Comparison of Student Learning about Space in Immersive and Computer Environments

COMPARISON OF STUDENT LEARNING ABOUT SPACE IN IMMERSIVE AND COMPUTER ENVIRONMENTS

Laurie Zimmerman and Stacia Spillane, *Houston Independent School District*
Patricia Reiff, *Rice University*
Carolyn Sumners, *Houston Museum of Natural Science*

Received February 26, 2014; Accepted April 25, 2014

Abstract: This paper is the summary of the external evaluation of *We Choose Space,* a 24-minute planetarium show for audiences "who dream of space and wonder about human spaceflight after Shuttle," in which we compared the student learning about space in digital and computer environments immediately afterwards and six weeks later. Paired *t*-tests and an independent *t*-test were used to compare the amount of learning that students achieved on the questionnaire. Interest questionnaires were administered to participants in formal (public school) settings and focus groups were conducted in informal (museum camp and educational festival) settings. Overall results from the informal and formal educational setting indicated that there was a statistically significant increase in test scores after viewing *We Choose Space* in both the portable Discovery Dome (9.75) as well as via the computer (8.88), when tested immediately after viewing. Most importantly, however, long-term retention of the material tested on the questionnaire was significantly better for the students who viewed it in the portable dome over those who learned by computer. Six weeks after viewing the content, the Dome students retained their gains in test scores (10.47), whereas computer-using students had lost most of their gain (3.49), and the improvements over the initial baseline for the computer learners were not statistically significant.

Keywords: students - middle school - space exploration - learning theory and science teaching - assessment - planetarium - immersive - retention

INTRODUCTION

Increasingly, the challenge of engaging youth in learning activities is competing with technology. The average daily time spent with screen media among 8- to 18-year-olds ranks second only to sleeping, increasing from an average of 4 hours and 40 minutes in 1999 to an average of 7 hours and 38 minutes in two decades (Rideout, Foehr, & Roberts, 2010). This impacts education and leads toward the potential expansion of the learning environment.

On another front, a meta-analysis of planetarium efficacy research conducted by Brazzelli & Espinoza (2009) indicated somewhat mixed results in terms of academic performance and/or attitudinal changes toward space science, although overall, the planetarium was found to be more of an effective teaching tool than not.

The positive effect of learning within a portable dome, as opposed to a fixed one, was addressed in an article by Sumners, Reiff, & Weber (2008) that highlighted the expectation that, by providing a direct and visual connection to the subject, higher order learning would accompany the experience. With the use of the portable dome, videos once viewed only in the museum were accessible to a larger pool by offering students access regardless of geographic location.

In his most recent article Jeffery Jacobson (2013) reviewed mastery of learning outcomes based on the communication medium. In addition to a comparison of learning outcomes between those using the computer versus those using the dome, the study addressed the larger question of whether the communication medium made a difference in education, with the contention that every medium provides differences which can be effectively used. Another question is the long term effect of viewing presentations.

Texas has a statewide emphasis on building STEM career awareness. High school students of Rice Engineering and Design Experience (REDE) participating teachers were asked what type of career they wanted to pursue. Over three years, the responses by students that specifically indicated they wanted to pursue space/aerospace or engineering/astrophysics careers increased from 3.4% in 2009-2010 to 6.8% in 2011-2012 (Spillane & Zimmerman, 2012). So in addition to wanting to improve learning outcomes, we were interested in evaluating the affective response with respect to desirability of having a space career.

BACKGROUND

As part of the "Future Space" Project developed with the Louisiana Art and Science Museum, the Houston Museum of Natural Science and Rice University developed programs to be used in a portable Discovery Dome, developed under a prior NASA cooperative agreement (www.eplanetarium.com), and presented both formal and informal learning opportunities for area youth. Funded by NASA under a grant to the Louisiana Art and Science Museum, *We Choose Space* was designed as a 24-minute planetarium show for audiences "who dream of space and wonder about human spaceflight after Shuttle." It was created by the Houston Museum of Natural Science, Home Run Pictures, and Tietronix with scientific oversight by Rice University, and was reviewed by NASA scientists and engineers. Educator Resources accompanied the presentation, including an Educator Guide, Questionnaires, and Activities, developed both by the production team and by teachers in the Rice University Master of Science Teaching program (Sumners et al., 2012). As part of the activities, each lesson was designed using science standards, providing specific directions along with a learning assessment activity. The video, *We Choose Space*, is available to watch in its entirety without charge on the ePlanetarium YouTube channel (*We Choose Space*, 2012).

