.
- Use small talk to move them out of the pathway to conduct the interview, e.g. "Where are you from?"
- If you are being turned down repeatedly, stop a few minutes and consider how you could improve. Don't get down on yourself! Everyone has some "nos."

Each participant who is approached for a survey – whether they agree to participate or not – is to be given a sticker at the end of your encounter with them.

Refusals--If someone refuses an interview, note it on the tracking map under Observer Notes. Hand them a sticker and say "Of course/Thank you! Please wear this sticker for the rest of your visit so we don't approach you again."

Response Rate—Calculate your response rate for surveys to see how well you are doing.

Here is the formula:

$$\text{Response Rate (in percent)} = \frac{\text{(Total Number of Completed Surveys * 100)}}{\text{Total Number of Adult Tracks over 90 seconds}}$$

Here is an example:

$$\text{62.5\% response rate} = \frac{\text{(75 completed surveys * 100)}}{\text{120 tracks}}$$

Target Response Rates:

- 0% to 40% = needs work (sample may be biased and unrepresentative of population)
- 40% to 60% = better but sample may still not be representative
- 60% to 85% = fairly good but sample may still not be totally representative of the population
- 85% to 100% = good and sample should be representative of the population

Target Numbers—We will stop collecting Tracking and Exit Interviews data when we reach the following targets:

- Mission: Mars Base Tracking: 10 Child Tracks
- Mission: Mars Control Tracking: 10 Child Tracks
- Mission: Mars Base Summative Exit Interviews: 40 Adult Exit Interviews
- Mission: Mars Control Summative Exit Interviews: 40 Adult Exit Interviews

Report your tracking and exit totals to Carey at the end of the day by email Carey will cc Kelley on emails, and data collectors should also cc Kelley on their emails to Carey.

Conducting the Survey--Fill out information on the top of the form (Case # from map), Your First Name, Date, Start time of Survey).

Types of Questions--*Remember: If you write in an option on a forced choice item, circle more than one item on a single option item, or your writing cannot be read--the item cannot be verified or used in the analysis. You have wasted YOUR time and the Visitor's time.*

(Select One)--be sure to select only ONE choice.
(Select all that apply.)--circle more than one option if appropriate.
Ratings--circle or write whole number. (If they give you a fraction, round down.)
Open-Ended: write direct quotes of keywords and phrases
There is only one skip on the Exit Interviews.

Missing Items—In this evaluation, many of the items are totaled to provide an impact score. That means if someone declines to answer one of these questions or if you forget to ask it that survey will not be able to be used in the analysis. We will be checking surveys to make certain there are an adequate number for analysis.

Concluding the Survey--When the Survey is over, thank them for their time.
Give the person you interviewed the small thank you gift. If a child/children have waited patiently, please give them one, too. Give a sticker to the adult participant saying "Thank you so much for your time. Please wear this sticker for the rest of your visit so we don't approach you again."

After the Survey
Take about five minutes and review your track and survey. Ask yourself:

- Is everything legible?
- Did I miss any questions?
- Are my notes complete?

At the end of your shift and data entry, drop off all instruments and clipboards to the designated areas of the desk.

