Summative Analysis for the Bell Museum
Planetarium Show and Corresponding Toolkit Activity

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Introduction

In fall 2019, the Bell Museum received funding via a NASA Teams II grant to create *Mars: The Ultimate Voyage*, a full-dome planetarium show and accompanying hands-on activities that focus on the interdisciplinary roles that will be needed to send humans to Mars.

Catalyst Consulting Group served as the program evaluators for the Bell Planetarium. This report presents the findings from the summative evaluation completed in March–May 2023. Eight planetariums from seven states participated in the evaluation by gathering data from students who watched the planetarium show and completed an activity. Sites were identified, contacted, and scheduled by Bell Museum staff. The goal of this evaluation was to document the impact of the project in relation to NASA's goals and objectives, with the intent to "immerse the public in NASA's work, enhance STEM literacy, and inspire the next generation to explore."

During this time, the evaluation team collected and analyzed quantitative and qualitative data to evaluate student feedback in the following categories, which were identified by the Bell Museum as the focus for the project: student engagement, student interest, and STEM literacy. These constructs are aligned to three of the five categories for the *Framework for Evaluating Impacts of Social Science Education* (Friedman et al., 2008). The Framework combines engagement and interest in one impact category. The project's construct of STEM literacy combines the knowledge/awareness and skills categories of the Framework, by defining this construct in relation to both the related scientific understanding and human factors.

Methods and Procedures

The evaluation collected data from a total of 407 students in grades four through eight over a period of six weeks. Students evaluated both a show and an activity as part of this evaluation. First, students watched the planetarium show, *Mars: The Ultimate Voyage.* The film is a feature-length full-dome planetarium show focusing on Moon-to-Mars exploration and the STEM-based careers that will enable those efforts. Upon completion of the show, students played a board game that was developed by the Bell Museum as part of the accompanying toolkit activities to support the show's themes and learning objectives. The game, *Mission to Mars,* is a cooperative board game that supports two of the project's goals:

1. To introduce the five hazards of deep space travel
2. To introduce the countermeasures that NASA is working on to protect NASA from the five hazards.

The game's objective is to land humans on Mars and return them safely to Earth. During the course of gameplay, participants encounter various hazards that could affect their mission. Using countermeasure cards that negate the effects of these hazards, participants can overcome these obstacles as they try to complete their mission. Clear facilitator instructions were provided to ensure consistency of gameplay across sites. The facilitators' guide clearly instructed students to play the game in groups of four. However, given the large number of student participants at many of the sites, the average group size was 6, with groups ranging in size from 4 to 13.

Upon completion of the game, students completed a paper survey to gather both quantitative and qualitative data. All surveys were completed anonymously. Students were identified only by site, with each survey assigned a unique number for data entry purposes. Copies of all completed student surveys were either scanned and emailed to the Catalyst team for data entry in Survey Monkey.

The survey was developed by Catalyst Consulting, with input from the Bell Museum staff. See Appendix A for the full student survey. The survey consisted of 13 multiple-choice questions, 12 of which were on a five-point Likert scale. Eight of these questions came from the Career Interest Questionnaire (Christensen, R. & Knezek, G., 2017). The final multiple-choice question had a four-point scale. Additionally, the survey included one open-ended question and five demographic questions.

When aligned to the three areas of focus for the evaluation, the survey included three questions addressing engagement, eight addressing interest, and three questions pertaining to STEM Literacy.

- This evaluation defined student engagement in the context of students' feedback about the show and game, as revealed in three Likert-scale questions. Going forward, this report will identify engagement results as feedback.
- Interest was defined in relation to career interest for the purposes of the evaluation and was measured using the two subscales from the Career Interest Questionnaire.
- The STEM literacy construct combined the knowledge/awareness and skills categories of the framework, by defining STEM literacy in relation to both scientific understanding and human factors. The survey's STEM literacy questions included two Likert-scale questions and the survey's single open-ended question.

For the purposes of analysis, the Catalyst team used Excel and SPSS to analyze the quantitative data. Two scales were explored as part of the analysis; the procedures for this analysis are presented in the Results section along with the data. The single qualitative question was coded and analyzed using NVivo. All results were analyzed to explore group differences based on several student identities: grade level, gender, race/ethnicity, primary language spoken at home, school type, and disability. Independent-samples t tests were used to analyze differences between two groups. One-way analyses of variance (ANOVA) were used to analyze differences between three or more groups; statistically significant ANOVA results were then explored further using the Bonferroni correction. Overall, there was not a consistent pattern in the results based on any specific identity.

Student identity data are presented in the next section, along with additional information about how groups were used in the analysis.

Student Participants

Figure 1 shows the breakdown of students who provided feedback by grade level. Percentages reflect the number of students per grade level out of the 407 total student participants. The Bell Museum aimed to assist the Catalyst team in collecting data from at least 50 students per grade level. They accomplished this goal, with the number of students per grade level ranging from 53 to 113.

The number of students varied across grade levels, with half of students in the sample being in either 5th or 6th grade.

The survey also asked students to self-identify their race and ethnicity. It is not uncommon for evaluation participants to choose to skip this question, and the students in this evaluation were no exception; 78% of students providing a response (n=314).

Figure 2 shows results as percentages of the total 407. Students could choose more than one category, therefore the totals are greater than 100%. An additional 16% of students chose "prefer not to say" and 2% who did not answer the question for the race/ethnicity category (n=66, 12.)

Given the uneven sample sizes across groups, the evaluation team chose to collapse race and ethnicity categories into two categories: White and BIPOC (Black, Indigenous, People of color). This decision was made in an attempt to conduct analyses that focused on those who are underrepresented and/or under-served in STEM. For the purposes of the analysis, BIPOC students where those who selected one or more of the following categories to describe their race and ethnicity: American Indian and Alaska Native, Black, Hispanic, Native Hawaiian or Pacific Islander. White students were those who only selected the white category. That breakdown is represented by Figure 3 and includes those who skipped the question and those who chose "prefer not to say" in the Not Disclosed category.

Figure 1. The sample included students from across the five grade levels of interest for the project, with the largest group of students being in 6th grade.

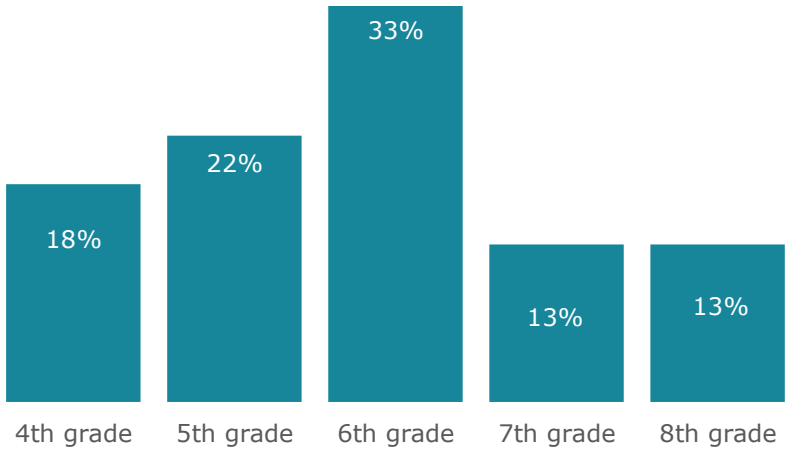


Figure 2. Half of the students in the evaluation identified as white, several identified as Black or Hispanic, and few identified as the other categories measured.

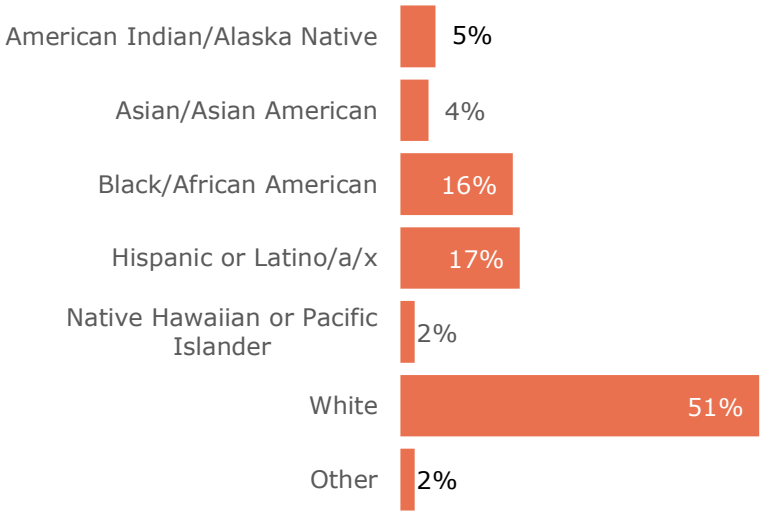


Figure 3. Similar portions of students identified as BIPOC and White.