NASA identified space science education as a method for engaging students in the pursuit of STEM careers, with astronauts seen as role models for students of all ages. They recognized that career choices would be built on experiences that could only happen if students became aware of the programs available and engaged in explorations, either real or virtual. Websites were developed, such as NASA Kids' Club (2013), targeted to appeal to students. The inflatable dome used in the study was a standard mirror-based Discovery Dome designed to hold approximately 25-30 students and used digital projection technology (ePlanetarium, 2014). A photograph of the dome is shown in Figure 1. The portable dome and interactive programs were designed to motivate youth to want to become astronauts and/or assist in solving the challenges in transporting and supporting humans in space and creating products for the next generation of scientists and engineers.

Figure 1. Picture of the portable discovery dome inflated at the public middle school with the dome operator, Dr. Ramkumar Bala, Department of Physics and Astronomy, Rice University.

EVALUATION STRATEGIES AND RESULTS

Evaluation Plan

An external evaluation was undertaken in 2013 to examine student learning and retention of the subject matter presented in the *We Choose Space* video. Student retention in both informal and formal learning settings was compared, as was the effectiveness of the delivery system in the formal setting only, by comparing a sample viewing the video in a portable immersive full-dome digital theater brought to the school to a sample presented the same material using a computer. The evaluation plan and instruments were approved by the participating school district prior to the study being conducted.

Population

In both formal and informal environments, a total of 374 participants, ages 11–17, engaged in the study by taking a pretest and posttest and viewing *We Choose Space*. Of the 374 participants, the informal sample consisted of 104 participants, predominantly boys, also ages 11–17, who attended summer camps held at the Houston Museum of Natural Science during July and August 2013, and 70 middle school students, predominantly girls, ages 11 to 13, who participated in the Sally Ride Festival held at Rice University in October, 2013.

The formal sample consisted of 200 middle school students attending an urban public school in the participating school district. A portable Discovery Dome was brought to the school and 93 students completed the pre/posttests and viewed *We Choose Space* in the dome. An additional 107 students completed the pre/posttests and viewed the video on the computer.

Instrument

A questionnaire was developed using information from the video with the content validity checked by NASA personnel. The instrument was used for all the participants with minor changes in the number of questions presented. In addition to the questionnaires, comments about participants' interest about science and space were collected.

Informal learning environment. In the informal learning environment, the evaluation instrument consisted of 16 multiple-choice items, displayed on one page in which students circled the correct responses (see Appendix A). Each student took the instrument as a pretest upon arrival at the Houston Museum of Natural Science prior to watching the video, *We Choose Space,* in the portable Discovery Dome. The same instrument was administered as a posttest after watching the video at the end of the day at the museum.

Museum personnel were interested in collecting formative data regarding the viewing experience. Therefore, questions for a focus group were developed, administered verbally to the groups, and the results were summarized (see Appendix B). A focus group was held in which participants were asked seven questions of which five centered on the show and two centered on career interest and career choice.

Modification of instrument. Based on feedback from personnel after reviewing the results from the informal learning environment, the questionnaire used for the school was slightly modified from 16 questions to 14 questions. More specifically, when comparing the original 16-question survey to the modified 14-question survey, questions 3 and 9 on the original survey were removed. Furthermore, the responses for question 8 were clarified. The original instrument as well as additional educational resources can be found on the show page at Space Update, Inc. (2013).

Formal learning environment. Because of the need to make it applicable to the educational environment, a comparison of the delivery system (computer vs. portable dome) was used only in the formal learning setting. For the formal learning environment, the evaluation instrument consisted of 14 multiple-choice items (Appendix C). For students who watched *We Choose Space* on the computer, the questionnaire was administered on the computer. For students who watched *We Choose Space* in the portable Discovery Dome, a paper version of the questionnaire was administered. Each student took the pretest the same day. The same instrument was given as the posttest directly after watching the video in the portable dome or on the computer.

