Impact Planning, Evaluation & Audience Research

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Formative Evaluation: *Sphere Corps* Program

Prepared for the
Science Museum of Virginia
Richmond, VA

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SUMMARY OF FINDINGS

INTRODUCTION

This summary presents key findings from the second of two rounds of formative evaluation of *Sphere Corps*, a Science on a Sphere-facilitated climate change program developed by the Science Museum of Virginia (SMV) with funding from the National Oceanic and Atmospheric Administration (NOAA). Data for this study were collected March to June 2012 by Randi Korn & Associates, Inc. (RK&A), and included observation of eight *Sphere Corps* programs and telephone interviews with 40 program participants. The following summary is organized according to intended program outcomes (see Appendix A). Because the program is in its formative stages, it is not appropriate to formally measure outcomes; however, the summary gives some indication of the extent to which intended outcomes may be possible to achieve and explores program implementation related to these outcomes. After two facilitated reflection workshops, staff modified the indicators related to these outcomes to more closely align with what they hope to and think is realistic to achieve through *Sphere Corps*. These modifications and the process of reflection that led to these modifications are presented in Appendix A and detailed in the Discussion on page vii.

The findings presented here are among the most salient. Please read the body of the report for a more comprehensive presentation of findings.

VISITOR ENGAGEMENT

One intended outcome is that *visitors are engaged in the program experience.* Findings related to this outcome are presented below.

- Most participants stayed for the entire program.
- Nearly all observed visitors participated in the program by responding to the iClicker poll questions.
- Observations showed that most participants did not ask questions (nor were they explicitly encouraged to ask questions during most observations); however, several interviewees reported asking questions of the educator.
- When educators used eye contact, body language, wait time, and/or voice inflection to indicate they were seeking a response, the response rate to questions was higher, especially among children.
- The program environment (e.g., background noise) appeared to hamper verbal dialogue between the educator and participants (e.g., educators were not able to hear some participants' responses). One-quarter of interviewees also said the noise from other gallery spaces was a distraction.
- At least one group of visitors was observed staying after the program to talk to the educator or learn more about the Sphere. A few interviewees also reported that they stayed after the program.

- Participants tended to be quiet but occasionally reacted to visualizations with audible expressions of surprise or delight; often, these expressions were made by children (e.g., child participants cheered and shouted after the correct iClicker answers were presented on the plasma screen).
- On a scale of 1, "Not at all interesting," to 7, "Extremely interesting," interviewees rated their opinion of the information presented in the program as interesting (mean = 5.7).

PERSONAL RELEVANCE

One intended outcome is that *visitors perceive the program experience as personally relevant.* Findings related to this outcome are presented below.

- Correct responses to several iClicker questions and individual participant responses indicated that the audience had some prior knowledge of the topic.
- Occasionally participants' responses indicated a personal connection to the material being presented (e.g., one child said, "I was in the Caribbean!" when the educator showed the visualization of Hurricane Irene).
- About one-half of interviewees said the program reminded them that they can actually make a difference by conserving energy; and, a few said the program reinforced that their current actions to conserve energy are on the right track.

CRITICAL THINKING

One intended outcome is that *Visitors use critical thinking in the program.* Findings related to this outcome are presented below.

- Observed body language (i.e., leaning in closely, pointing to the Sphere) showed that most participants looked closely at the Sphere and plasma screen throughout the program.
- Observations show that audience responses to questions indicated that observation was taking place (e.g., During the Carbon Tracker (2004 Plumes) visualization, a child participant said, "Oh, it's getting yellower, getting yellower, and even yellower!")
- Observations show that participants' responses to educator questions sometimes indicated use of visual evidence to support interpretations (e.g., during the visualization showing the Northwest Passage changing over time, the educator pointed out the reduction in ice and asked, "What does this suggest?" A participant answered, "Melting.")
- Observations show that the educators asked several questions that required a combination of close-looking at the Sphere and applying prior knowledge (e.g., the educator said, "Here is a cool weather event from August. What was that?" Several people looked at the Sphere and responded by saying "Irene!")
- Observations show that many of the iClicker questions required prior knowledge (as opposed to observation of the Sphere); similarly, some non-iClicker questions asked by the educators were close-ended and required prior knowledge (e.g., "Does this data suggest things are getting warmer or cooler?" or, "How many people are on Earth right now?").
- About one-third of interviewees provided mostly complete interpretations of at least one visualization that was based on something specific they remembered observing on the Sphere.

- About one-third of interviewees provided partial interpretations of at least one visualization that was based on observations of the Sphere but the observations were vague or general
- Less than one-third of interviewees provided interpretations of visualizations that were based on prior knowledge (not on observation of the Sphere).

CONTENT KNOWLEDGE

One intended outcome is that *Visitors gain content knowledge about climate change.* Findings related to this outcome are presented below.

- In some observed programs, the educator asked the audience to distinguish between climate and weather more than once; there was an increase in correct responses over time, indicating new knowledge about this distinction.
- About one-half of interviewees said that the program emphasized or reinforced their existing knowledge by visually presenting the effects of climate change.
- About one-half of interviewees said they took away new information about how climate change affects the Earth; some provided a specific example (the melting glaciers and ice caps and the resulting sea level rise), while others spoke more generally.