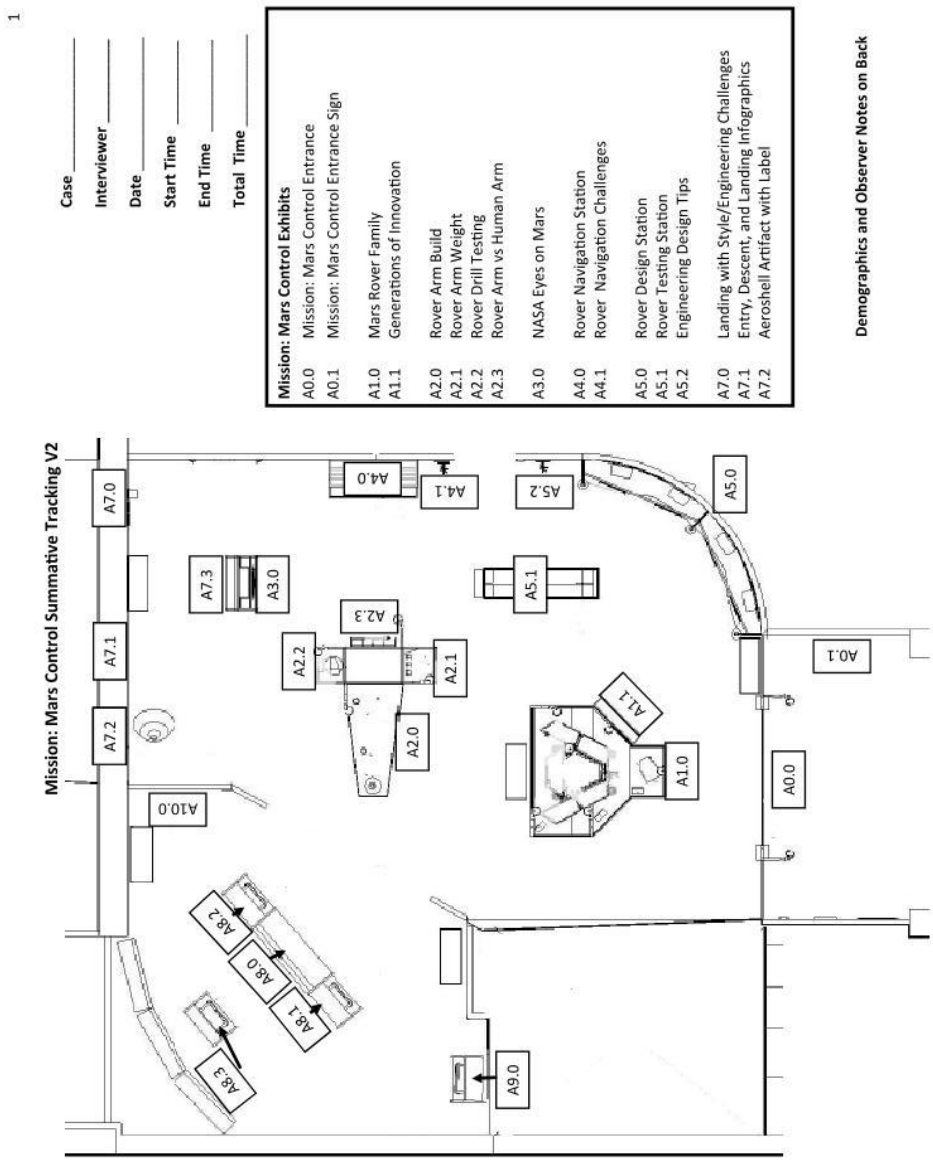
LINKS FOR DATA ENTRY

Practice links for data entry are below. Final data entry links will be given to you by email prior to the beginning of data collection.

Note: For the CONTROL AND BASE TRACKING FORMS, you will enter the total STOP TIME at an exhibit and the as well as OBSERVED DEMOGRAPHICS. Please make certain that this information is legible on your tracks.

Appendix C: Summative Evaluation Control and Base Tracking Forms

Control Summative Tracking Form--Front



Control Summative Tracking Form--Back

Demographics

Observed Gender
Female
Male
Other

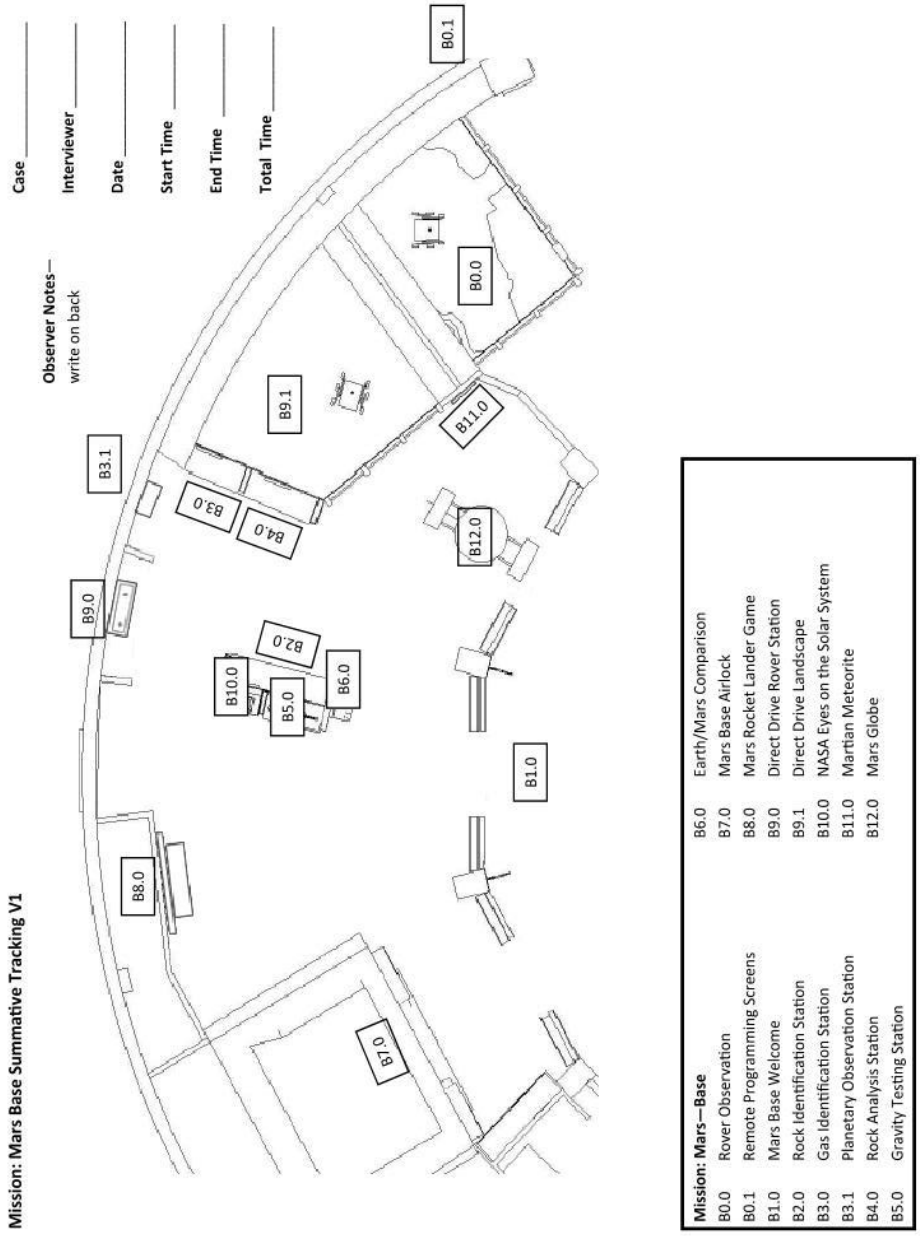
Observed Age (Circle one)		
7-10	18-24	45-54
11-13	25-34	55-64
14-17	35-44	65+