To assess their interest in science as well as their overall experience, students took a 25-question interest survey, either online for those who watched the show on the computer or a paper version of the same interest survey for those watching in the portable Discovery Dome. Both multiple-choice and open-ended questions were included (see Appendix D). Of the 25 questions, students answered five that centered on telling something about themselves. The final question addressed their long-term career interest.

To examine long-term retention of the material, a sample of 105 students, of which 58 students had originally watched the video in the portable Discovery Dome and 47 students who had originally watched the video on the computer, were administered the posttest on one of the following days: December 17, 18, or 19. The posttest was the same test that was administered on October 31, 2013. The posttest was administered online for all participants.

Participants Attending Summer Camp at the Houston Museum of Natural Science

Description of study. Five different summer camps were chosen to participate in this study. Four of the five consisted of Boy Scouts who were earning merit badges that included Aerospace, Weather, Space Exploration, and Astronomy. The fifth group was comprised of Girl Scouts. The pretest was given to all of the participants the morning they arrived at the Houston Museum of Natural Science. Participants were post-tested using the same instrument at the end of the day. (In Tables 1 through 4, the numbers are given as percentages of questions answered correctly and the gain is a gain of percentage. All questions were weighted equally. For each student, if the student missed all of the items, the minimum percentage would be 0 and if the student knew all of the items, the maximum would be100.)

Table 1

Summer Camp at the Houston Museum of Natural Science, Results of Paired-Samples T-Test

Pretest		Posttest			95% CI for Mean		
M	*SD*	*M*	*SD*	*N*	Difference	*t*	*df*
66.29	14.94	73.38	17.68	104	-9.96, -4.23	4.91**	103

Note. **$p < .001$ (two tailed).

Data analysis. Table 1 summarizes the results of the analysis. Pre- and posttest results were paired for 104 participants and the differences were evaluated using a t-test for paired samples and eta-squared (η^2). There was a statistically significant increase in the mean student test score from pretest (M = 66.29, SD = 14.94) to posttest (M = 73.38, SD = 17.68), $t(103) = 4.91$, $p < .0005$ (two-tailed). The mean increase in test scores was 7.09. The η^2 statistic (.189) indicated a large effect size (Pallant, 2010, p. 247; Cohen, 1988, pp. 284–287).

Participants Attending the Sally Ride Festival at Rice University

Description of study. An annual event at Rice University, the day-long Sally Ride Festival centers on exposing and interesting middle school girls in science by participating in science and engineering activities. In October, 2013, workshops were available for teachers and parents, and astronaut Barbara Morgan was a speaker.

Due to time constraints caused in part by inclement weather, participants were either pretested or post-tested using the 16-item multiple-choice instrument. An independent t-test was conducted to compare student achievement scores of a group of participants prior to watching *We Choose Space* to a group of participants who had watched the show in a portable Discovery Dome attending the Sally Ride Festival.

Table 2

Sally Ride Festival at Rice University, Independent Samples T-Test

	M	*SD*	*n*	Difference	*t*	*df*
Group A Pre-test	36.74	15.06	41	-19.01, -3.85	3.00*	74
Group B Post-test	48.21	18.29	35			

Note. *$p < .05$ (two-tailed)

Data analysis. Table 2 summarizes the results. There was a statistically significant difference in scores when comparing those participants who had not watched the show in the portable Discovery Dome (M = 39.46, SD = 13.87) to those participants who had watched the show and immediately took the posttest (M = 48.21, SD = 18.29, $t(68) = 2.26$, $p = .027$). The magnitude of the difference in the means was moderate ($\eta^2 = .069$) (Pallant, 2010, p. 243; Cohen, 1988, pp. 284–287).

Participants at a Public Middle School

Description of study. Students attending an urban public middle school in the participating school district took part in this study as part of their science curriculum. A total of 93 students in grades 6-8 saw the show, *We Choose Space*, in a portable Discovery Dome, and took a pretest prior to watching the show and a posttest after watching the show along with an interest and career survey. The hard-copy, one-page instrument consisted of 14 multiple choice questions and was administered as both the pretest and the posttest. The interest survey consisted of a hard-copy, one-page instrument with 25 multiple choice and open-ended questions administered after the posttest. A total of 107 grade 6-8 students took the pretest prior to watching the show on the computer, and took the posttest as well as the interest survey online after watching *We Choose Space*.