SCIENTIFIC PROCESS RELATED TO SPHERE DATA

One intended outcome is that *Visitors are aware of the scientific process as it relates to Sphere data.* Findings related to this outcome are presented below.

- When educators showed the All Satellites and World Wide Buoy Locations visualizations, they sometimes mentioned scientists as part of this process (e.g., "How do you think scientists gather data about the Earth?").
- Most interviewees did not explicitly mention the scientific process or scientists when describing where the data from the Sphere visualizations come from but rather indicated that this was the case by referencing agencies or organizations responsible for collecting scientific data (e.g., NOAA).
- About one-quarter of interviewees specifically said the data from the Sphere came from satellites, buoys or the National Oceanic and Atmospheric Administration.

ENVIRONMENTALLY-FRIENDLY BEHAVIOR CHANGE

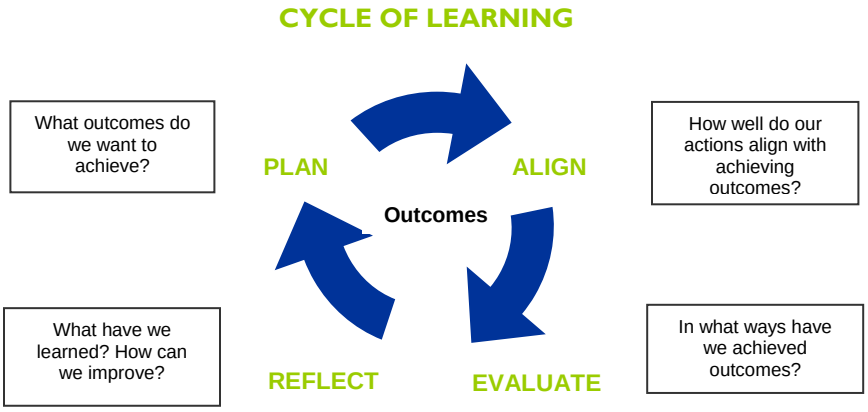
The last intended outcome is that *visitors consider making an environmentally-friendly behavior change.* Findings related to this outcome are presented below.

- In observed programs, environmentally-friendly behavior changes were addressed in the middle-school case study and final iClicker question, when visitors were asked what they were willing to do to reduce the amount of carbon dioxide emitted to the atmosphere.
- More than one-half of interviewees said the program did not pique their interest to explore anything further (e.g., several said they had already explored the topic of climate change).
- A few interviewees said they were curious to explore personal actions they could take to address climate change.

DISCUSSION

INTRODUCTION

The *Sphere Corps* planning and evaluation project conducted by Randi Korn & Associates, Inc. (RK&A) for the Science Museum of Virginia (SMV) included several intentional steps framed around the idea of using evaluation as a learning tool to improve planning and practice. Central to this idea is the Cycle of Learning—four interconnected and continual steps guided by four related questions—which depicts an ideal work cycle in museums.



In order to develop a successful *Sphere Corps* program, we believe SMV must be intentional in its practice by continually clarifying its purpose, aligning all practices and resources to achieve its purpose, measuring outcomes, and learning from practice to strengthen its ongoing planning and actions. To this end, the *Sphere Corps* project included five phases of work—a literature review, a workshop to define intended program outcomes, two rounds of formative evaluation, and two reflection workshops. In this discussion, we focus on the last project step—reflection—and explore how staff's vision for the *Sphere Corps* program has changed over time as they learned from evaluation results and reflected on what is possible to achieve. Following this discussion, we provide recommendations for the *Sphere Corps* program that were collaboratively developed with SMV staff during the final reflection workshop.

WHAT HAVE WE LEARNED FROM THE *SPHERE CORPS* EVALUATION?

At the beginning of the project, SMV staff's goal was to create an inquiry-based Science on a Sphere program about climate change. To inform their planning, RK&A conducted a literature review to explore best practices for Science on a Sphere programs using inquiry in short-format programming (http://www.oesd.noaa.gov/network/SOS_evals/Sci_Mus_of_VA_eval.pdf). The literature review confirmed that SMV's intention to provide a facilitated Sphere experience was in keeping with best practices (as visitors' understanding of Sphere data sets is lessened when a facilitator is absent) (RK&A, 2009; RMC Research Corporation, 2004) and revealed that using inquiry methods in a 20-minute program would be challenging but worth exploring further to help achieve the program's intended outcomes. During a planning workshop entitled, "Clarifying Intended Visitor Outcomes," staff

brainstormed and honed the outcomes they hoped to achieve in the *Sphere Corps* program (see Appendix A). These outcomes guided planning and script development over the next few months, after which RK&A conducted the first of two rounds of formative evaluation. Findings from the first round of formative evaluation (RK&A, 2011) identified implementation barriers, such as noise interference from nearby exhibits, low lighting, and high technological demands, all of which created a challenging environment for educators to effectively use inquiry. Further, staff integrated many iClicker questions into the program script leaving insufficient time for educators to ask open-ended questions that were intended to encourage observation and interpretation of Sphere data sets. Upon reflection, staff reduced the number of iClicker questions and added visualizations and questions that required close observation of the Sphere to answer (such as a visualization showing that most hurricanes originate off the western tip of Africa). Moving the Sphere to a quieter, more isolated exhibit space is a work-in-progress as the Museum remodels; however, in the interim, staff strove to modify their facilitation methods to combat an exhibit environment not conducive to inquiry (for example, moving seating to one side of the Sphere to control the viewing angle).