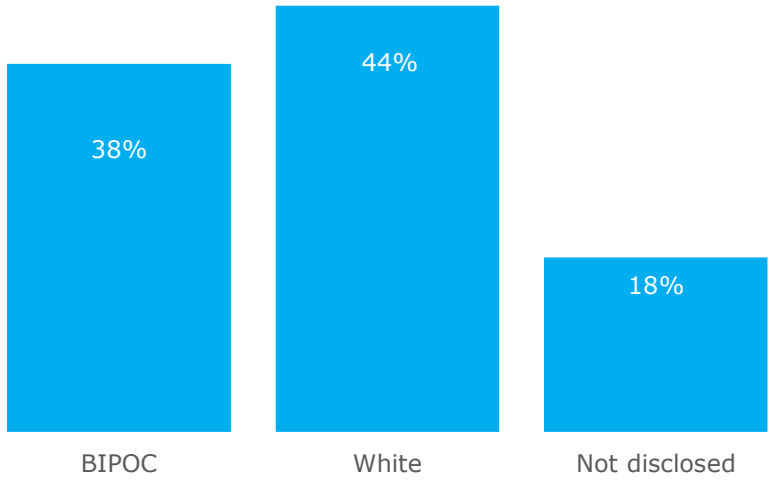


Figure 4. Most students identified as male or female, with a small portion choosing other, or choosing not to answer the question.

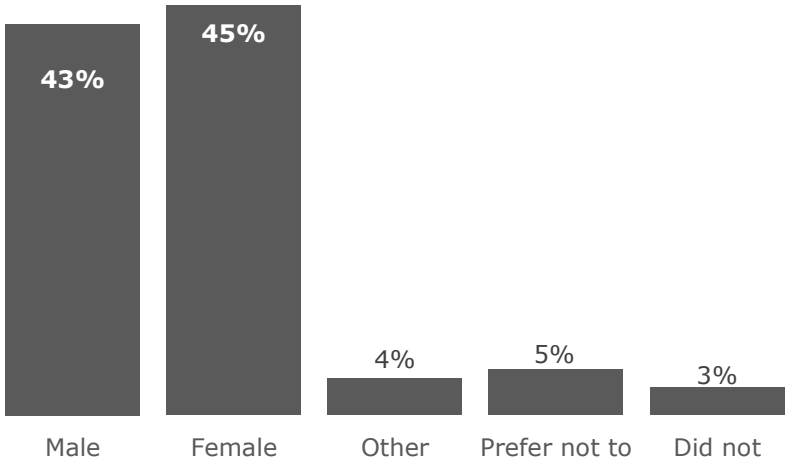


Figure 5. Planetarium partners indicated that most students were from schools located in urban environments.

Students were also asked to indicate which language they speak at home. Most students (88%) chose a single language, including 314 English speakers (77%) and 46 who speak another language at home (11%). The multi lingual category was selected by 33 students who selected English and another language (8% of the sample). Fourteen students did not respond to this question (3%). Students were asked to self-identify their gender. The participants included similar numbers of males (n=174) and females (n=185), with a small number (n=15) identifying as "other" and 5% choosing not to identify their gender (n=22) Eleven students did not answer this question. For the purposes of quantitative analysis, only the responses from males and females were used. For group analysis of the qualitative data, all responses were used.

School type for all student respondents was provided by an adult administrator for each site. The majority of student participants attend urban schools. Less than one-quarter represent a suburban demographic, and a smaller percentage (12%) come from rural schools.

Structure of this Report

The purpose of this report is to share the findings from the evaluation. The findings are organized by the three categories of evaluation questions. Quotes are provided in Appendix B to share examples of the findings in participants' own words. Student responses were transcribed verbatim and the quotes have been edited only to improve readability and to ensure anonymity. Given that the responses were written by children, there were instances where words were unclear or misspelled and/or punctuation was incorrect. The evaluators made every attempt to understand and interpret the students' writing when transcribing their written responses.

Results

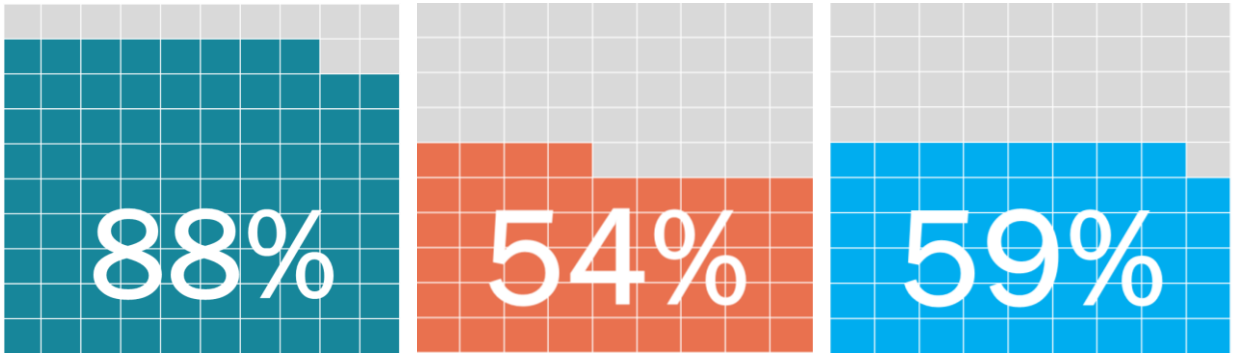
This section presents the evaluation results based on the three areas of interest for the project. Engagement is presented first, described as student feedback. Next, the career interest data are presented. The final section shares results related to STEM literacy.

Student Feedback

Students rated three aspects of their field trip experience to provide feedback on *Mars: The Ultimate Voyage*. All ratings were provided on a five-point scale. Students rated the show highly, with 88% of students using one of the top two ratings to describe how much they liked the show (n=335). Students also liked playing the game, with 54% choosing one of the top two ratings (n=325). Most also reported that the connection between the show and game was clear to them, with 59% reporting that the planetarium show helped prepare them to be successful in the game (n=335).

A series of correlation analyses indicated that students who provided a positive rating for one of these three items also tended to provide positive ratings for the other items. The opposite was also true. Students' ratings of the show, for example, were positively correlated with their ratings of the game (r=.33, p<.001) and with their ratings for how the show helped prepare them for the game (r=.36, p<.001). Similarly, students' ratings of the game were also positively correlated with their rating for how the show helped prepare them to succeed in the game (r=.39, p<.001).

Figure 6. Most students used the top ratings possible to describe **the show**, **the game**, and the **ways that show prepared them to succeed** with the game.

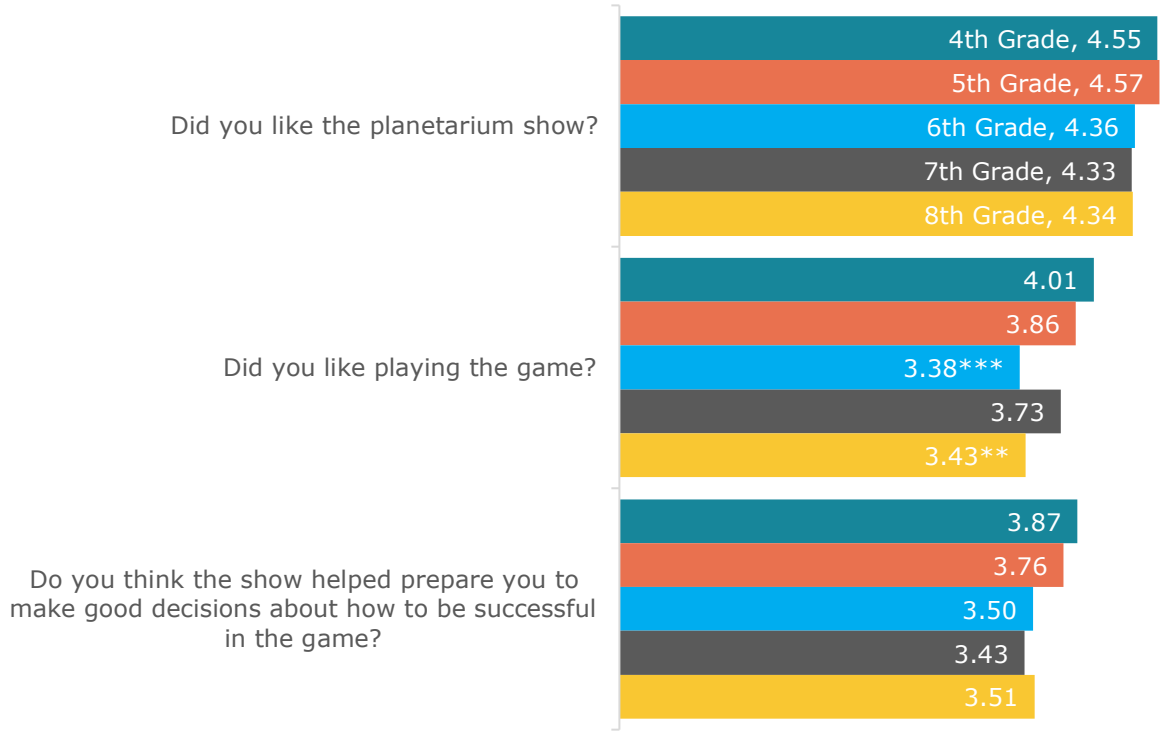


Recall that the toolkit suggested that the game be played by teams of four students, and that many students reported playing with much larger teams than this recommended number. Two correlation analyses were conducted to determine whether the number of players affected students' ratings of the game overall. The first indicated no relation between the number of game players and students' rating of the game (r=.09, p=.08). The second indicated no relation between the number of game players and students' ratings of how the show prepared them to succeed with the game (r=.006, p=.90)

A series of one-way analysis of variance (ANOVA) tests were performed to explore whether students with different identities had different reactions to the three aspects of their field trip experience: the show, the game, and the ways the show prepared them to succeed in the game. No consistent differences were found based on gender, those who identified as White versus BIPOC, primary language spoken at home, or disability status.