Observed Social Group (Circle one)			
Alone	Three Adults	Organized group	Adults & children
Two adults	Three + adults	School Group	

Level of Crowding (Circle one)	
Nearly empty (1-2 exhibits in use	Crowded (Most exhibits in use)
Low level (3-4 exhibits	Very crowded (All exhibits in use)
Medium level (1/2 exhibits in use	

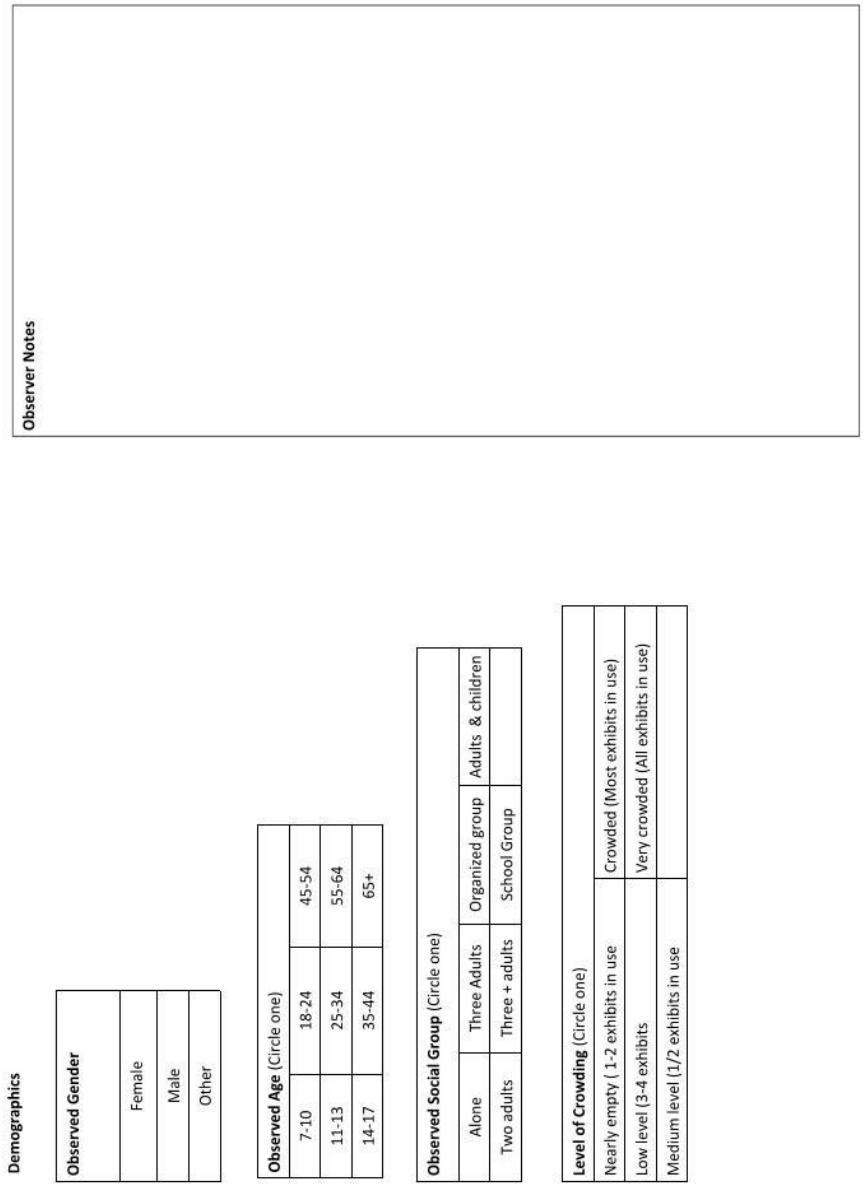
Observer Notes

Base Summative Tracking Form--Front



Mission: Mars—Base		B6.0	Earth/Mars Comparison
B0.0	Rover Observation	B7.0	Mars Base Airlock
B0.1	Remote Programming Screens	B8.0	Mars Rocket Lander Game
B1.0	Mars Base Welcome	B9.0	Direct Drive Rover Station
B2.0	Rock Identification Station	B9.1	Direct Drive Landscape
B3.0	Gas Identification Station	B10.0	NASA Eyes on the Solar System
B3.1	Planetary Observation Station	B11.0	Martian Meteorite
B4.0	Rock Analysis Station	B12.0	Mars Globe
B5.0	Gravity Testing Station		

Base Summative Tracking Form--Back



Demographics

Observed Gender
Female
Male
Other

Observed Age (Circle one)		
7-10	18-24	45-54
11-13	25-34	55-64
14-17	35-44	65+

Observed Social Group (Circle one)			
Alone	Three Adults	Organized group	Adults & children
Two adults	Three + adults	School Group	

Level of Crowding (Circle one)	
Nearly empty (1-2 exhibits in use	Crowded (Most exhibits in use)
Low level (3-4 exhibits	Very crowded (All exhibits in use)
Medium level (1/2 exhibits in use	

Observer Notes

Appendix D: Summative Evaluation Control and Base Exit Interviews

Mission: Mars Control Summative Exit Survey 4F

Introduction

Script: Hello, my name is _____ and I work for the Science Center. We want to learn about your experience in the Mission: Mars Control gallery that you just visited. Would you take 5 to 10 minutes to tell me about it?

[If uncertain of age the respondent . . .] Are you at least 18 years old? I am only supposed to interview people over 18, so I am just checking.

[If yes . . .] Your survey responses will be strictly confidential and data from this research will only be used in aggregate. Your information will remain confidential.