Long-term retention was evaluated by administering to a sample of 105 students from the original 200 an online 14 multiple-choice posttest in December, approximately 6 weeks after students watched *We Choose Space*. The middle school student population is 61% eligible for free or reduced lunch and primarily underserved minorities (African American: 33.3%, American Indian: 1.3%, Asian: 5.8%, Hispanic: 57.5%, and White: 2.2%).

Data analysis. The October formal learning environment pretest and posttest results were paired for 200 students and the differences were evaluated using a t-test for paired samples and η^2, the numbers being given as the percentages of questions answered correctly. The coefficient α for the 14-item posttest was .70, reflecting appropriate internal consistency, especially given the low number of items (Nunnally, 1978). There was a statistically significant increase in the mean student test score from pretest (M = 52.21, SD = 19.46) to posttest (M = 61.50, SD = 21.00), $t(199) = 7.07$, $p < .001$ (two-tailed), that gain being a gain in percentage. The mean increase in test scores was 9.29 (SD = 18.48). The η^2 statistic (.200) indicated a large effect size (Pallant, 2010, p. 247; Cohen, 1988 pp. 284–287).

LONG TERM AND INTER-FORMAT DATA ANALYSES

We wanted to analyze the results in more depth, to see if there were time and format interactions and significance. We examined the results with two mixed methods ANOVA tests. The first mixed between-within subjects analysis of variance was conducted to assess the impact of two different delivery formats (computer, portable dome) on participants' scores on the questionnaire across two time periods (pre-test and post-test). There was no significant interaction between delivery type (computer, portable dome) and time, Wilks' Lambda = 1.00, $F(1,198) = .11$, $p = .74$, partial-$\eta^2 = .001$. There was a substantial main effect for time, Wilks' Lambda = .80, $F(1,198) = 49.83$, $p < .001$, partial-$\eta^2 = .20$, with both groups showing an increase in pretest to post-test scores (see Table 3). The main effect comparing the types of delivery format (computer, portable dome) was not significant, $F(1,198) = 1.20$, $p = .29$, partial-$\eta^2 = .006$, suggesting no difference in the effectiveness of the two delivery formats, computer and portable dome, when both are done immediately around the learning event (Pallant, 2010, p. 282).

Table 3

Public Middle School Students, Pre-Post Test Scores for 'We Choose Space' by Delivery System, October

	Computer (N = 107)		Portable Dome (N = 93)	
Time Period	M	SD	M	SD
Pre-Test	53.67	20.64	50.54	17.97
Post Test	62.55	21.45	60.29	20.52

The second mixed between-within subjects analysis of variance was conducted to assess the impact of two different delivery formats (computer, portable dome) on participants' scores on the questionnaire across a longer timeframe, from pretest and six-week follow-up (see Table 4). There was no significant interaction between delivery type (computer, portable dome) and time, Wilks' Lambda =.98, $F(1,103) = 2.47$, $p = .12$, partial-$\eta^2 = .02$. There was a main effect for time, Wilks' Lambda = .91, $F(1,103) = 9.92$, $p < .05$, partial-$\eta^2 = .09$, with both groups showing an increase in pretest to posttest scores. The main effect comparing the types of delivery format (computer, portable dome) was significant, $F(1,103) = 4.93$, $p = .029$, partial-$\eta^2 = .046$, suggesting there was a difference in the effectiveness of the two delivery formats, computer and portable dome, meaning better retention via the portable dome delivery system (Pallant, 2010, p. 282).

Table 4

Public Middle School StudentsPre-Post Test Scores for 'We Choose Space' by Delivery System, Long Term Retention

	Computer ($N = 47$)		Portable Dome ($N = 58$)	
Time Period	*M*	*SD*	*M*	*SD*
Pre-Test	60.49	21.88	50.12	15.57
Post Test	63.98	23.31	60.59	17.15

The numbers are given as the percentages of questions answered correctly, and the gain as gain in percentage. For the students who had watched the show on the computer, the long-term gain was only 3.49 (compared to the short-term gain of 8.88) while students who watched the show in the Discovery Dome had a statistically significant long-term gain (10.47) that was actually slightly larger than their short-term content gain (9.75). Thus, not only did the students who watched the show in the Discovery Dome learn more, they retained it far better than those watching the show on a computer.