Statistically significant differences were found in relation to two identity categories: grade level and school type. The series of one-way ANOVAs conducted based on grade level indicated that there were no grade level differences in how students responded to the show, or in the ways they believed the show prepared them to be successful in the game (see Figure 7; note that ANOVA statistics are based on the average rating provided by different groups of participants, and so the bars represent mean scores for each group). Grade level differences were found in ratings of the game. Younger students reported slightly higher scores than older students.

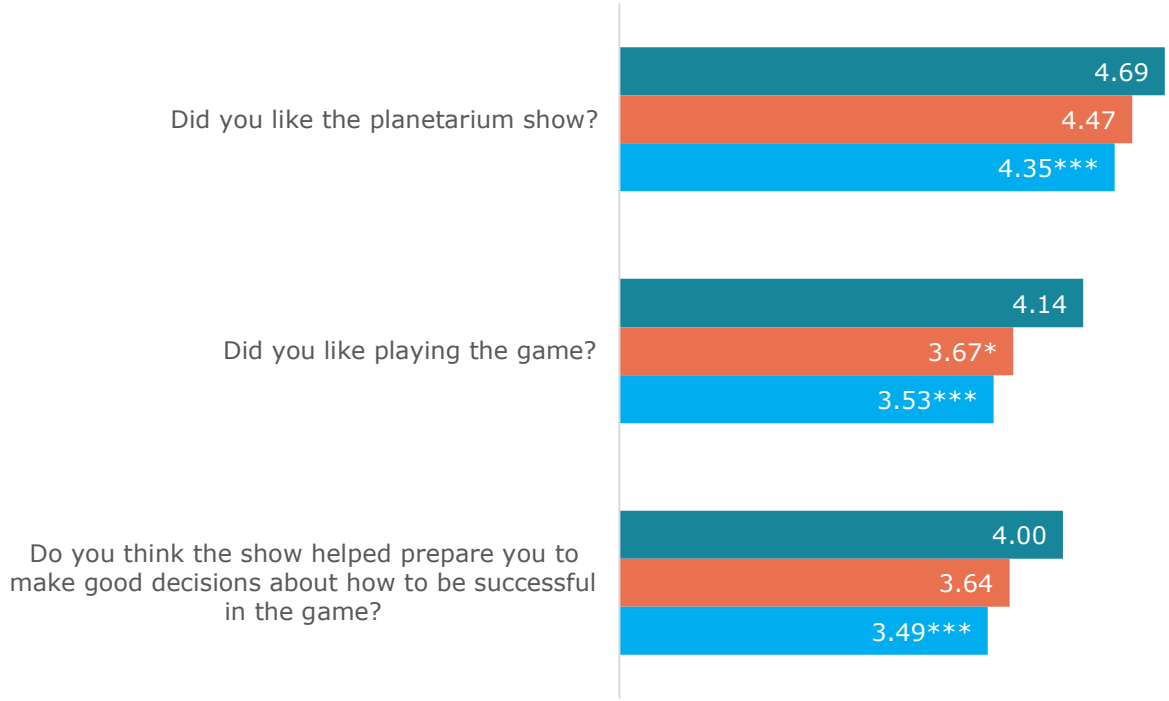
Figure 7. Ratings by grade level indicated that students provided similar ratings to describe the show and the ways that the show helped them be successful in the game. Younger students rated higher than any other group.



***Statistically significant difference when compared to 4th grade scores at p<.01*
****Statistically significant difference when compared to 4th grade scores at p<.001; in addition, the scores of 6th grade students were significantly lower than those of 5th graders at p<.05*

Regarding school type, a series of one-way ANOVAs revealed different ratings across all three questions (Figure 8). The overall analysis indicated that there were significant differences. Follow-up tests indicated that suburban students reported higher engagement scores than urban students to rate all three program components. For the game only, suburban students also reported significantly higher engagement scores than rural students. The ratings from urban and rural students did not differ statistically across any of the three items.

Figure 8. Student responses differed by school type, with suburban students indicating higher level of engagement for both the show and the game.



**Statistically significant difference when compared to Suburban scores at p<.05*
****Statistically significant difference when compared to Suburban scores at p<.001*

Student Interest

The survey included two scales designed to measure student interest in science careers. Generally speaking, scales are designed to measure a specific idea or construct. For the purposes of this evaluation, one scale measured Interest in choosing a science career and the other measured the perceived Importance of science careers. Each used a five-point Likert-style rating scale that ranged from 1-5.

Constructs are usually considered to be complex and to have multiple dimensions that cannot be measured directly. Scales are used in these cases because we assume that no single question can perfectly measure a complex construct. Instead, scales are created to include multiple questions with each question attempting to measure a slightly different aspect of the construct. Summing across the individual items and creating an average score helps measure the full picture of the construct instead of focusing on only the smaller component parts. This approach is considered more rigorous and accurate when compared to analyzing individual items alone.

Because constructs cannot be measured directly, we use statistics to help us know whether our scales do seem to be measuring different component parts or related aspects of an idea. We do that by looking at each scale's *internal consistency*, which is an indicator of how closely related the underlying items are. If items are internally consistent, then people who provide high ratings on one individual item are likely to provide similarly high ratings on the other items in the scale. The opposite is also true. We use a statistic called Cronbach's alpha to measure internal consistency of a scale. This statistic can range from 0–1, with higher scores indicating more internal consistency in how items

were rated. If a scale's Cronbach's alpha value is above the .70 threshold, then there is good evidence that the scale's items are similar enough that the scale should be considered as a whole rather than the individual items.

The Interest scale from the Career Interest Questionnaire had high enough internal consistency to warrant collapsing across items and reporting the overall change (Cronbach's alpha=.80). Overall, students seemed ambivalent in their Interest in science careers. The average rating for the entire sample was 2.97 out of 5, indicating that most were *undecided* about their Interest in science careers. Indeed, the greatest number of ratings for each individual item were in the undecided category with a similar portion of students using the upper and lower ends of the scale to describe their Interest (or lack thereof).

As with the previous results, a series of one-way ANOVAs and t-tests were used to explore group differences. No differences were found based on gender, BIPOC versus white identity, language spoken at home, disability status, or school type. Differences were found based on grade level, for two grades. Students in 5th grade reported the highest Interest ratings across the sample. Their ratings were higher, at a statistically significant level when compared to those of 6th grade students who reported the lowest Interest ratings of any group (5th grade mean = 3.27 compared to 6th grade mean at 2.75, $p<.001$). None of the ratings provided by students from other grade levels differed from each other or from those of 5th or 6th graders at a statistically significant level.

The Importance scale from the Career Interest Questionnaire did not meet the threshold needed to create a scale score (Cronbach's alpha=.60). Instead, results are shared below for each item. Overall, when compared to the ratings for Interest, students shared more positive impressions of the Importance of science careers (See Table 1). Higher ratings were provided in response to the two general items compared to those that focused on students working in science careers themselves.

Table 1.
Students provided moderate to high ratings to describe the Importance of science careers.

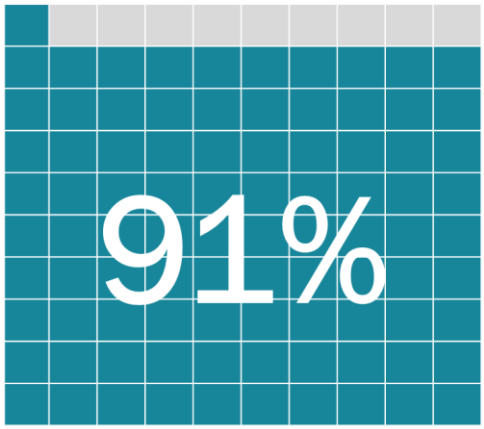
	Average Rating
A career in science would enable me to work with others in meaningful ways.	3.57
Scientists make a meaningful difference in the world.	4.47
Having a career in science would be challenging.	4.19
I would like to work with people who make discoveries in science.	3.38

STEM Literacy

Two closed-ended survey questions were used to assess students' understanding of the STEM literacy concepts included in the show and game. These questions were intentionally broad, without a focus on specific content. Rather, the objective was to gauge whether and how students understood the overall themes of the show and activity. Students were asked to indicate whether they had learned something new from their experience, whether they think a mission to Mars will be a challenging undertaking, and what they think is important to NASA. These questions directly addressed the project's goal that, by viewing the film and engaging in related activities, fourth- through eighth-grade students will identify sustainable space exploration as a key area of NASA research and understand NASA's role in future space exploration endeavors.