* 1. Survey Info

CASE (from tracking)	
Interviewer	
Date (mm/dd/yyyy)	
Time interview began (hh:mm)	
Time interview ended (hh:mm)	
Total interview time (mm)	

Mission: Mars Control Summative Exit Survey 4F

Reactions

Script: The next few questions will ask you to rate qualities of this gallery area. For all questions 0 = a low rating and 10 = a high rating. You may rate the item at any number across that scale.

2. How likely are you to recommend visiting this gallery of the Science Center to a friend or colleague? 0 = very unlikely to 10 = very likely

0	1	2	3	4	5	6	7	8	9	10	N/A
○	○	○	○	○	○	○	○	○	○	○	○

3. How Interesting was this area compared to other Science Center galleries? 0 = not interesting to 10 = very interesting

0	1	2	3	4	5	6	7	8	9	10	N/A
○	○	○	○	○	○	○	○	○	○	○	○

1

4. How much fun was this area? 0= not fun at all to 10 = lots of fun!

0	1	2	3	4	5	6	7	8	9	10	N/A
○	○	○	○	○	○	○	○	○	○	○	○

5. When people design galleries for the science center, they want to communicate one or more Big Ideas. For example, a Big Idea of a gallery about photosynthesis could be "The Sun is the source of energy for all living things." Which of the following do you think are the Big Ideas for this specific gallery? Choose all that apply.

- ☐ Mars has a wide range of living species ranging from simple t complex organisms.
- ☐ Scientists and engineers working for NASA are diverse in gender, ethnicity, and age.
- ☐ Engineers build, test, and program Mars rovers for science missions, and you can do the same at the Science Center.
- ☐ Scientists and engineers work together to explore Mars--what scientists want and what engineers can deliver!
- ☐ In the future, scientists will be living and doing scientific work on Mars, and you can play that role today at the Science Center.
- ☐ Explorers use a joystick to navigate a rover across the Mars landscape.
- ☐ Scientific exploration of Mars helps us learn about Earth.

6. In this gallery, to what extent did you feel you stepped into the shoes of an engineer? 0 = very little to 10 = a great deal

0	1	2	3	4	5	6	7	8	9	10	N/A
○	○	○	○	○	○	○	○	○	○	○	○

Mission: Mars Control Summative Exit Survey 4F

Impacts

Script: The next questions ask you to describe how visiting the gallery affected YOU. We are using these questions to find out how effective the exhibits were in providing good learning experiences. We are <u>NOT using them to make judgments about YOU!</u> You will be asked to rate items thinking about BEFORE you visited the gallery as well as AFTER visiting the gallery. (If you visited this gallery prior to today, please rate the item prior to that experience in the gallery.)

7. [ATTITUDES] Please rate your perceptions of the following topics BEFORE AND AFTER using exhibits in this area. Ratings range from 0 = a very low level to 10 = a very high level

	BEFORE visiting the gallery	AFTER visiting the gallery
Level of interest in engineering (design, building, and testing) tools and vehicles to explore Mars		
Level of interest in the exploration of Mars		
Level of Interest in NASA missions		
Respect for the work of NASA engineers		
Respect for the work NASA scientists		

8. [ASPIRATIONS] Please rate your disagreement or agreement with the following statements BEFORE AND AFTER visiting this area. Ratings range from 0 = strongly disagree to 10 = strongly agree

	BEFORE visiting the gallery	AFTER visiting the gallery
I can see myself as a engineer		
I can see myself as a programmer		
I want to find out more about the scientific exploration of Mars		
I want to find about out more Mars		
I want to find out more about NASA Mars rover missions		

9. [SKILLS] Please rate your confidence in carrying out the following activities BEFORE AND AFTER using exhibits in this area. Ratings range from 0 = a low level of confidence to 10 = a high level of confidence.

	BEFORE visiting the gallery	AFTER visiting the gallery
Completing an engineering design cycle (build, test, rebuild) to accomplish a goal		
Building a model rover to successfully move across challenging Martian terrain		
Building a model rover arm to reach different distances		
Programming a model rover to explore key locations on Mars		
Carrying out a simulation of long-term scientific mission to explore Mars		

10. [KNOWLEDGE] Please rate your level of knowledge of the following BEFORE AND AFTER visiting this area. Ratings range from 0 = very low level of knowledge to 10 = very high level of knowledge

	BEFORE visiting the gallery	AFTER visiting the gallery
Mars rover missions		
The challenges of exploring Mars (Mars terrain and atmosphere)		
Rover instruments		
Engineering Design (testing and revising components on Earth)		
How NASA scientists and engineers work together		

11. Which of the following NASA missions do you remember hearing about in this gallery?

- ☐ New Horizons
- ☐ Sojourner
- ☐ Spirit
- ☐ Opportunity
- ☐ Friendship
- ☐ Curiosity

12. What was the best thing about this gallery? (write key words)

4

13. What aspects of this gallery need to be improved? (Write key words)

Mission: Mars Control Summative Exit Survey 4F

Demographics

Script: Information requested in this last section is to help us group responses for analysis. No individual data will be shared.

14. Prior to today, have you visited this gallery?

- Yes
- No

15. Today, or on a previous visit, have you visited a gallery in the Planetarium Building named Mission: Mars Base? (Show photo.)

- Yes
- No

16. With what gender do you identify?

- Female
- Male
- Other
- Prefer not to answer

17. In what ZIP code is your home located? (enter 5-digit ZIP code)

18. What is the highest level of education you have completed?

- Elementary school
- Middle school
- Graduated from high school
- Associated degree/Some college
- Graduated from college
- Advanced degree
- Prefer not to answer

19. Which category contains your age?

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 and older
- Prefer not to answer

20. As a tax supported institution, the Science Center reports a summary of information about visitors' racial backgrounds. Would you describe yourself as . . . ?