Student Interest and STEM Careers

Formal Learning Environment. To assess the effectiveness of the video *We Choose Space* on interest about learning about space and STEM careers, we gave the students a 25-question interest survey. Of the 194 students that answered the question, 150 (77.3%) liked the video and 44 (22.7%) did not like the video. Figure 2 summarizes what students liked best about the video based on a 4-point scale where 1 was *Little* and 4 was *Great*. The majority of students liked when the video talked about the future of the Moon (3.21). This was followed by the way the space station was built (3.12), and what it would be like to live and work on the Moon (3.01).

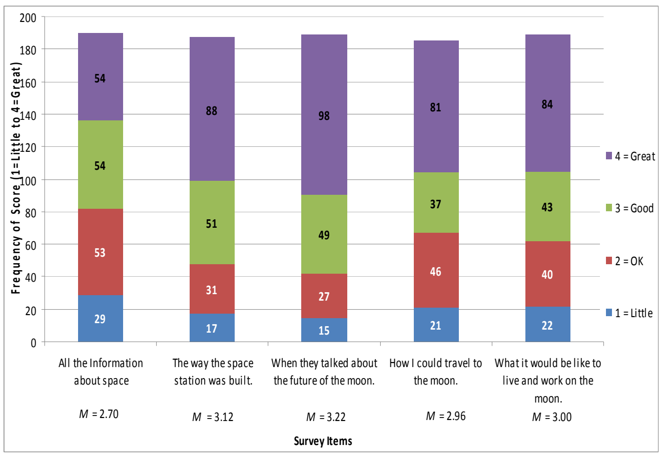

Figure 2. Bar graph showing score distributions (4-point scale, where 1 = Little and 4 = Great) for five survey items answering the question, "What I liked best about the video." Means for each are below the x-axis.

Out of six different items, the highest percentage of students indicated that after viewing the video, they wondered what it would be like to live on the Moon (69.4%), while 64.7% wanted to know more about how to live in space, and 60.2% wondered what it would be like to live on the International Space Station (see Table 5).

Students were asked what they would like to know more about after viewing the video. Of the three selections, space travel received the highest percentage with 59.6%, followed by the Moon (57.1%), and lastly, space careers (25.5%). There were 28 students that provided an additional response. Eleven students wanted to learn more about living on the Moon/life in a dome/building an interplanetary lab, or the International Space Station. Six students wanted to know more about astronauts, space, astronomy, space food, or NASA.

A total of 64 students provided at least one response regarding what they liked or did not like about watching the video in the portable dome. Ten of the responses centered specifically on the dome experience. Comments included, "I liked that it looked 3-D, and we didn't have to wear glasses;" "I like it because it motivated me to learn more about space;" and, "I like how you move to see what's happening, and that it's dark in here."

Table 5

Interest Survey Results: After Viewing 'We Choose Space'…

	N	Yes	No	Maybe
Do you want to know more about space travel?	190	46.3	13.7	40.0
Did you want to know more about how to live in space?	190	64.7	16.8	18.4
Did you wonder what it would be like to live on the moon?	186	69.4	13.4	17.2
Would you want to be a space traveler?	185	33.5	31.9	34.6
Did you wonder what it would be like to live on the space station?	186	60.2	20.4	19.4
Did you wonder what it would be like to live under a dome?	189	51.3	26.5	22.2

Students were asked if they were more interested in space science after watching *We Choose Space*. Out of 184 students who responded to the question, 43.5% indicated *Yes*. When asked if they would like to study more about the Moon and space, 42.2% of 185 respondents indicated *Yes*. Approximately 34% of the respondents indicated that they wanted to learn more about becoming a scientist, while 35% expressed an interest in a career in space science (Table 6).

Students were asked what career they were most interested in pursuing. Out of 198 responses, 102 selected a Science, Technology, Engineering, or Mathematics career, while 12 students specifically indicated a career as an astronaut, aerospace engineer, astronomer, or working at NASA. Sixty-eight students chose non-STEM careers (e.g. musician, professional athletes, law enforcement, and lawyers).