Students rated their learning from the field trip on a four-point scale that included the following options: *Yes, I learned a lot of new things*; *Yes, I learned some new things*; *I'm not sure if I learned anything*; and *No, I didn't learn anything new*. Overall, 91% of students chose one of the top two ratings, indicating that they learned something new from watching the show and playing the game (n=402). A series of ANOVAs and independent samples t-tests revealed no differences in the amount of learning reported by students, based on any of the categories explored.

Figure 10. Almost all students reported learning something new based on their field trip experiences.

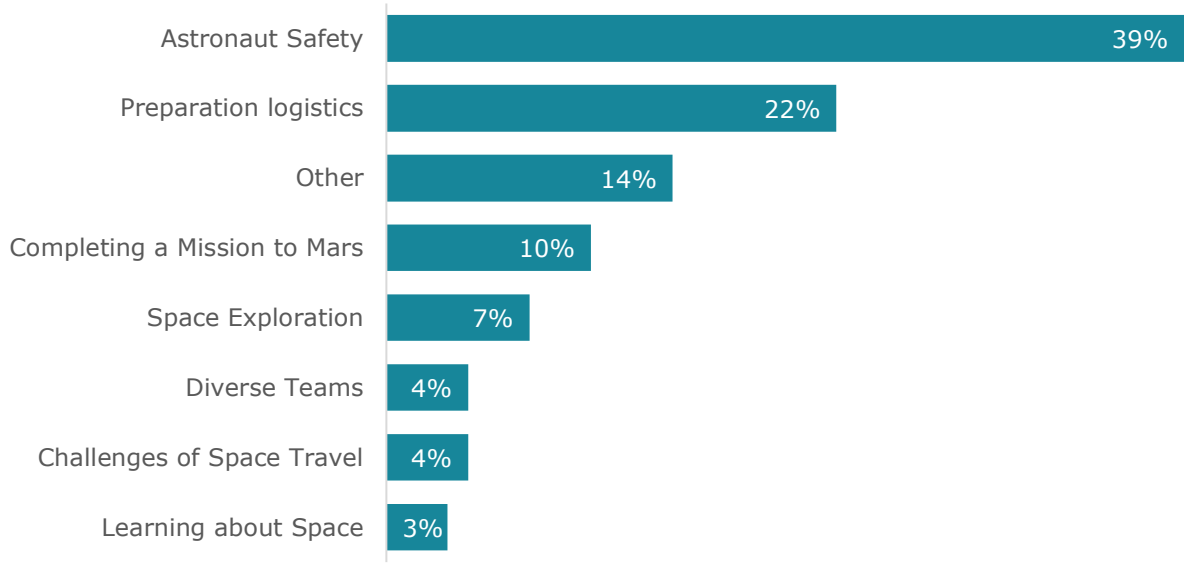


A series of correlation analyses indicated that students' ratings of how much they learned were positively related to their ratings for each component of the field trip experience, such that students who reported more learning also provided higher ratings for the show (r=.33, p<.001), the game (r=.29, p<.001), and the ways the show helped them be successful with the game (r=.33, p<.001). Interestingly, a positive relation was also found between learning and the number of students who played the game indicating that as team size for the game increased, ratings of learning increased as well (and vice versa; r=.11, p=.03).

Students also reported how challenging they thought it will be for NASA to plan a mission to Mars. Ratings were provided on a five-point scale: *Extremely easy, Somewhat easy, Neither challenging or easy, Somewhat challenging* and *Extremely challenging*. Most students (76%) reported that they think it will be challenging for NASA to plan a mission to Mars (n=388). As with the previous question, no group differences were found based on student identity category. Students' ratings on this question were not correlated with their ratings of the field trip components, or with the amount of learning they reported. Ratings for challenges were negatively correlated with group size in the game, indicating that the larger the team for the game the less challenging students rated the planning needed for a mission to Mars (and vice versa; r=-.18, p<.001).

A total of 378 students responded to the survey's single open-ended question, "Given what you learned about in the show and the game today, what is one thing you think is important to NASA?" To assist with coding, the Bell Museum provided the evaluation team with a list of eight factors that were believed to be important to NASA, and that were covered by the show and/or game in some capacity. Analysis of students' written responses revealed that all eight factors were identified by some number of students, but that there was no one factor that stood out to a majority of students. Additionally, although the question asked students to provide a single factor that they think is important to NASA, 13 students provided more than one answer (3%). Figure 11 below presents the student response data for factors, plus Other. Each category is then described below.

Figure 11. Students indicated seven primary factors they believe are important to NASA, and a small amount of students also identified Other factors which did not align with any of NASA's stated priorities.



Key takeaways from student responses for what is important to NASA include the following:

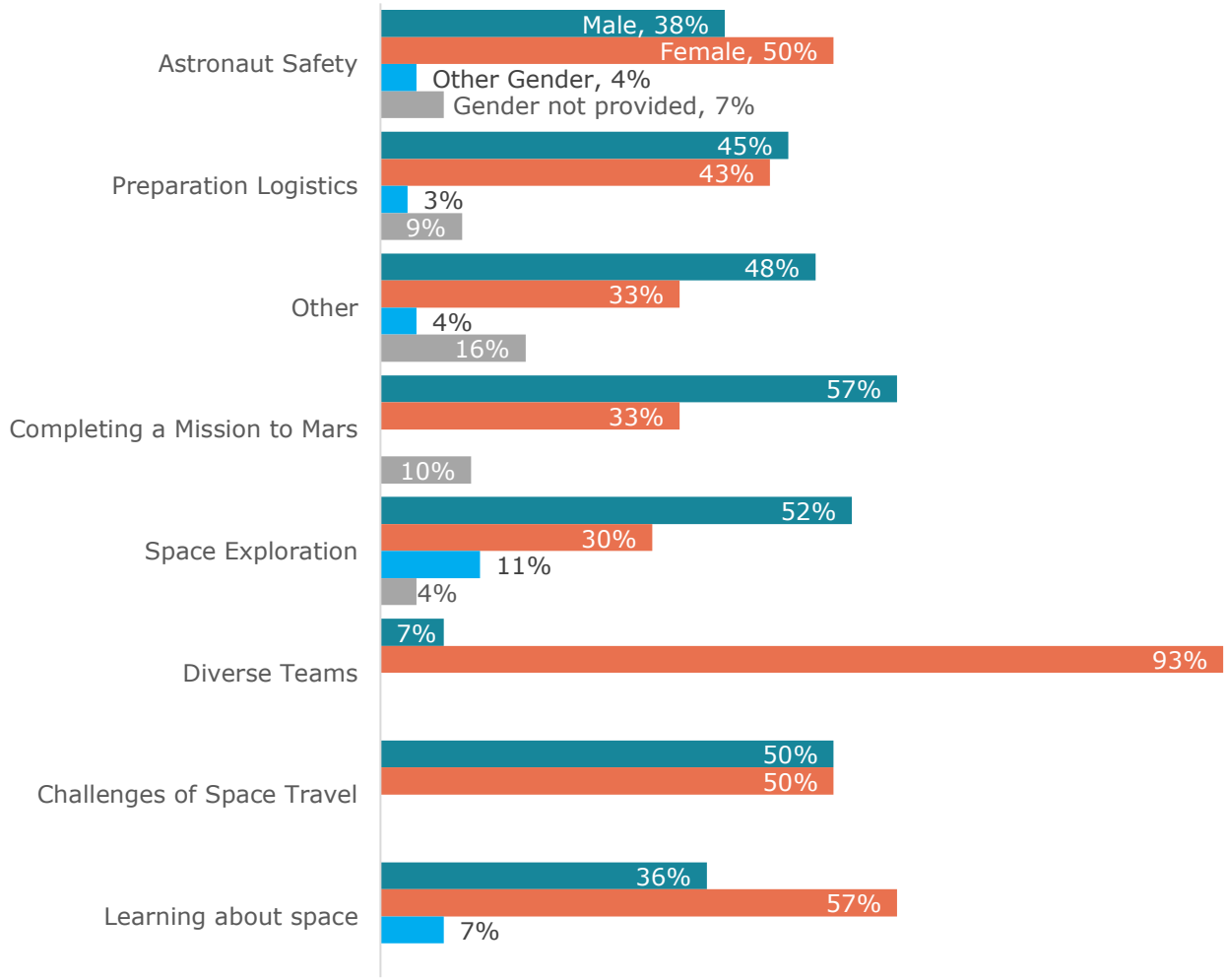
- Astronaut Safety included any mention of the health, safety, and well-being of the mission crew, and was identified by the largest number of students (n=160).
- The second most common response, provided by 89 students, was Preparation Logistics, which encompassed the materials and resources required for a mission to Mars, and any discussion of planning details.
- Completing a Mission to Mars, indicated by 40 students, included any comment focused on successfully arrival on Mars.
- Space Exploration, Challenges of Space Travel, and Learning About Space included an array of comments that fit into each of those broad categories (n=27, 16, 14 respectively).
- The fifteen students who identified Diverse Teams as important to NASA spoke of the specialists whose expertise is required to plan and support a mission to Mars.
- The figure does not include Careers Involving Space, which is one of the eight factors important to NASA, but which was only identified by two students, representing less than 1% of all respondents.
- Two percent of students said they did not know what is important to NASA, while 7% of students did not answer the question (n=8, 30).