Following a second round of formative evaluation (the findings of which are detailed in this report), some of the same challenges re-appeared; specifically a noisy environment and few verbal questions asked of visitors (the program still relied primarily on iClicker questions). Staff again made changes to the existing program script to incorporate more open-ended verbal questions, strategies to encourage more observation of the Sphere, and a "backyard" example to increase the program's relevance to visitors (i.e., showing images of the changes at Newpoint Comfort Lighthouse in Chesapeake Bay to demonstrate the effects of sea level rise in Virginia) (see Appendix B). Yet, staff continued to reflect on whether it is realistic to use inquiry and encourage visitors to think critically about the science behind climate change in a single 20-minute program. During the first reflection workshop, staff began to think differently about their approach. Given that the existing script covered a range of topics related to climate change, staff wondered if they should instead go deeper with one topic while encouraging more visitor observation and interpretation of Sphere data. Staff noticed that visitors seemed to take the data visualizations at face value without thinking about *why* or *how* the data came to be, and evaluation findings show that visitors asked few, if any, questions during programs. As one staff member put it, "We want people to *see*, not just look." Out of this discussion arose the idea of "mini-programs"—a series of programs that would focus on communicating one key idea about climate change, such as helping people understand the difference between weather and climate.

HOW CAN WE IMPROVE THE *SPHERE CORPS* PROGRAM?

Central to the idea of the "mini-program" is the idea of doing less to achieve more. Often museums and museum practitioners are asked (or ask themselves) to accomplish too much with one program. Impact and outcomes are incredibly difficult to achieve and trying to achieve too much often results in accomplishing very little. An analogy that illustrates this point well is that of a funnel; if you pour sand into a funnel, it concentrates in one focused stream at the other end. Pour the sand in through the narrow end of the funnel, and the sand scatters. So it is with the resources and outcomes for a museum program; if a museum tries to put limited resources toward achieving too many outcomes, those resources and outcomes become scattered, as there are not enough resources to meaningfully achieve any of the outcomes. Alternatively, if a museum prioritizes and streamlines what it hopes to achieve and focuses resources and efforts to that end, it can go deeper and may be more likely to achieve those outcomes in a more meaningful way.

The second reflection workshop was designed to support staff in embracing the idea of doing less to achieve more. Prior to the workshop, staff conducted internal discussions to prioritize and streamline

the outcomes and indicators in their Outcomes Matrix (Appendix A). Staff successfully removed several indicators from the Matrix, recognizing that while those indicators may be important, the *Sphere Corps* program was not the right platform to try to achieve them. Staff recognized and took comfort in the fact that other exhibits and programs in the Museum were better suited to achieve the indicators. Staff also recognized that their primary goal with the *Sphere Corps* program is to encourage visitors to think more critically about the science behind climate change. To do so, staff brainstormed ideas for "mini-programs," each of which would intentionally focus on: (1) one key idea or question related to climate change; (2) achievement of only a few intended outcomes; and (3) implementation of specific facilitation strategies to achieve those outcomes. The result of this brainstorm is detailed in Appendix F. To illustrate staff's strategy to do less to achieve more, this discussion focuses on one "mini-program" idea that emerged from staff's discussions—*Weather versus climate—what's the difference?*

Staff proposed to focus one "mini-program" on the difference between weather and climate. In this program, staff might use a data set, such as Real-Time Color Enhanced Infrared Satellite, to encourage visitors to investigate the idea of weather, having them focus on what's happening to the local weather in Virginia. This visualization provides visitors with a familiar entry point from which to start their investigation because it is similar to what people see on the Weather Channel and focuses their attention on where they live. Staff might then use a data set, such as Accumulative Hurricane Tracks 1950-2005, to encourage visitors to investigate the idea of climate and climate patterns, having them observe the origin of most of the hurricanes that have affected Virginia. While these choices of visualizations are preliminary, the important thing is that this program would focus on answering one question: What is the difference between weather and climate? Moreover, this program would focus on achieving only two outcomes—*Visitors use critical thinking in the program and recognize these skills as things they do in everyday life* and *Visitors gain content knowledge about climate change*. While other outcomes may result from this program, such as *Visitors are engaged in the program experience*, staff's focus on two outcomes means the resources and facilitation strategies will be focused on achieving these outcomes. For instance, staff proposed to use the following four implementation/facilitation strategies outlined in the Matrix to achieve the above two outcomes:

- Educators ask questions that encourage connections between visitors' prior knowledge and experiences and Sphere visualizations, especially as a way for visitors to enter into the program experience ("What do you know about X?");
- Educators encourage questions, observations, and interpretations grounded in the Sphere visualization (i.e., "What do you think is going on here?" and "What do you *see* that makes you say that?");
- Educators use compare/contrast methods to encourage close looking; and
- Educators use guiding, open-ended questions that elicit multiple responses.