Table 6

Interest Survey Results: After Today…

	N	Yes	No	Maybe
Are you more interested in space science?	184	43.5	25.0	31.5
Do you want to study more about the moon and space?	185	42.2	20.0	37.8
Would you be interested in a career in space science?	184	34.8	36.4	28.8
Did it make you want to learn more about being a scientist?	182	34.1	39.6	26.4

Informal Learning Environment. Five focus groups were held at the conclusion of the day's activities. Participants were asked whether they were interested in pursuing a career in space science. Out of 68 participants that answered the question, 18 or 26% indicated that they were interested in pursuing a career in space science. Participants were asked what career they were interested in pursuing. A total of 39 indicated they were interested in a STEM career while four indicated they were interested in a career as a space scientist, isolation specialist, launching satellites, or studying space health. Five indicated that they were interested in non-STEM careers.

CONCLUSIONS

This study reflects a continuation of a previous study conducted by Sumners et al. (2008). In the current study, the expansion of the environments and long-term retention was measured. Overall results from the informal and formal educational settings indicated that there was a statistically significant increase in test scores after viewing *We Choose Space* in the portable Discovery Dome as well as viewing with the computer. All students who were in the long-term retention group in December took the posttest online, making the evaluation method for collecting the data the same. Since this was the first time that a video was viewed in the portable dome at the school, there is a possibility that this could have affected the results. Therefore, further research is indicated to determine the reliability of this finding.

When examining the long-term retention by delivery format, those students who viewed the show in the dome also had statistically significant increases in test scores, but those students who viewed the show on the computer did not have statistically significant increases. The increase in test scores post – pretest were virtually the same after six weeks for Dome participants as they were just after watching the show in the dome, whereas the students who watched on the computer retained less of their post-show gain in scores. Thus the Dome is a powerful way to not only spark interest, but to help promote learning retention. Possible reasons for this increased retention may be the novelty of the dome environment, fewer distractions in an enclosed environment, and longer-term memory storage from multiple sensory inputs (e.g. direct and peripheral vision).

REFERENCES

Brazzelli, B., & Espinoza, S. (2009). Meta-analysis of planetarium efficacy research. *Astronomy Education Review,* 8(1), 010108. doi: 10.3847/AER2009033

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

ePlanetarium. (2012). *We Choose Space*. [Video file]. Retrieved on 23 March 2014. http://www.youtube.com/watch?v = oC0qS4mHfbs

ePlanetarium. (2014). *Planetarium Domes*. Retrieved from http://www.eplanetarium.com/domes.php

Jacobson, J. (2013). Digital Dome Versus Desktop Display: Learning Outcome Assessments by Domain Experts. *International Journal of Virtual and Personal Learning Environments* 4(3), 51-65. doi:10.4018/jvple.2013070104

NASA. (2013). NASA Kids' Club. Retrieved from http://www.nasa.gov/audience/forkids/kidsclub/flash/#.UsdM-NJDu1g

Nunnally, J.O. (1978). *Psychometric Theory*. New York, NY: McGraw-Hill.

Pallant, J. (2010). *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS for Windows (4th ed.)*. Maidenhead, UK: Open University Press/McGraw-Hill.

Rideout, V., Foehr, U., & Roberts, D. (2010). *Generation M2: Media in the lives of 8- to 18-year-olds*. A Kaiser Family Foundation Study. The Henry J. Kaiser Family Foundation (KFF) - Publications. Retrieved from http://kff.org/other/report/generation-m2-media-in-the-lives-of-8-to-18-year-olds/

Spillane, S. & Zimmerman, L. (2012). *Rice Engineering Design Experience (REDE) Final Evaluation Report for 2010-2012*. Houston, TX: Rice University.

Sumners, C., Reiff, P., & Elvert, J. (2012). *We Choose Space*. Retrieved from http://www.spaceupdate.com/?shows/ddome/we_choose_space/we_choose_space.html

Sumners, C., Reiff, P., & Weber, W. (2008). Learning in an immersive digital theater. *Advances in Space Research*, *42*, 1848-1854. doi: 10.1016/j.asr.2008.06.018

Laurie Zimmerman is a researcher in the Houston Independent School District and the corresponding author. Her email address is laurie.zimmerman42@gmail.com.