In summary, students walked away from their field trip with different impressions of what is important to NASA. Appendix B includes sample student responses for each category.

The following series of figures present a breakdown of these student responses for various demographic categories. For each set of figures, the percentages show the portion of students from different identity groups who mentioned each topic; as such, the total percentage for each topic is 100%. When viewing these charts, keep in mind the small number of respondents for many of the NASA themes.

Students' interpretations of NASA's priorities were similar for male and female students (see Figure 12.) Females were more likely to identify the themes of Learning about Space, and Astronaut Safety, while more males noticed an emphasis on Space Exploration and Completing a Mission to Mars. Exactly half of the responses for Challenges of Space Travel came from each gender. Notably, all but one of the students who identified Diverse Teams were female. It is possible that the messaging about the varied jobs and expertise required to plan, prepare, and execute deep space travel resonated more with girls than boys.

Figure 12. Male and Female students identified similar priorities for NASA, but percentages for each category differed by gender.

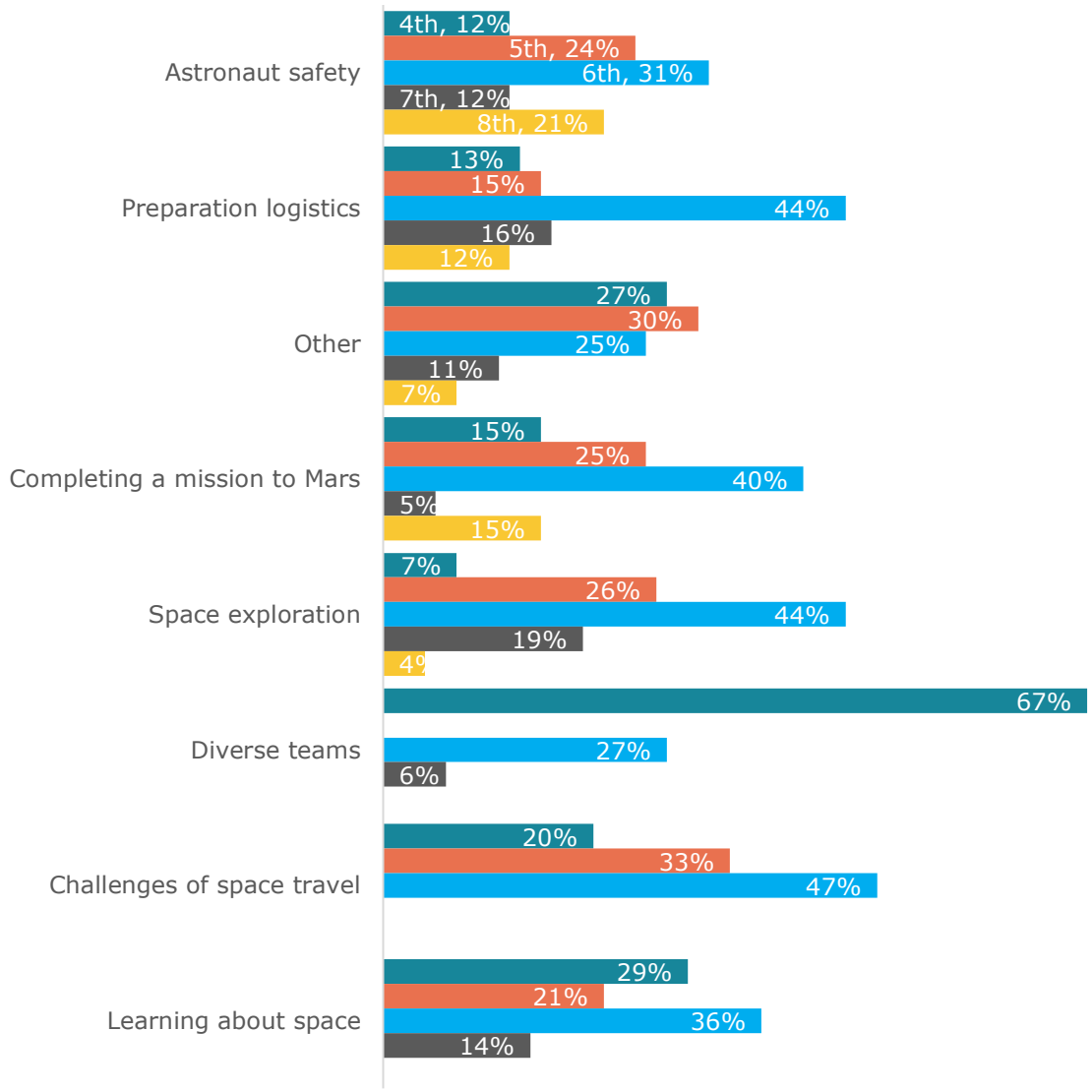


The team from the Bell Museum was particularly interested in the ways students from different grade levels responded to this question. Formative evaluation results indicated that the project might be a better fit for middle school compared the elementary school students. The results below in Figure 13 do show grade level differences in some of the topics focused on by students' responses in different grades. Even so, five of the categories were represented by comments in all five grades.

Some general findings include the following:

- Of the 15 students who mentioned Diverse Teams, 67% were fourth graders (n=10.) A smaller number of sixth and seventh graders identified this factor (27% and 7%), while no fifth or eighth graders did.
- Three categories received the largest percentage of responses by all five grade levels: Astronaut Safety, Preparation, and Other. None of the other five categories received more than 17% of responses from any grade level.
- Learning About Space was mentioned by 4% of respondents in all grades except eighth grade, where no students indicated this as an important factor to NASA.
- Fourth and sixth graders were the only two grades that provided responses in all eight categories.
- Eighth graders provided responses in the least number of categories, only mentioning five factors.

Figure 13. Five of the eight categories important to NASA were mentioned by all grades, while the range and percentages of student responses for each individual category differed across grades

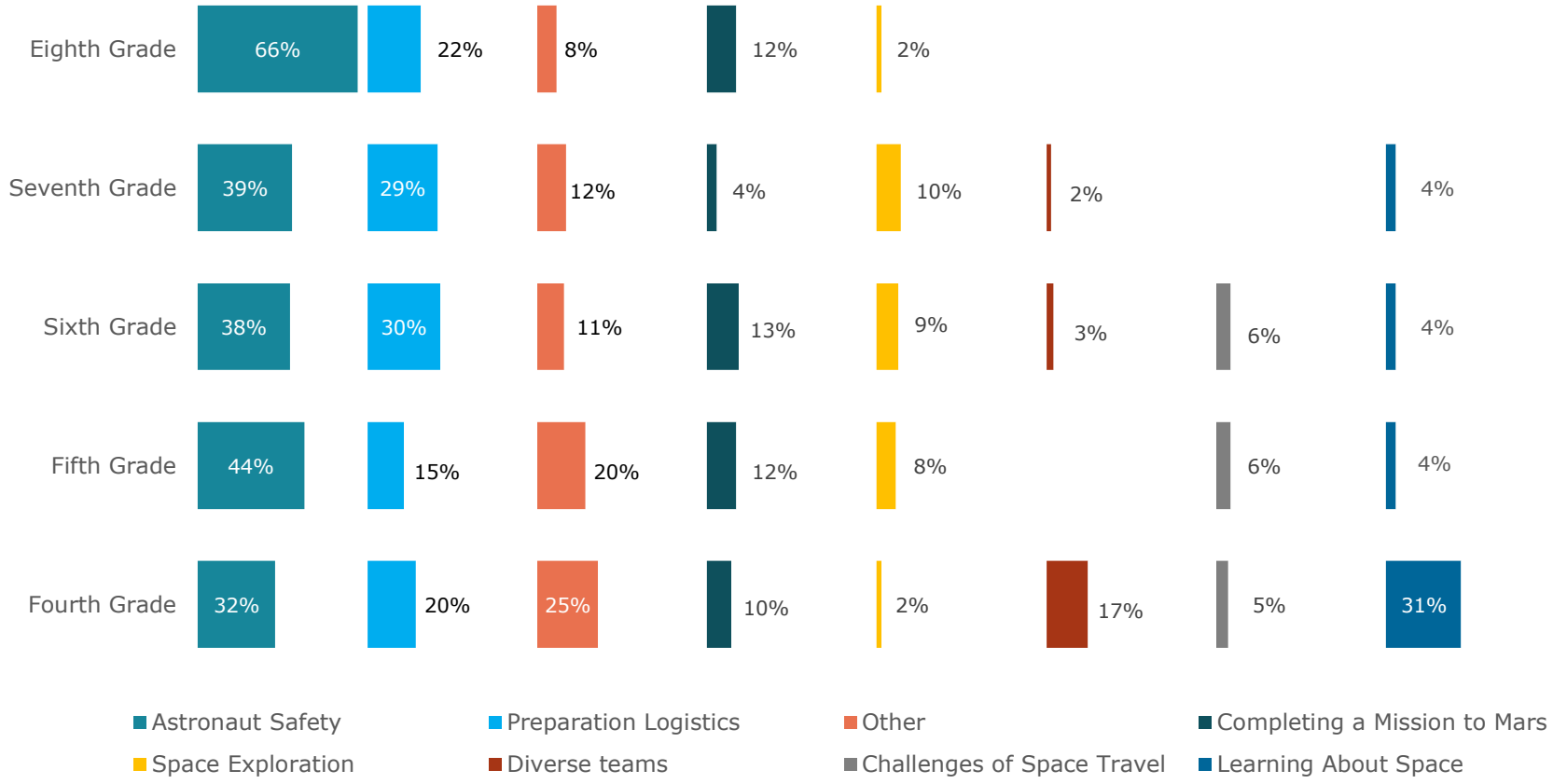


An additional way to view these results is to organize them by grade level (see Figure 14 below.) Both perspectives were of interest to the team from the Bell Museum and so the results are presented again in the charts that follow, organized by grade level instead of topic. With this format it is possible to do a more direct comparison of which NASA objectives were identified by students at each grade. Percentages were calculated out of the total number of students who responded at that grade level (fourth=60, fifth= 85, sixth=127, seventh=49, and eighth=50 students.) Because some students provided more than one answer, the totals may be greater than 100%.