Intentionally covering less content opens up opportunities to more effectively use inquiry methods (such as those outlined in the bullets above) and achieve outcomes. Focusing on asking one question about a familiar topic such as climate and weather also increases the likelihood that visitors will walk away with new knowledge or perceptions, as they can build on their existing knowledge to create an "ah-ha" moment (RK&A, 2012; RK&A, 2009; National Research Council, 2000; Ansbacher, 1999).

While staff's reflection and brainstorming around the idea of doing less to achieve more was a pivotal moment for the *Sphere Corps* program, continued reflection and honing of their ideas are important next steps. To this end, RK&A and staff identified some recommendations and next steps for the *Sphere Corps* program (described below).

RECOMMENDATIONS

- Using Appendix F as a starting point, prioritize and streamline "mini-program" ideas that staff brainstormed by reducing the number of programs from eight to four. As there is natural overlap among the eight program ideas, combining the programs is a logical next step.
- Consider framing each program title as a question to be answered; some of the "mini-program" ideas already do this. Posing a question aligns with *Sphere Corps'* focus on using inquiry and promising to answer an intriguing question about a familiar topic is a "hook" for visitors.
- In addition to using new visualizations and developing different educator and iClicker questions that will encourage visitors to "see not just look," leverage relevant content and questions in the existing versions of the script (Appendix B) so as not to overburden staff.
- Consider the target audience for each program and whether honing the audience would help staff achieve more with each program.
- Consider experimenting with the four new "mini-programs" in place of the current climate change scripts and have educators observe one another to provide constructive feedback about implementation (e.g., How, if at all, were the proposed facilitation strategies used? What was visitors' response? How can we improve?)

ACKNOWLEDGEMENT

RK&A would like to acknowledge SMV staff's willingness to embrace a hybrid planning and evaluation approach to the *Sphere Corps* project. Planning and evaluation are inextricably linked yet too often one is not used to inform the other—a missed opportunity. In this project, SMV staff fully participated in the process, using evaluation as a learning tool to inform their planning and practice. For that, we commend them.

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INTRODUCTION

The Science Museum of Virginia (SMV) contracted with Randi Korn & Associates, Inc. (RK&A) to study its *Sphere Corps* program. This evaluation studies how effectively the *Sphere Corps* program is being implemented. The design of the study was guided by the Sphere Corps Impact Matrix developed collaboratively between RK&A and SMV in March 2011. The matrix outlines the program's intended visitor outcomes and indicators of achievement (see Appendix A).

METHODOLOGY

Two methods were used to collect data: naturalistic observations and in-depth interviews.

PROGRAM OBSERVATIONS

Observations provide objective, qualitative data about how participants experience a program. RK&A conducted eight observations on weekend days in March 2012 of the *Sphere Corps* program about climate change. Program educators used a script as a guide to present the program, and observers reviewed this script in advance for context (see Appendix B). Observers took detailed notes of educators' and participants' behaviors, interactions, and conversations, using an observation guide to focus the observations (see Appendix C).

IN-DEPTH INTERVIEWS

Visitor observations are limiting if they are the only method used to assess the quality of a program. Thus, RK&A also conducted in-depth interviews with program participants to explore the nuances of participants' experiences related to the intended program outcomes. Following several weekend programs, RK&A collected telephone numbers from willing participants at the beginning of each program using a telephone number recruitment form and protocol (see Appendix D). Interviewees were randomly selected from those who completed the form. All interviews were conducted via telephone approximately one week after participants' program experience.

RK&A conducted interviews using an open-ended interview guide (see Appendix E), and following the interview, captured demographic and visit information. RK&A audio-recorded interviews with participants' permission to facilitate analysis.

DATA ANALYSIS AND REPORTING METHOD

Observations and interviews produce descriptive data that are analyzed qualitatively, meaning that the evaluator studies the data for meaningful patterns and, as patterns and trends emerge, groups similar responses. Trends and themes within the data are presented in thematic sections, and, within each section, findings are reported in descending order starting with the most-frequently occurring. The data are presented in narrative. Interviewees' verbatim quotations (edited for clarity) are included, and the interviewer's questions appear in parentheses. Interviewees' gender and age are included in brackets following quotations. Findings are organized in two sections:

SECTIONS OF THE REPORT:

1. Program Observations
2. Telephone Interviews

PRINCIPAL FINDINGS: PROGRAM OBSERVATIONS

INTRODUCTION

RK&A observed eight *Sphere Corps* programs about climate change between March 3 and March 24, 2012. Since all eight programs followed the same script, data for program observations were analyzed together. Five programs were observed between March 3rd and 4th, and three were observed on March 24th. Findings in this section of the report are based on observations conducted on-site.

SPHERE CORPS PROGRAM

An average of 23 participants (14 adults and 9 children) attended each program, with the largest program attended by 35 people (19 adults and 16 children) and the smallest program attended by 16 people (14 adults and 2 children). Slightly more males attended the programs than did females, with an average of 13 males to 11 females per program. Although the adult participants ranged in age, about one-half appeared to be 35-54 years. Slightly more than one-half of the child participants were estimated to be under the target age of 10 years old. All programs lasted approximately 20 minutes.

ENGAGEMENT IN PROGRAM EXPERIENCE

In all programs, most participants watched the presentation closely, shifting their attention between the educator, the Sphere, the iClicker, and the plasma screen. Specific indicators of engagement, developed by the Museum at the beginning of the evaluation, are explored below (see Appendix A).