APPENDIX A

We Choose Space! Questionnaire

Your responses will assist in the overall evaluation. Please complete by ***circling the letter next to*** *your answer choice for the 16 questions. After finishing the questionnaire return it to the Evaluator. Thank you.*

1. Which U.S. President announced, at Rice University that we would travel to the moon?
   a) John F. Kennedy
   b) Lyndon B. Johnson
   c) Dwight D. Eisenhower
   d) Richard M. Nixon

2. Which country was the first to put a human into space?
   a) The United States
   b) Italy
   c) The Soviet Union
   d) Japan

3. A young Earth was formed from which of the following?
   a) accretion
   b) condensation
   c) planetesimals
   d) all of the above

4. Which of the following theories is the accepted idea of how our moon formed?
   a) fission
   b) impact
   c) capture
   d) co-formation

5. Which celestial object is responsible for Earth's tides?
   a) Sun
   b) comets
   c) Moon
   d) asteroids

6. What is the duration of time an astronaut typically stays on the International Space Station?
   a) 6 months
   b) 6 weeks
   c) 6 days
   d) 6 years

7. What is the main source of power for the International Space Station?
   a) nuclear power
   b) solar power
   c) rocket fuel
   d) oxygen

8. The areas that contain trapped ice on the Moon are:
   a) the poles
   b) the near side
   c) the far side
   d) the craters

9. Sixty five million years ago Earth had an impact with what type of object that destroyed over half of all species?
a) comet
b) meteor
c) planet
d) asteroid

10. What energy fuel on the moon could power tomorrow's nuclear fusion reactors on Earth?
a) hydrogen
b) solar
c) helium 3
d) oxygen

11. The flying human in the lunar habitat is most like
a) an eagle
b) a bat
c) a flying squirrel
d) a moth

12. Creating a human-rated habitat on the moon will likely be
a) expensive
b) difficult to construct
c) not in the near future
d) all of the above

13. If someone is born on and grows up on the Moon, what might happen if they visit Earth?
a) they will be stronger and have weaker bones than folks who grew up on Earth
b) they will be weaker and have weaker bones than folks who grew up on Earth
c) they will be stronger and have stronger bones than folks who grew up on Earth
d) they will be weaker and have stronger bones than folks who grew up on Earth

14. One of the most important things that we have learned from the space program is
a) that Earth is the planet best suited for us to live in so we should take care of it
b) that the Moon would be easy to colonize
c) that a space station can be created quickly and inexpensively
d) that we should use up all our oil on energy and not develop solar energy

15. How does the gravity on the Moon compare to the gravity on Earth?
a) less gravity on the Moon
b) more gravity on the Moon
c) the same amount of gravity
d) there is no gravity on the Moon

16. How often is there a sunrise on the space station?
a) every 24 hours
b) every 90 hours
c) every 24 minutes
d) every 90 minutes

APPENDIX B

The Houston Museum of Natural Science

Focus Group Questions

1. What did you think of *We Choose Space*?
2. What was the best part of your experience?
3. Which programs did you like better and give at least one reason?
4. What is one thing you learned?
5. Is there anything more you would like to know about?
6. After viewing the movie *We Choose Space*, how many of you are interested in knowing more about a career in space science? How many of you are interested in pursuing a career in space science?
7. What careers are you interested in pursuing?

APPENDIX C

We Choose Space! Questionnaire

Your responses will assist in the overall evaluation. Please complete by ***circling the letter next to*** *your answer choice for the 14 questions. After finishing the questionnaire return it to the Evaluator. Thank you.*

1. Which U.S. President announced, at Rice University that we would travel to the moon?
   a) John F. Kennedy
   b) Lyndon B. Johnson
   c) Dwight D. Eisenhower
   d) Richard M. Nixon

2. Which country was the first to put a human into space?
   a) The United States
   b) Italy
   c) The Soviet Union
   d) Japan

3. How often is there a sunrise on the space station?
   a) every 24 hours
   b) every 90 hours
   c) every 24 minutes
   d) every 90 minutes

4. Which of the following theories is the accepted idea of how our moon formed?
   a) fission
   b) impact
   c) capture
   d) co-formation

5. Which celestial object is responsible for Earth's tides?
   a) Sun
   b) comets
   c) Moon
   d) asteroids

6. What is the duration of time an astronaut typically stays on the International Space Station?
   a) 6 months
   b) 6 weeks
   c) 6 days
   d) 6 years