Notable findings from the individual grade-level analysis include the following:

- Fourth grade percentages for Other were higher than any other grade level.
- Fourth grade provided a much higher percentage for Diverse Teams than any other grade.
- Fifth grade responses for Preparation Logistics were higher than for any other grade.
- No fifth graders indicated that Space Exploration is an important factor for NASA.
- Sixth grade students provided responses in all eight categories. (Recall that more sixth graders completed the survey than any other grade.)
- A larger percentage of sixth graders identified Completing a Mission to Mars as an important factor than any other grade.
- Seventh graders provided responses in all categories except Challenges of Space Travel.
- Seventh grade had the highest percentage of students mention Space Travel of all grades.
- Eighth grade students' responses focused primarily on three categories
- A majority of eighth grade responses related to Astronaut Safety (66%.)
- No eighth graders mentioned Space Exploration, Diverse Teams or Challenges of Space Travel.

Figure 14. Analysis of each individual grade level shows that all grades identified Astronaut Safety as the factor most important to NASA, while the other factors were mentioned by varying percentages within each grade level.



Analysis of responses to what is important to NASA by language reveals that similar responses were provided by students of all language background. However, Learning About Space received a proportionately larger number of responses from students who do not speak English at home. Both English and non-English speakers were most likely to identify Astronaut Safety, followed by Preparation Logistics, Other, and Completing a Mission to Mars, in that order. The remaining categories differed slightly in order, but given that these categories had small numbers of respondents, the differences are not notable. These results can be viewed in Figure 15 below.

Figure 15. Language spoken at home did not have a notable effect on which factors students identified as important to NASA, although a much larger percentage of non-English speaking students said that Learning About Space is important, relative to the other factors.

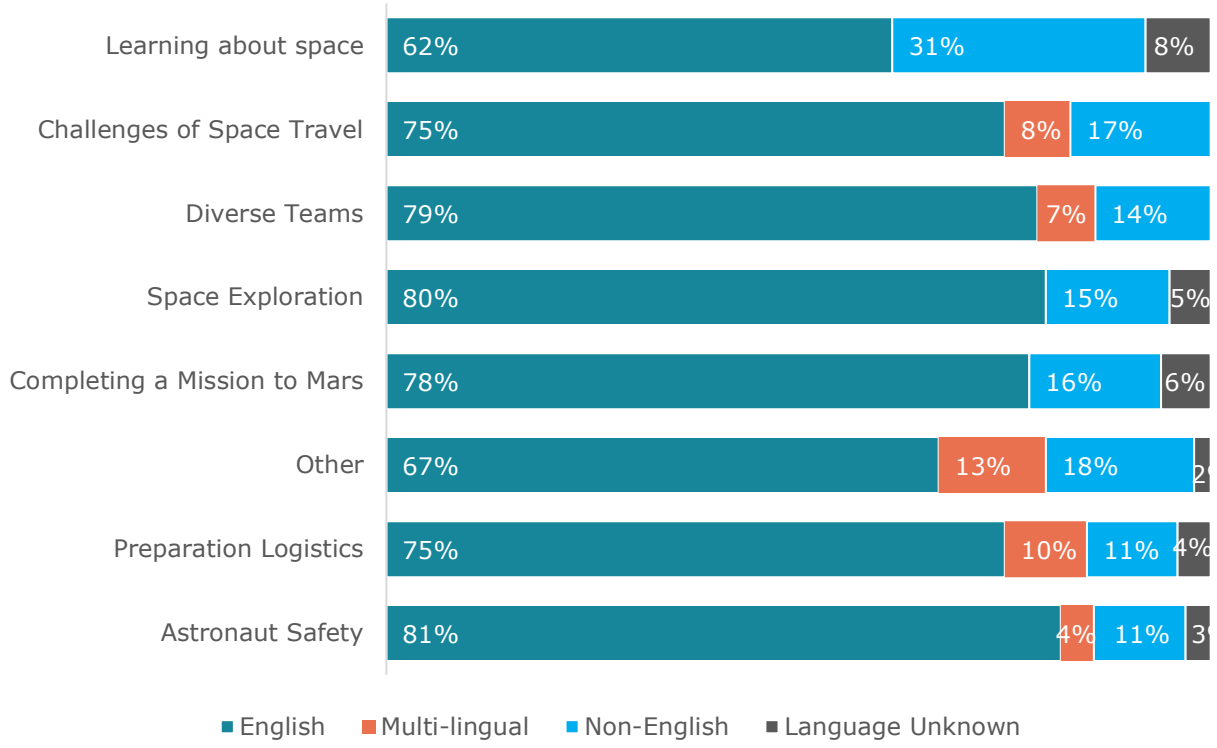


Figure 16 below presents the results for what students think is important to NASA by school type. Students from all school types identified Astronaut Safety as the primary factor important to NASA, with Preparation Logistics being mentioned by the second largest number of students for all school types. Larger percentages of suburban students identified Diverse Teams and Learning about Space than their urban and rural peers. Urban and suburban students provided responses from all eight primary categories, while rural students' responses only fell into five categories: Astronaut Safety, Preparation Logistics, Space Exploration, Completing a Mission to Mars, and Challenges of Space Travel.

Keep in mind that these results reflect 274 urban students, 86 suburban students, and 47 rural students. Astronaut Safety, which received the highest number of overall responses, was overwhelmingly identified by urban students, with 70% of respondents in this category representing urban schools (n=111.) Urban students also provided 73% of responses for Preparation Logistics (n=65). No rural students identified Diverse Teams or Learning About Space as something that is important to NASA.

Figure 16. Students from all school types indicated that Astronaut Safety is the most important factor to NASA. Urban and suburban students identified all eight categories, while rural students' responses targeted five important factors.