QUESTIONS ASKED BY PARTICIPANTS

Observations show that participants were not explicitly told to ask questions, and programs were fast-paced, which did not naturally allow for questions. Overall, the evaluator noted three questions, all asked by children. The nature of the questions and the way the educator responded varied. For example:

- In one program, a child asked, "What about the purple and red ones?" during the World Wide Buoy Locations visualization. In response, the educator explained what each color buoy monitors and then said, "That was a good question."

AUDIENCE RESPONSE TO QUESTIONS

The educators asked the audience many questions throughout the program. About one-half were iClicker poll questions, and others were directed openly to the audience; however, there was not usually enough wait time allowed for the audience to respond. Findings below detail the audience's response.

- Little time was built in for the audience to respond to non-iClicker questions. Often educators paused briefly after asking a question before providing the answer or making further remarks.
- When educators used eye contact, body language, wait time, and/or voice inflection to indicate they were seeking an answer, the response rate was higher, especially among children (adults rarely responded). When educators acknowledged correct answers by children, most of the children smiled and/or expressed delight in response.
- The program environment, which includes low lighting, intense technological demands, and considerable background noise from nearby exhibits, impeded verbal dialogue between the educator and audience. In a few cases, audience members attempted to answer by speaking aloud or raising a hand but went unnoticed due to these constraints.

- Some non-iClicker questions asked by the educators were closed-ended and required prior knowledge. For example, the program frequently prompted audiences with "either-or" questions, such as "Does this data suggest things are getting warmer or cooler?" as well as questions with only one correct response, such as "How many people are on Earth right now?"

iCLICKER POLLS

Nearly all visitors participated in the iClicker polls, with the exception of some children under the age of five, latecomers to the program, and a small number of adults. Visitors who entered the program late were not given iClickers. Of those who did not participate in the polls by choice, most were very young children, some of whom shared an iClicker with a parent. Educators read aloud each iClicker question and its multiple-choice options, and then encouraged the audience to select a response.

- Body language and facial expressions indicated that most children who participated in the iClicker polls enjoyed the experience, especially when questions were read aloud with enthusiasm by the educator.
    - During the iClicker question, the educator enthusiastically asked, "Where does all this energy come from?" and read each possible answer aloud. After a few moments, the educator showed the iClicker responses on the screen and shouted, "THE SUN!! You are correct!" Several kids spontaneously cheered, "Yes!" and smiled as the educator continued with the script.
- Most participants' responses were correct, indicating that the questions may be too easy.
- As with some of the non-iClicker questions, many of the iClicker questions required prior knowledge (as opposed to observation of the Sphere).

EXPRESSIONS OF SURPRISE OR DELIGHT

- Although the audience in most programs was quiet, occasionally participants reacted to Sphere visualizations with audible expressions of surprise or delight.
    - Participants said "Whoa!" or "Wow!" in response to certain images, including the volcanic eruptions and airplane visualizations.
- Child participants often smiled or expressed delight after iClicker questions, especially when questions were read aloud with enthusiasm by the educator.
    - In one program, child participants cheered and shouted after the correct iClicker answers were presented on the plasma screen. In response to this, many adult participants laughed.
- Several adult participants laughed quietly at jokes made by the educator or parts of the script, such as the "energy hog" example at the end of the program.
- Adults in the audience frequently nodded throughout educator remarks, indicating their understanding and engagement. A few adults took photos of the Sphere before, during, or after the program.
- Some parents pointed to the Sphere or whispered to explain visualizations to their children, especially in response to educator comments or iClicker questions.

LENGTH OF STAY AND DISTRACTIONS

Most participants stayed for the entire program. Some of those who left in the middle of the program appeared to do so in order to tend to the needs of a child or infant; others were adult-only groups. Usually, at least two people entered the program after it had begun, sometimes standing in the doorway and watching a portion of the program in passing.

In more than one-half of the programs, at least one group lingered after to talk to the educator or learn more about the Sphere. Most people who lingered after the program got out of their seats and walked towards the Sphere to see it more closely and speak with the educator.

Only a small number of participants seem distracted or bored during the program.

- Body language and quiet conversations showed that young children and their parents were occasionally distracted during the program.
- Adults' body language indicated that they were rarely distracted or disengaged by something other than their children. Only a few adults checked their cell phone, yawned, or consulted a museum map during the program.

PRIOR KNOWLEDGE AND PERSONAL RELEVANCE

- Correct responses to several non-iClicker questions from the script indicated that the audience had some prior knowledge.
  - Participants were able to answer the following questions that required prior knowledge: "[Does] anyone know what the current that goes across the United States is? It starts in the Gulf…" "What is the sun?" "Why is Earth always warm around the middle?" "Every time you breathe, what comes out of your mouth?"
- Occasionally participants' responses indicated a personal connection.
  - The Sphere visualization showing Hurricane Irene sometimes elicited a personal response. For example, one child said, "I was in the Caribbean!" when the educator discussed the hurricane.

INQUIRY AND CRITICAL THINKING

Educators encouraged critical thinking by asking questions that are grounded in Sphere visualizations such as "What do you notice about the Northwest Passage today?" or "What does this suggest to us about ice?"