7. What is the main source of power for the International Space Station?
   a) nuclear power
   b) solar power
   c) rocket fuel
   d) oxygen

8. The areas that contain trapped ice on the Moon are:
a) the craters near the equator
b) the near side
c) the far side
d) the craters near the poles

9. What energy fuel on the moon could power tomorrow's nuclear fusion reactors on Earth?
a) hydrogen
b) solar
c) helium 3
d) oxygen

10. The flying human in the lunar habitat is most like
a) an eagle
b) a bat
c) a flying squirrel
d) a moth

11. Creating a human-rated habitat on the moon will likely be
a) expensive
b) difficult to construct
c) not in the near future
d) all of the above

12. If someone is born on and grows up on the Moon, what might happen if they visit Earth?
a) they will be stronger and have weaker bones than folks who grew up on Earth
b) they will be weaker and have weaker bones than folks who grew up on Earth
c) they will be stronger and have stronger bones than folks who grew up on Earth
d) they will be weaker and have stronger bones than folks who grew up on Earth

13. One of the most important things that we have learned from the space program is
a) that Earth is the planet best suited for us to live in so we should take care of it
b) that the Moon would be easy to colonize
c) that a space station can be created quickly and inexpensively
d) that we should use up all our oil on energy and not develop solar energy

14. How does the gravity on the Moon compare to the gravity on Earth?
a) less gravity on the Moon
b) more gravity on the Moon
c) the same amount of gravity
d) there is no gravity on the Moon

APPENDIX D

Future Space Program

Student Survey

Your answers to this survey will be used for evaluation of the program and will not affect your grade in any way. Read the items and mark your answer. After you complete all the survey questions, please return all the materials to your teacher. Thank you!

Please circle the letter corresponding to your answer in the box below.

1. What did you think of the video *We Choose Space*?

A	I liked it	B	I didn't really enjoy it

Because (write a reason)

2. How would you rate seeing *We Choose Space* in the Dome using a 4-point scale?

A	1 Little	B	2 Ok	C	3 Good	D	4 Great

3. What did you like or not like about viewing We Choose Space in the Dome?

Circle the letter corresponding to your answer choice. Please indicate how strongly you agree or disagree with the following statements.

What I liked best about the video…		**Little**	**OK**	**Good**	**Great**
4.	All the information about space.	A	B	C	D
5.	The way the space station was built.	A	B	C	D
6.	When they talked about the future of the moon.	A	B	C	D
7.	How I could travel to the moon.	A	B	C	D
8.	What it would be like to live and work on the moon.	A	B	C	D

Answer the following questions by circling the letter corresponding to your answer choice.

After viewing this video …		**Yes**	**No**	**Maybe**
9.	Did you want to know more about space travel?	A	B	C
10.	Did you want to know more about how to live in space?	A	B	C
11.	Did you wonder what it would be like to live on the moon?	A	B	C
12.	Would you want to be a space traveler?	A	B	C
13.	Did you wonder what it would be like to live on the space station?	A	B	C
14.	Did you wonder what it would be like to live under a dome?	A	B	C

Share something you wonder about.

Please circle all that apply. After viewing this video, I want to learn more about…

15.

A	Space travel	B	The moon
C	Space careers	D	Other_________________________

Please circle all that apply. After viewing this video, how would you find out more about it?

16.

A	From a book	B	Search internet	C	Ask a teacher	D	Other____________________

Please circle the letter that corresponds to your answer.

After today		**Yes**	**No**	**Maybe**
17.	Are you more interested in space science	A	B	C
18.	Did it make you want to learn more about being a scientist?	A	B	C
19.	Do you want to study more about the moon and space?	A	B	C
20.	Would you be interested in a career in space science?	A	B	C

Give a reason why you would or would not be interested in a career in space science?

Please circle the letter corresponding to your answer that tells us something about you.

21. I am:

A	Female	B	Male

22. I'm in grade:

A	5	B	6	C	7	D	8
E	9	F	10	G	11	H	12

23. I'm scheduled for the following class during this time.

A	Science	B	Math	C	Technology	D	Other_________________________

24. For High School I would like to attend __________________________________

25. The career I am most interested in ______________________________