- White/Caucasian
- Asian/Pacific Islander
- Black/African American
- American Indian-Alaska Native
- Hispanic/Latino
- Multi-racial
- Prefer not to answer

21. Which of the following best describes the group you are with today?

- Alone
- Two adults
- Three or more adults
- Organized Group
- Camp group
- Adults with children

22. How many adults are in your group?

23. How many children under 18 years old are in your group? (If there are no children in the group, SKIP to the THANK YOU section.)

24. If we define group members under 18 years old as children, what is the age of the . . . ? [Enter whole numbers 0-17 using "0" for children less than one year old]

YOUNGEST child in your group

OLDEST child in your group

25. How many children in your group are . . ?

Girls

Boys

Mission: Mars Control Summative Exit Survey 4F

Thank you!

Script: Thank you for taking the time to provide you perspectives and feedback. We appreciate your time! Here is a small gift to say thank you!

Mission: Mars Base Summative Exit Survey V3

1. Introduction

Script: Hello, my name is _____ and I work for the Science Center. We want to learn about your experience in the Mission: Mars Base gallery that you just visited. Would you take 5 to 10 minutes to tell me about it?

[If uncertain of age the respondent . . .] Are you at least 18 years old? I am only supposed to interview people over 18, so I am just checking.

[If yes . . .] Your survey responses will be strictly confidential and data from this research will only be used in aggregate. Your information will remain confidential.

* 1. Survey Info

CASE (from tracking)	
Interviewer	
Date (mm/dd/yyyy)	
Time interview began (hh:mm)	
Time interview ended (hh:mm)	
Total interview time (mm)	

Mission: Mars Base Summative Exit Survey V3

2. Reactions

Script: The next few questions will ask you to rate qualities of this gallery area. For all questions 0 = a low rating and 10 = a high rating. You may rate the item at any number across that scale.

2. How likely are you to recommend visiting this specific area of the Science Center to a friend or colleague? 0 = very unlikely to 10 = very likely

0	1	2	3	4	5	6	7	8	9	10	N/A
○	○	○	○	○	○	○	○	○	○	○	○

3. How Interesting was this area compared to other Science Center galleries? 0= not interesting to 10 = very interesting

0	1	2	3	4	5	6	7	8	9	10	N/A
○	○	○	○	○	○	○	○	○	○	○	○

4. How much fun was this area? 0 = not fun at all to 10 = lots of fun!

0	1	2	3	4	5	6	7	8	9	10	N/A
○	○	○	○	○	○	○	○	○	○	○	○

5. When people design galleries for the science center, they want to communicate one or more Big Ideas. For example, a Big Idea of a gallery about photosynthesis could be "The Sun is the source of energy for all living things." Which of the following do you think are the Big Ideas for this gallery? Choose all that apply.

- ☐ Mars has a wide range of living species ranging from simple t complex organisms.
- ☐ Engineers build, test, and program Mars rovers for science missions, and you can do the same at the Science Center.
- ☐ In the future, scientists will be living and doing scientific work on Mars, and you can play that role today at the Science Center.
- ☐ Scientific exploration of Mars helps us learn about Earth.
- ☐ Scientists and engineers working for NASA are diverse in gender, ethnicity, and age.
- ☐ Scientists and engineers work together to explore Mars--what scientists want and what engineers can deliver!
- ☐ Explorers use a joystick to navigate a rover across the Mars landscape.

6. In this gallery, to what extent did you feel you stepped into the shoes of a scientist? 0 = very little to 10 = a great deal

0	1	2	3	4	5	6	7	8	9	10	N/A
○	○	○	○	○	○	○	○	○	○	○	○

Mission: Mars Base Summative Exit Survey V3

3. Impacts

Script: The next questions ask you to describe how visiting the gallery affected YOU. We are using these questions to find out how effective the exhibits were in providing good learning experiences. We are NOT using them to make judgments about YOU! You will be asked to rate items BEFORE visiting the gallery and AFTER visiting the gallery. If you used this gallery on a previous visit, please think back to the a time BEFORE your FIRST visit to the gallery.

7. [ATTITUDES] Please rate your perceptions of the following topics BEFORE AND AFTER using exhibits in this area. Ratings range from 0 = a very low level to 10 = a very high level

	BEFORE visiting the gallery	AFTER visiting the gallery
Level of interest in Mars		
Level of interest in the scientific exploration of Mars		
Interest in NASA missions		
Respect for the work of NASA scientists		
Respect for the ability of science to discover new things		

8. [ASPIRATIONS] Please rate your disagreement or agreement with the following statements BEFORE AND AFTER visiting this area. Ratings range from 0 = strongly disagree to 10 = strongly agree

	BEFORE visiting the gallery	AFTER visiting the gallery
I can see myself as a scientist.		
I can see myself as an astronaut exploring Mars.		
I want to find out more about Mars.		
I want to find out more about the scientific exploration of Mars.		
I want to find out more about NASA Mars missions.		

9. [SKILLS] Please rate your skills on the following tasks BEFORE AND AFTER using exhibits in this area. Ratings range from 0 = a low level of this skill to 10 = a high level of this skill.

	BEFORE visiting the gallery	AFTER visiting the gallery
Operating a model Mars rover		
Reading a graph to identify gases on Mars		
Reading a graph to identify rocks on Mars		
Using a magnifier to identify rocks found on Mars using color and texture		
Using color filters to identify different features on Mars.		