EVIDENCE OF CLOSE OBSERVATION

Most participants maintained eye contact with the educator or Sphere throughout the program, except during iClicker questions. Body language (i.e., leaning in closely, pointing to the Sphere) showed that most participants looked closely at the Sphere and plasma screen throughout the program.

- Occasionally, audience responses to questions indicated that observation was taking place. For example:
  - During the Carbon Tracker (2004 Plumes) visualization, a child participant said, "Oh, it's getting yellower, getting yellower, and even yellower!"
  - During the glacier images on the plasma screen, a participant described the changes observed when the educator asked how it was changing.
- Occasionally, educators identified the audience's use of critical thinking strategies by attributing their correct answers to close observation of Sphere data sets. For example:
  - During the Accumulative Hurricane Tracks 1950-2005 visualization, the educator first pointed out major landmasses and oceans before the iClicker question about the origin of Virginia hurricanes. After the poll, the educator reinforced the idea that the correct

answer was found through close observation of the Sphere by saying, "Alright! Way to read the data set!"

USE OF VISUAL EVIDENCE TO SUPPORT INTERPRETATIONS

- Participants' responses to educator questions sometimes indicated use of visual evidence to support interpretations.
  - During the visualization showing the Northwest Passage changing over time, the educator pointed out the reduction in ice and asked, "What does this suggest?" A participant answered, "Melting."
  - The educator said, "As we look at North America last spring, what happens to the snow and ice as we get into the summer?" An 8 year-old girl in front yelled, "It's melting!" The educator said, "Right!" and further explained that it's receding north.
- Several questions asked by the educators required a combination of close-looking at the Sphere and applying prior knowledge.
  - The educator said, "Here is a cool weather event from August. What was that?" Several people looked at the Sphere and responded by saying "Irene!"
  - During the Earth at Night visualization, the educator asked, "What's all the white stuff?" and two children answered, "Lights!" The educator validated the correct response and built on it by asking, "Who makes them? We do!"

CONTENT KNOWLEDGE ABOUT CLIMATE CHANGE

Due to the reserved nature of the audiences, there was little evidence from observations that participants gained new knowledge about climate change as a result of the program. However, based on body language and verbal murmuring, it was clear that many participants seemed surprised by some of the visualizations. In some programs, the educator asked the audience to distinguish between climate and weather more than once, with an increase in correct responses over time, indicating new knowledge about this distinction.

Occasionally, participants' responses indicated misconceptions about the differences between hurricanes, tornadoes, and volcanoes.

- The educator asked, "What's that picture of right there?" A boy said, "Oh, it looks like a hurricane!" His grandfather corrected him by saying, "volcano," and then the educator explained that it is a volcano.
- The educator asked, "What is that going up the East Coast?" A man said, "Irene," but the educator did not hear him. A boy yelled, "tornado," and the educator explained that it is not a tornado.

AWARENESS OF SCIENTIFIC PROCESS AS IT RELATES TO SPHERE DATA

Educators showed the All Satellites and World Wide Buoy Locations visualizations and explained that these tools are used to collect the information that is seen on the Sphere. Occasionally, the educator mentioned scientists as part of this process. Questions posed by the educator on this topic ranged from "How do you think scientists gather data about the Earth?" to "How do we know this [information about climate change]? Do we put our head outside?" In most programs, participants did not respond audibly to the questions about satellites and buoys, making it difficult to determine their awareness of scientific process as it relates to Sphere data.

CONSIDERATION OF ENVIRONMENTALLY-FRIENDLY BEHAVIOR CHANGE

The educators addressed environmentally-friendly behavior changes through the middle school case study and the final iClicker poll question. For instance:

- During the final iClicker question about environmentally-friendly behavior changes, the educator said, "All of these answers are great things you could be doing to reduce energy use. What are you most likely to do?" In another program, the educator said, "There's a lot that you can do too! [These] are all things you can do to help reduce heat-trapping gases. Just remember that the key thing is to reduce, reuse, and recycle! Save some money and reduce heat-trapping gases."
- During the final iClicker question about environmentally-friendly behavior changes, the educator said, "If you were to make a change, what would you do? There is no right answer, of course, and you might not want to do any of these things. So, of course, for everything, throw this in there: reduce, reuse, and recycle; why not." In another program, the educator similarly explained, "You might not do any of these things; there is no wrong answer."

PRINCIPAL FINDINGS: TELEPHONE INTERVIEWS

INTRODUCTION

RK&A randomly selected 40 interviewees from 124 program participants who provided their telephone numbers onsite at weekend programs in March and April 2012.[1] Telephone interviews were conducted one week after participants' *Sphere Corps* program experience. About three-quarters of interviewees are female (70 percent). Interviewees ranged in age from 18 to 79, with a median age of 41 years. Three-quarters of interviewees (73 percent) were visiting with children. The children ranged in age from 0 to 13, with a median age of 8 years. The majority of interviewees (60 percent) were visiting the Science Museum of Virginia for the first time, and about one-fifth (18 percent) said they had been to a Science on a Sphere program before.

Interviewees also were asked to rate their concern about climate change on a scale of 1, "I am not at all concerned," to 7, "I am extremely concerned." Overall, interviewees indicated a moderate level of concern about climate change (mean = 5.1).