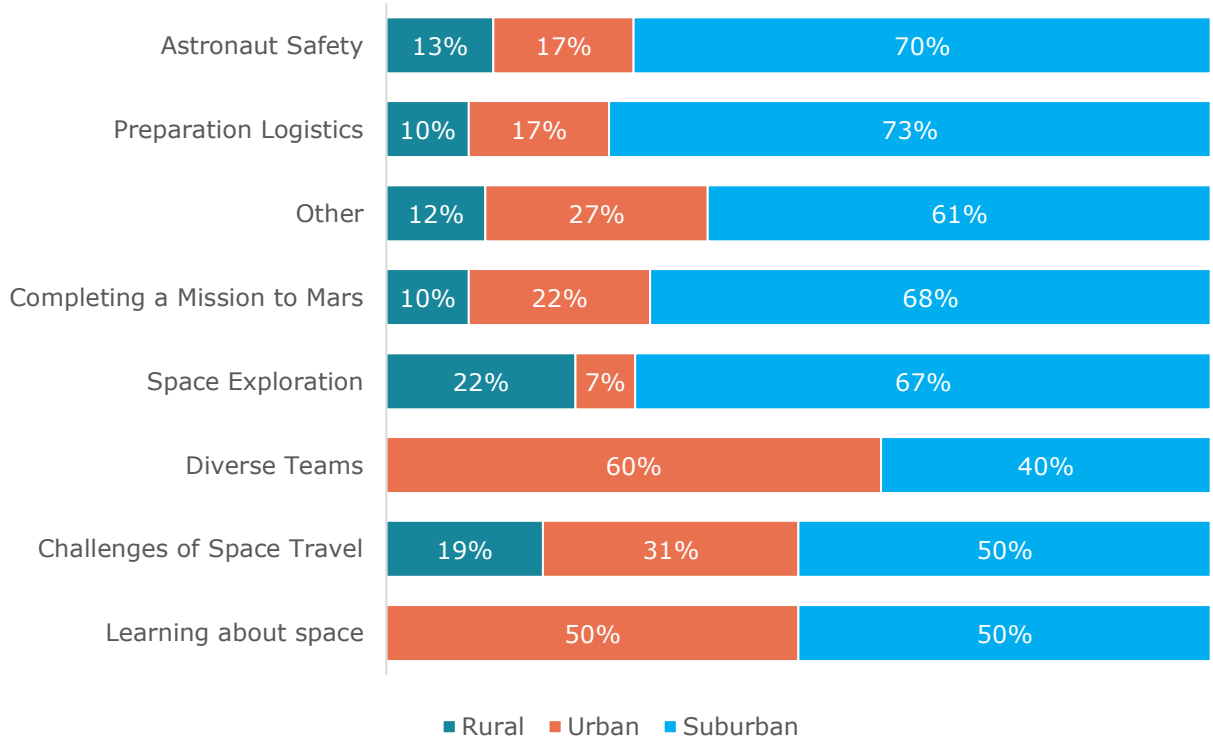
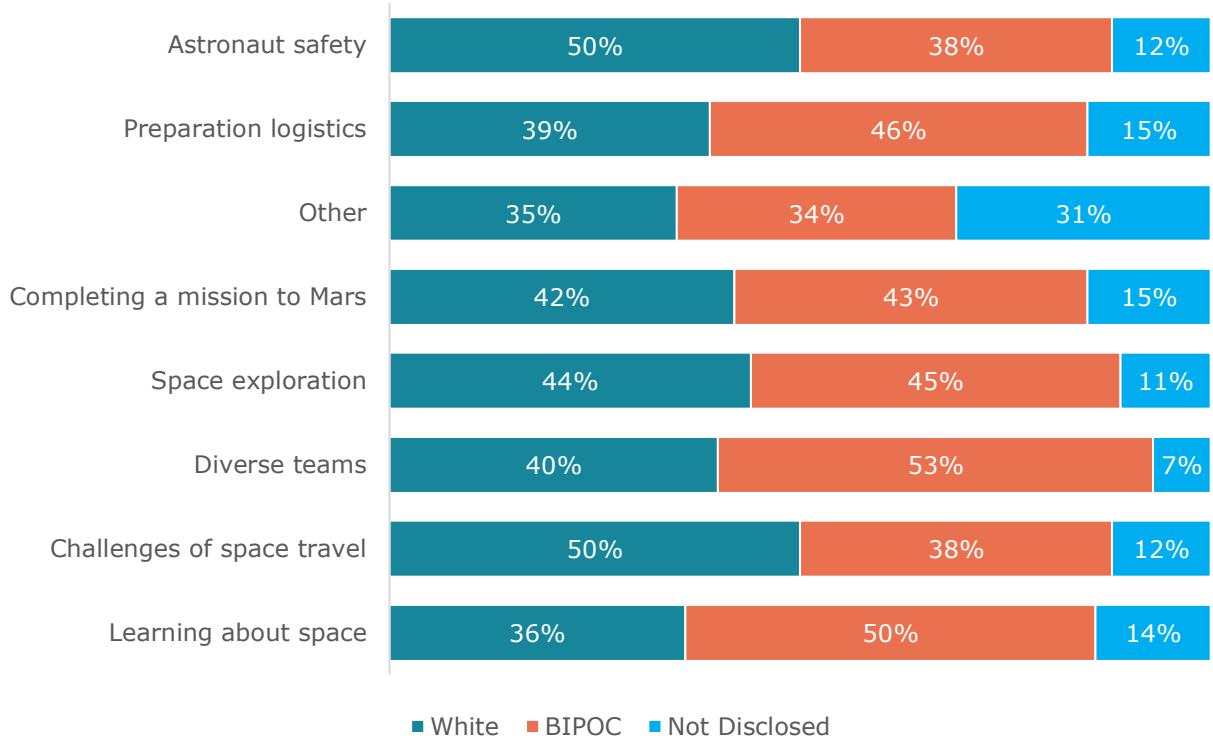


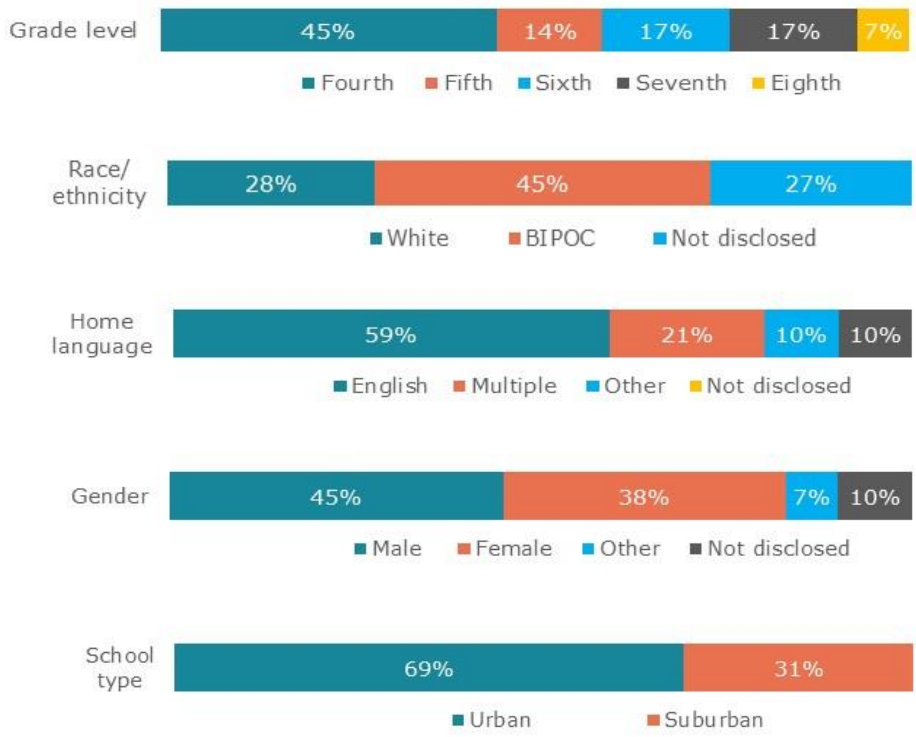
Figure 17. Both white and BIPOC students provided similar responses for all categories. For all three reported categories of students, the largest number of responses were for Astronaut Safety, Preparation Logistics, and Other.



Twenty-nine students (7%) did not respond to the open-ended question. Analysis of these students revealed some findings which may be useful when considering the results, as seen in Figure 18 below. (This figure presents percentages of the twenty-nine students who skipped the question.)

- Recall that more fourth graders identified Other factors outside of those prioritized by NASA compared to students in other grades. Similarly, fourth graders were more likely to skip this question. Perhaps this is another indication of the youngest students feeling more uncertain about the STEM literacy elements of the show and game.
- Despite the overall demographics representing similar percentages of white and BIPOC students, many more BIPOC students did not provide an answer relative to their white peers (45% compared to 28%).
- Males were slightly more likely to skip this question than females, even though they were almost equally represented in the overall sample.
- Given that more English-speaking and urban students responded to the survey than other school types, it is logical that students in these categories represented the highest number of students to skip this question.

Figure 18. Students who did not respond to the open-ended question were primarily fourth graders, BIPOC, English-speaking, male, and from urban schools.



Conclusions

Strengths

Results from this evaluation show that the Bell Museum has developed a planetarium show and corresponding activity that students enjoy, that teaches them new concepts, and that enables them to identify elements that are important to NASA. While students liked both the show and the game, the show was more highly rated, with 88% of students "liking" the show, compared with 54% who "liked" the game. Fourth and fifth grade students reported the highest ratings for "liking" the show and game. Student feedback responses did not differ by gender, language, race/ethnicity, or disability status. Therefore, the project's development appears to have successfully considered and accommodated a range of demographics. Given that more than half of students (59%) indicated that watching the show allowed them to be successful in the game, it is also clear that the content of the show and game are deliberately related. Further evidence of the strong relationship between the show and the game was evidenced by the fact that students reported that watching the show helped them be successful in the game. Additionally, the correlation between high feedback ratings and increased learning ratings indicates that students' enthusiasm for the show and game experiences resulted in understanding new ideas and concepts. Despite playing the game in groups larger than intended, the large group size resulted in higher learning ratings for many students. This finding was an unexpected benefit of the necessity to increase the game group size.

Through their experiences, the vast majority (91%) of students learned something new, and 76% of them believe it will be challenging to send people to Mars. Students were able to independently identify a range of concepts that they view as important to NASA, writing about seven of the eight factors prioritized by NASA. Among these factors, students were primarily focused on the ways that NASA can keep astronauts safe in space and how NASA is preparing for a mission to Mars. These combined takeaways demonstrate that the project successfully addressed its three goals of engagement, interest, and STEM learning.

Challenges and Recommendations

While the project accomplished many of its objectives, there is also always room for improvement. The feedback aspect of the project produced mostly positive results. However, given that suburban students provided more positive feedback about the show and activity, additional data collection and consideration may be warranted to determine which specific elements did not resonate as well for urban and rural youth so that those factors can be addressed or altered in future presentations of the film and/or game.