10. [KNOWLEDGE] Please rate your level of knowledge of the following BEFORE AND AFTER visiting this area. Ratings range from 0 = very low level of knowledge to 10 = very high level of knowledge

	BEFORE visiting the gallery	AFTER visiting the gallery
The atmosphere of Mars		
Gravity on Mars		
The geology and types or rocks and minerals of Mars		
The tools used by scientists to explore Mars		
How scientists use rovers to study Mars		

11. Scientists use many tools to study Mars only some of which are featured in the gallery. Which of the following tools (including vehicles) that scientists use to study Mars do you remember seeing in the gallery?

- [ ] Dynamometer
- [ ] Electroscope
- [ ] Spectrometer
- [ ] Magnifier
- [ ] Rover
- [ ] Landspeeders
- [ ] Polygraph

12. What was the best thing about this gallery? (write key words)

13. What aspects of this gallery need to be improved? (Write key words)

Mission: Mars Base Summative Exit Survey V3

4. Demographics

Script: Information requested in this last section is to help us group responses for analysis. No individual data will be shared.

14. Prior to today, have you visited this gallery?

- Yes
- No

15. Today, or on a previous visit, have you visited a gallery in the Main Building named Mission: Mars Control? (Show photo.)

- Yes
- No

16. With what gender do you identify?

- Female
- Male
- Other
- Prefer not to answer

17. In what ZIP code is your home located? (enter 5-digit ZIP code)

18. What is the highest level of education you have completed?

- Elementary school
- Middle school
- Graduated from high school
- Some college/associate degree
- Graduated from college
- Advanced degree
- Prefer not to answer

19. Which category contains your age?

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 and older
- Prefer not to answer

20. As a tax supported institution, the Science Center reports a summary of information about visitors' racial backgrounds. Would you describe yourself as . . . ?

- ○ White/Caucasian
- ○ American Indian-Alaska Native
- ○ Asian/Pacific Islander
- ○ Multi-racial
- ○ Black/African American
- ○ Prefer not to answer
- ○ Hispanic/Latino

21. Which of the following best describes the group you are with today?

- ○ Alone
- ○ Organized Group
- ○ Two adults
- ○ Camp group
- ○ Three or more adults
- ○ Adults with children

22. How many adults are in your group?

23. How many children under 18 years old are in your group? (If there are no children in the group, SKIP to the THANK YOU section.)

24. If we define group members under 18 years old as children, what is the age of the . . . ? [Enter whole numbers 0-17 using "0" for children less than one year old]

YOUNGEST child in your group

OLDEST child in your group

25. How many children in your group are . . ?

Girls

Boys

Mission: Mars Base Summative Exit Survey V3

5. Thank you!

Script: Thank you for taking the time to provide you perspectives and feedback. Please wear this sticker for the rest of your visit so we don't approach you for another study. Here is a small gift to say thank you! We appreciate your time!

6

Appendix E: Characteristics of Subjects

Demographics

Gender

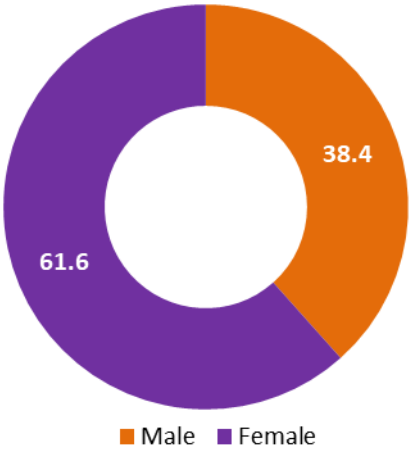


*Figure E1. Gender Control -- Tracking (*N = *159)*

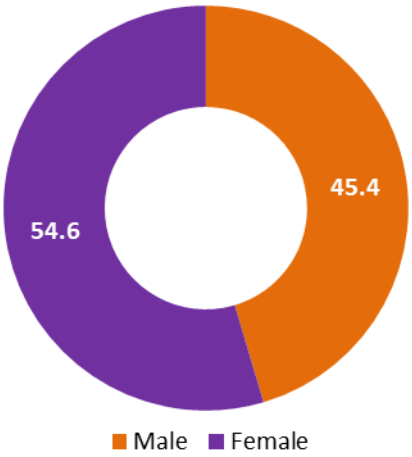


*Figure E2. Gender Base -- Tracking (*N = *163)*

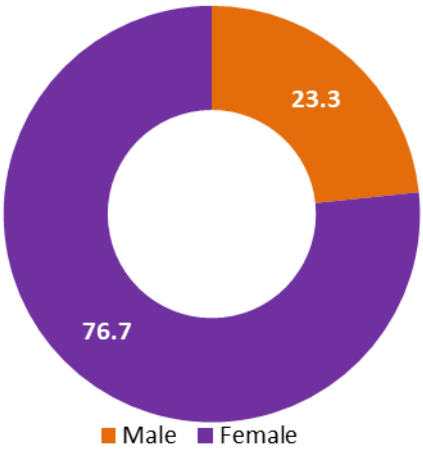


*Figure E3. Gender Control Exit Interview -- (*N = *30)*

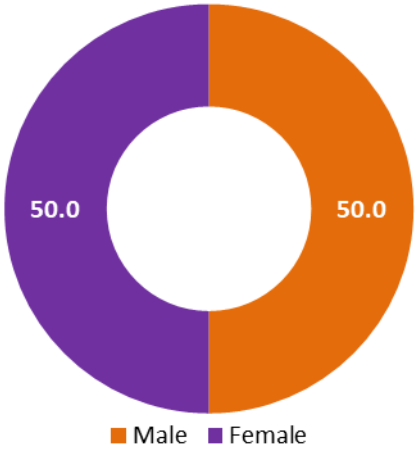


Figure E4. Gender Base – Exit Interview (N = *28)*

Age

In comparison of ages in E5 and E6, Control and Base age categories were not significantly different.