OVERALL EXPERIENCE

Interviewees were asked to rate how much they enjoyed their Science on a Sphere experience on a scale from 1, "I did not enjoy my experience at all," to 7, "The experience was extremely enjoyable." Overall, interviewees found the experience enjoyable (mean = 5.6).

MOST INTERESTING ASPECTS

When asked what they found most interesting about the program, nearly two-thirds of interviewees said the visualizations and/or the Sphere itself was most interesting, either because of the imagery or because of the unique perspective the Sphere affords (see the first and second quotations below). Almost one-half also described one or more specific visualizations they found most interesting. For example, several said they found the Airplane visualization interesting because of the number of planes in flight on any given day (see the third quotation). A few liked the Sea Ice visualization because it was dramatic and showed the impact of climate change. A few liked the 5-year Average Global Temperature Anomalies from 1880-2008 visualization, and one interviewee each liked Earth at Night, Accumulative Hurricane Tracks 1950-2005 and other hurricane-related visualizations, Earthquakes, and Ocean Temperatures (see the fourth quotation). About one-fifth also said they were most interested in the depictions of how the Earth has changed over time (see the fifth quotation). About one-quarter of interviewees also said they liked using the iClicker to respond to questions in the presentation (see the sixth quotation below).

> The globe itself was really [interesting], and I liked that [the presenter] could go through and change how it looked and answer questions by showing it on the globe. That was cool. [female 24]

> The fact that you could see [the world] in 3-D; it really gave you a perspective on it. [female 41]

[1] No program attendees declined to participate. RK&A compared the obtained sample to the interview sample, and there are no differences, indicating a representative sample.

I really liked the fact that [the presenter] could show you all the flight patterns near the end. . . . I thought that was really cool. (And why was that most interesting?) Just because I didn't know there were really that many planes flying at all times. [female 18]

I think the overview of the different aspects of energy use and production and their influences on the climate [was most interesting]. (Why was that most interesting to you?) Because it really showed, especially with things like average heat over time going back to 1900 or even earlier and coming forward, it showed a clear picture of how average temperatures are increasing. [female 42]

It was neat that you could look back over the course of the last several years and look at the climate change. I thought that was pretty cool. [female 42]

I really liked that it was interactive, the Q&A with the hand held [to give your] answers. [female 29]

LEAST INTERESTING ASPECTS

When asked what they found least interesting about the program, about one-half of interviewees said there was nothing, with one clarifying that this may not have been the case for children. About one-half of interviewees named something least interesting, and their responses varied. A few said that the iClicker questions were the least interesting part of the program, stating that the questions disrupted the flow of the program or were too easy (see the first quotation below). A few said that the program lacked in-depth information (see the second quotation). A few interviewees described one or more specific visualizations that they found least interesting (see the third quotation). A few said the presenter's facilitation style was the least interesting part of the program (e.g., how he or she operated the Sphere). The remaining responses were idiosyncratic (e.g., the least interesting parts of the program were the lack of interactivity or the topic) (see the fourth quotation).

I didn't think that the iClicker was that effective with the questions. . . . (And why not?) The questions were pretty much right or wrong and just really basic type of questions. [female 43]

I think the back and forth to different things. . . . (And can you give me an example of the back and forth just so I understand it?) When they were talking about global warming. . . . I would have liked to have more information on things that are happening that are really important. [female 65]

The physical appearance of the planets, I didn't think it was as interesting as the Earth stuff. (And any particular reason?) I feel like that's information I've seen before, that other information was all totally new. . . . It was really cool to watch the globe and to see [the visualizations] move, whereas . . . seeing a planet on a sphere and seeing how the pattern changed, that's information I've seen before. [female 43]

[The presenter] ended [with a] push about climate change and fossil fuel usage. (And why was that least interesting to you?) I didn't think it was [going to] be such a political session. [male 40]

CHALLENGES

Interviewees also were asked what, if anything, they found challenging about the program. Less than one-half said that nothing was challenging. One-quarter said that the location/set-up of the Sphere program was challenging because, for instance, the noise from other gallery spaces was a distraction (see

the first quotation below) or the light streaming in from the front doors interfered (see the second quotation).

> Where they have the Sphere located it wasn't acoustically shut off from the rest of the Museum so the sound reverberates. So there was a lot of reverberation from other exhibits. [female 27]

> We were facing the front of the building where the light came in where it might be better to have the seats on the other side facing inward. [male 79]

One-quarter of interviewees said that the format of the program presented challenges. More specifically, a few said the pace was too fast (see first quotation below). A couple said the program was too short or too long. A few said the technology was not integrated well or the timing of the iClicker questions was unclear (see the second quotation). A couple said the movement of the Sphere was unpredictable (see the third quotation).

> A lot of stuff was fairly new to me so I wish we could [have] go[ne] a little slower. [male 26]

> [The educator] didn't communicate very well how much time we had to answer the question. So, I think some of us clicked and we didn't know whether it registered or not. . . . or if [he or she] had stopped the answer process before we clicked it. So, I didn't really like that part because we didn't know, 'was my answer in this or not?' [female 21]

> The erratic movement of the Sphere [was a challenge], so it was difficult to process the information being presented. [male 52]

A few interviewees said that the program content was a challenge, especially for children (see the quotation below).