The student interest findings did not indicate significant differences between demographic groups. However, the STEM literacy results did reveal some areas for consideration. These takeaways should be evaluated with the caveat that most students played the game in a group significantly larger than the recommended team size of four. It is possible that having so many people within a group impacted students' ability to engage with the game's content. The group size effect may explain students' diminished understanding of the challenges impacting deep space travel, despite this being a primary focus for NASA. As far as learning about STEM, fourth graders had the highest percentage of responses in this category, and were most likely to skip the question, which may mean that the main ideas are less clear to younger audiences. Given that this finding supports earlier formative assessment results which revealed that older students grasped and articulated the content more easily, future programs may want to consider focusing on STEM content deliberately targeting grades at the lower end of the spectrum. In contrast, fourth graders were the primary group to identify that

diverse backgrounds, people, and experience are essential for a successful Mars mission. Female students also identified this objective more than males. For future development, the Bell Museum may want to think about ways that older students and males can better connect with and identify this important aspect of NASA's work. One final grade-related takeaway is the fact that eighth graders only identified five of the eight factors that are important to NASA. The Bell Museum can debate whether this finding should be considered a strength or a challenge. Perhaps older students were more clearly focused on certain themes within the show and the game. However, it is also possible that the other three themes did not resonate with students of this age and developmental level. One interesting consideration is the contrast between younger grades providing the highest ratings for feedback and interest, versus the older grades indicating a deeper grasp of the STEM concepts prioritized by NASA. The Bell Museum may want to think more about how to find the correct balance between an enjoyable experience and a meaningful learning experience when they develop future projects.

The analysis revealed that school type influenced student responses to questions about what is important to NASA. This may indicate that students' prior exposure and curriculum background influenced their interpretation and understanding of the show and games' content. Program staff may want to consider how to emphasize specific themes with different groups, when demographic information is available. This could be done verbally, through the introductory comments provided by museum and planetarium staff before presenting the show or game, or visually, by adding signage, marketing materials, or a brief video introduction at the start of a presentation.

Finally, more students who do not speak English at home chose Learning About Space as what is important to NASA compared to their English-speaking peers. Given that this is a broad category and somewhat of a catch-all that encompasses any mention of new space-related understanding, it may be interpreted that students for whom English is a secondary language understood that the show and game were generally about space, but did not walk away with a strong understanding of the show's and game's specific messages.

Final Comments

Overall, the Bell Museum's Planetarium show, *Mars: The Ultimate Voyage*, and corresponding toolkit activity, *Mission to Mars*, were successful in accomplishing the project's goals. In order to better engage all types of students, encourage students' futures in science, and improve content understanding, there are some elements that could be improved or enhanced. Although the potential for minor enhancements exists, the project resulted in two products that provide strong, meaningful learning opportunities for students in grades four through eight. Both the show and the game have the potential to affect the way that students view NASA's work and their understanding of what it will take to send humans to Mars.

References

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Appendix A

Student number:_____
DATE: _____ **Site**_____ **School type:** Urban Suburban Rural

bell museum

Mars: The Ultimate Voyage

We want to know what you thought about the show and the board game, Going the Distance.

	YES! I liked it a lot!	Yes, I liked it.	It was ok.	No, I didn't like it.	NO! I didn't like it at all!
1. Did you like the planetarium show?	☐	☐	☐	☐	☐
2. Did you like playing the game?	☐	☐	☐	☐	☐

	Yes, I definitely needed to watch the show in order to successfully play the game.	Yes, the show helped me play the game.	I'm not sure.	No, the show didn't help me play the game.	No, I could have played the game successfully without watching the show.
3. Do you think the show helped prepare you to make good decisions about how to be successful in the game?	☐	☐	☐	☐	☐

	Yes, I learned a lot of new things.	Yes, I learned some new things.	I'm not sure if I learned anything.	No, I didn't learn anything new.
4. Did you learn anything new from watching the show and playing the game?	☐	☐	☐	☐

	Extremely easy	Somewhat easy	Neither challenging or easy	Somewhat challenging	Extremely challenging
5. How easy or challenging do you think it will be for NASA to plan a mission to Mars?	☐	☐	☐	☐	☐

6. Given what you learned about in the show and game today, what is one thing that seems to be important to NASA?

	Strongly agree	Agree	Undecided	Disagree	Strongly Disagree
7. I would like to have a career in science.	☐	☐	☐	☐	☐
8. My family is interested in the science courses I take.	☐	☐	☐	☐	☐
9. I would enjoy a career in science.	☐	☐	☐	☐	☐
10. My family has encouraged me to study science.	☐	☐	☐	☐	☐
11. A career in science would enable me to work with others in meaningful ways.	☐	☐	☐	☐	☐
12. Scientists make a meaningful difference in the world.	☐	☐	☐	☐	☐
13. Having a career in science would be challenging.	☐	☐	☐	☐	☐
14. I would like to work with people who make discoveries in science.	☐	☐	☐	☐	☐

ABOUT YOU

15. What grade are you in? (Circle one) 4th 5th 6th 7th 8th

16. What category or categories describe you? (Circle all that apply)

American Indian or Alaska Native
Asian or Asian American
Black or African American
Prefer not to say
Hispanic or Latino/a/x
Native Hawaiian or Pacific Islander
White
Other _____

17. What is your gender? (Circle one)

Male Female Prefer not to say Another category; please specify _____

18. If you have a permanent or temporary disability, how do you describe it? (Circle all that apply)
Mobility (Moving)
Visual (Seeing)
Auditory (Listening and Hearing)
Learning (Understanding, acquiring new knowledge)
Cognitive (Thinking, reasoning, remembering, sensing, feeling)
Prefer Not to Say
Prefer to Self-Describe: _____

19. What language do you speak at home? (Circle one) English Other

20. How many people were in your game group? (Including you) _____

Appendix B

Selection of Students' Descriptions of What is Important to NASA

Astronaut Safety (29%)	• *"Keeping the astronauts safe"* • *"To keep you body in shape to stay alive"* • *"One thing that seems important is getting the astronaunts [sic] home safely, alive, and in the same condition"* • *"How to take care of the humans they send out to space"* • *"To make sure there [sic] team is healthy"* • *"To keep people alive on there [sic] way to Mars and on the way home (Earth)"* • *"I think one of NASA's number one priority is keeping the astronauts safe from launch to landing."* • *"Survival"* • *"Humans being alive when coming back"* • *"One thing that seems important to Nasa [sic] is their crew because they need to protect them from things like radiation"* • *"The wellbeing of the Astronauts and their health, as said if their bones or body weakens it would end terribly."* • *"You need to be virus-free, or else the whole crew can get sick and even die."* • *"To keep the astronts [sic] mentally [sic] powerful so they don't go crazy on the roket [sic] ship."* • *"The astronauts and their mental/physical health."* • *"People not dieing [sic]"* • *"I think it is inportant [sic] to NASA that they solve the problems that can affect the astronauts."* • *"The life of the astronauts"* • *"The mental health of thier [sic] astronauts going to mars"* • *"Making sure it's safe for humans"*
Preparation Logistics (18%)	• *"Almost everything is important if one thing is prepared wrong the whole mission could fail"* • *"Have the right resorses [sic] or stuff could go rowg [sic]"* • *"Food air"* • *"Make things as acurit [sic] as possible"* • *"preparing for the trip, organizing"* • *"to have enough food and supplies on the ship to last the whole time"* • *"Making sure everything is packed tightly"* • *"Planning is extremely vital to having a successful trip."* • *"Isolation, clean environment, protection for radiation, distance, and gravity."* • *"Making sure theres [sic] a even balance of stuff when building"* • *"If you have enough gas!!"* • *"That there is just the right food, fuel, oxygen"* • *"research, traing [sic]"* • *"1 Fuel 2 Proper food 3 Water"* • *"to laene [sic] how to work like how to do the buttens [sic] and know how to start the ship"*
Other (10%)	• *"There [sic] space ships"* • *"everything"*

	• *"have to study and write notes and do hard work in class"* • *"the time it takes to go there"* • *"Getting people a new home in case earth is not availble [sic]"* • *"I learned about more space i didn't [sic] know"* • *"help people that don't know about nasa"* • *"money"* • *"I learned that their [sic] are millions of galaxys [sic]"* • *"Getting input from students"*
"Completing a Mission to Mars (8%)	• *"Learn how to get astronauts to the red planet"* • *"succsesfuly [sic] going to Mars"* • *"The mission and concerns going to mars"* • *"Something to seem to be important to NASA is that they been working trying to get to mares [sic] for years"* • *"What I think is important to nasa is compleeting [sic] the missin [sic]"* • *"To help people to go t [sic] mars"* • *"One thing I think is important to NASA is to make it so that people can go to mars"*
Space Exploration (5%)	• *"space"* • *"makeing diskoverys [sic]"* • *"Improving technology so that NASA can go to new places"* • *"being able to explore the universe"* • *"being able to explore different planets"* • *"travel to space"* • *"space exploration"*
Challenges of Space Travel (3%)	• *"Hazards. They need to figure them out in order to go. It's important for NASA to fix them"* • *"How hard it is to get to Mars"* • *"The 5 hazards"* • *"What seems to be important to NASA is being able to fix something when it goes wrong in space, and to have solutions to the problems that may occur in space"*
Diverse Teams (3%)	• *"smart people"* • *"other NASA people"* • *"good team members/scientists"* • *"One thing that is important to NASA is their teammates! they NEED their teammates because they would not make it to Mars or anywhere else alive without them. (Some are doctors to help them)"*
Learning About Space (3%)	• *"Getting to learn about Mars and its mysteries [sic]"* • *"learning new things"* • *"data about space (info)"* • *"space"*