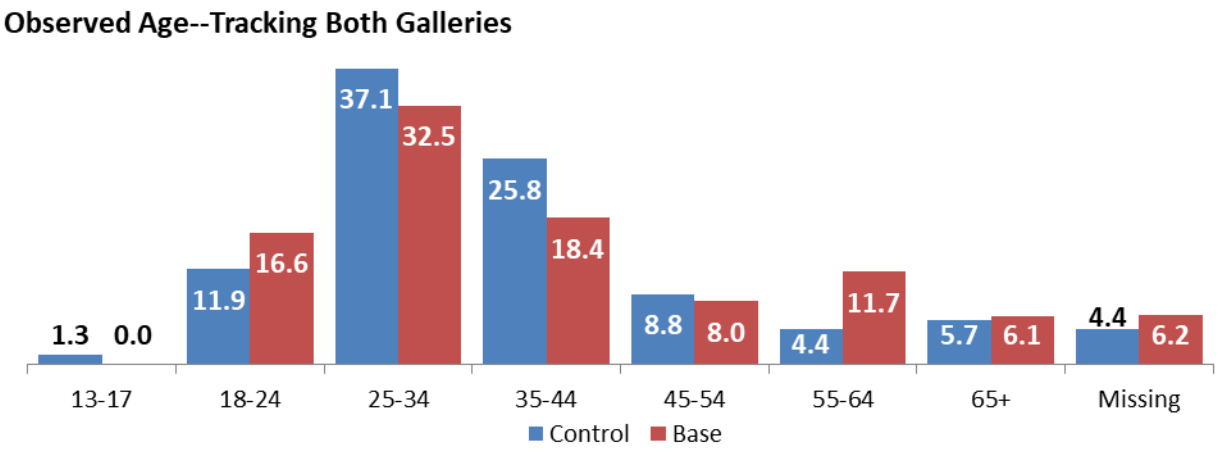


Figure E5. Observed Age Tracking – Control and Base in Percent (Control N = *159, Base* N = *163)*

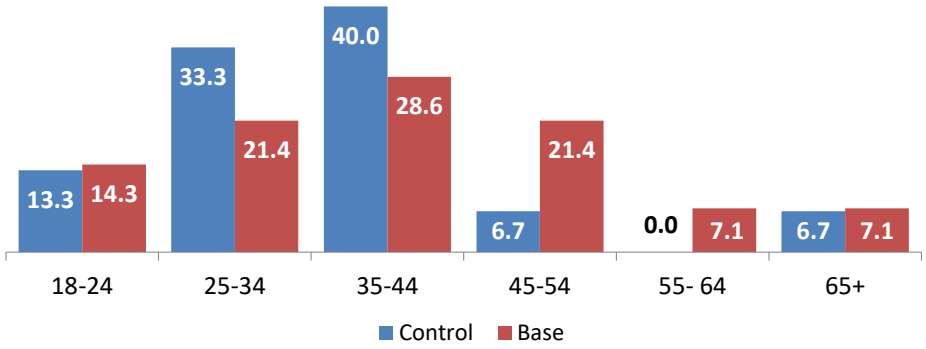


Figure E6. Age Exit Interview – Control and Base in Percent (Control N = *30, Base* N = *28)*

Group Type by Protocol

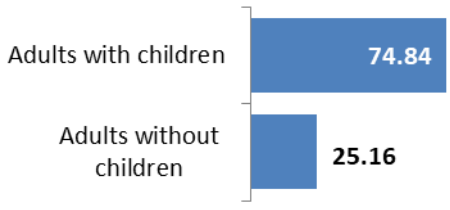


*Figure E7. Control Tracking – Group Type in Percent (*N = *159)*

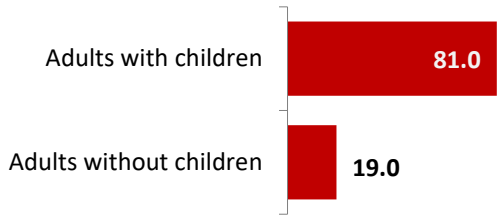


*Figure E8. Base Tracking – Group Type in Percent (*N = *163)*

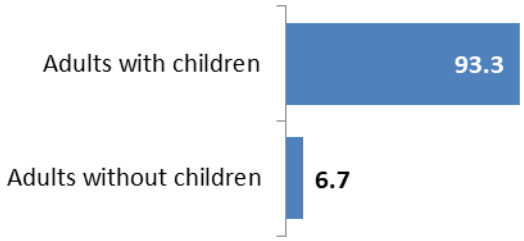


*Figure E9. Control Exit Interview – Group Type in Percent (*N = *30)*

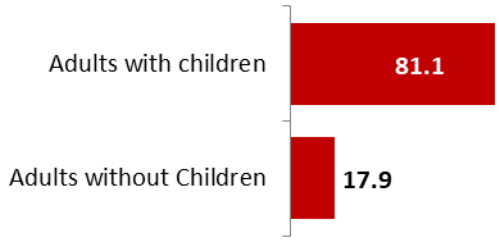


*Figure E10 Base Exit Interview—Group Type in Percent (*N = *28)*

Ages of Children in Groups

Table E1. Exit Interview Control -- Numbers of Adults and Children in Groups of Adults with Children

Control	Number of Adults	Number of Children	Age of Youngest Child	Age of Oldest Child
Mean	1.9	2.4	4.9	10.5
N	28.0	27.0	23.0	25.0
SD	0.7	1.2	3.6	3.5

Table E2. Exit Interview Base -- Numbers of Adults and Children in Groups of Adults with Children

Base	Number of Adults	Number of Children	Age of Youngest Child	Age of Oldest Child
Mean	1.7	2.5	6.0	9.5
N	22.0	22.0	23.0	22.0
SD	0.8	1.5	3.8	3.3

Education Level

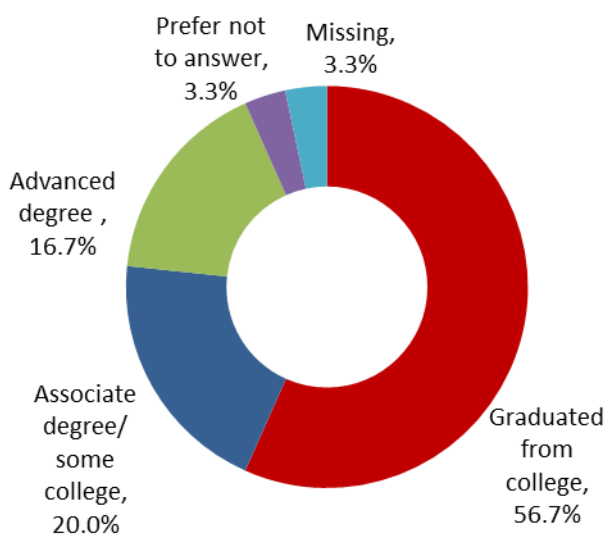


Figure E11. Exit Interview Control (N = *30)*

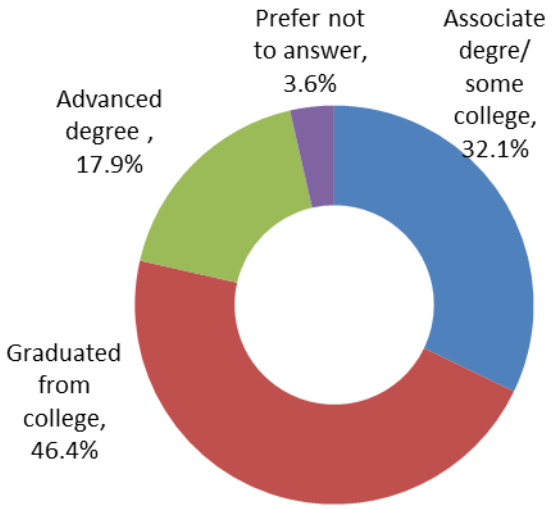


Figure E12. Exit Interview Base (N = *28)*

Race

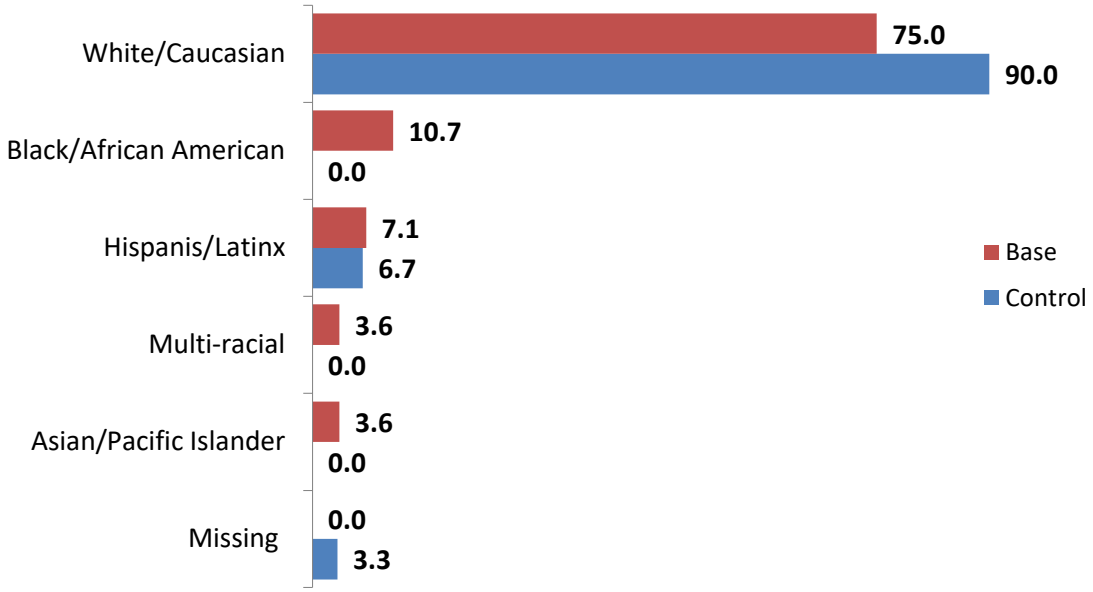


Figure E13. Exit Interview Control and Base Race in Percent (Control N = *30, Base* N = *28)*

Residence

*Figure 14. Control Exit Interview -- ZIP Code Map (*N = *29)*

*Figure E15. Base Exit Interview -- ZIP Code Map (*N = *28)*

The material contained in this report is based upon work supported by NASA under grant award NNX14AD08G. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration (NASA).