> I thought the content of [the educator's] presentation was good. . . . As an adult, I had no trouble keeping up, but I thought for children, [the educator] might have reduced how much [he or she] was covering in one presentation to [be] more focused on one area or another. [female 42]

PROGRAM PARTICIPATION

Interviewees were asked if they participated or interacted during the program, and many said they did. When asked how they participated, nearly all said by using the iClicker to vote in the question polls. Of those that did not participate, most explained that they did not receive an iClicker, usually because they entered the program late.

When probed about whether they participated verbally, most interviewees said they did, either by answering the educator's questions or by asking a question of the educator (a few did so after the program) (see the first quotation below). Many of these interviewees also said they responded to the educator's questions (see the second quotation). A few indicated that the educator did not call on specific individuals, but instead had the group respond as a whole (see the third quotation).

> Several of [my group members] stayed afterward and [the presenter] went [in]to even more detail, and the people in my group really enjoyed that. (And so [do] you remember specific[ally what] the people in your group were asking about or [were] more interested in learning about

after the program?) I think they saw more about the other planets, I think that's what [the presenter] was showing them. [female 43]

When [the presenter] was showing the Polar ice caps on the North Pole, [he or she] asked who lived up there. And my nephew said Santa. (And how did the presenter respond to that?) [The presenter] agreed, yes, Santa did live there. That was the correct answer. . . . And then [the presenter] said polar bears live there, too. [female 54]

[The presenter] was asking a question of the group in general, and I answered out loud with a couple other people. [male 40]

INTERPRETATION OF SPHERE VISUALIZATIONS

RK&A asked interviewees a series of questions about Sphere visualizations to explore the extent to which they recalled and made sense of what they saw on the Sphere.

DESCRIPTION OF SPHERE VISUALIZATIONS

RK&A asked interviewees to describe the visualizations they remember seeing on the Sphere. Many interviewees gave a moderate level of description, indicating the subject of the visualization ("temperature changes in the ocean" "hurricanes" "planes flying") and a partial description of what they saw on the Sphere (providing a vague mental picture of the images they saw) (see the first quotation below). Several gave few, if any, details in their description, often unable to recall what they saw on the Sphere (see the second quotation). A few gave a more detailed description of what they saw on the Sphere, providing a clearer mental picture of at least one visualization (see the third quotation).

[The educator] had one with the clouds on it, and then [the educator] did one with the jet streams; that was interesting. [Then] some time lapse where the ice caps melted and the sea levels rose. I think [also] one of hurricanes or tropical storms. [female 24]

(What did you see on the Sphere?) A lot of things. The Sun, the weather. . . . I'm just trying to think. I don't remember; I'm sorry. [female 58]

There were several different images of the globe as a whole. One [visualization] was the changing ice sheets over the years. There were pictures of different locations different glaciers, before and after pictures, current pictures and pictures from decades ago of a glacier in Canada, and the Matterhorn [or] Kilimanjaro. [male 50]

INTERPRETATION OF SPHERE VISUALIZATIONS

RK&A asked interviewees probing questions about each visualization they remembered, including what they thought the visualization was communicating and what they saw on the Sphere or heard from the presenter that helped them understand that idea. About one-third of interviewees provided a mostly complete interpretation of at least one visualization that was based on something specific they remembered observing on the Sphere (see the first quotation below). About one-third provided a partial interpretation of at least one visualization that was based on observation of the Sphere but the observation was vague or general (see the second quotation). The remaining one-third provided interpretations of visualizations that were based on prior knowledge (or something the educator told them), or they were unable to provide interpretations of Sphere visualizations (see the third quotation).

I know she showed the amount of snow at the poles and brought it from 1600 forward and you could just see as it [the snow] shrunk, and then the same thing she showed several places around the world . . . a picture of what it [the place] looked like back in 1975 and again in 2005, from the same position, same time, same everything. And, you could really see that in 1975, it was completely snow covered, and [30] years later, there was no snow, there was just nothing there. I mean it wasn't even dusted [with snow]. [female 52]

Basically, I focused on the United States, and I saw that almost every state that is along the coastline has a problem with warming up, and it's going to affect them. [female 65]

(You mentioned [seeing] the air traffic. What did you think that represented or was trying to communicate?) I don't really recall that being connected, you know what I mean? In the moment, I just thought, 'oh, that's cool.' I've always wanted to see what that [flight patterns] looks like. I don't think of it in my memory as being connected to overuse of resources and pollution. [female 42]

CONTENT KNOWLEDGE

Interviewees were asked how interesting they found the information presented in the program on a scale of 1, "Not at all interesting," to 7, "Extremely interesting." Overall, interviewees found the information presented in the program interesting (mean = 5.7).

PROGRAM TAKEAWAYS

Interviewees were asked what they learned or took away from the program. About one-half of interviewees explained that they already knew most of the information in the program.

The remaining one-half of interviewees said they took away new information from the program. Of these, slightly more than one-quarter said they learned about how climate change affects the Earth but could not provide a specific example. Slightly less than one-quarter said they learned about the effects of climate change and provided a specific example. Of these, several mentioned learning about the melting glaciers and ice caps and the resulting sea level rise (see the first quotation below). A few each said they learned about the changing Earth temperatures, the changes in climate and weather patterns, the formation and paths of hurricanes, and the buoys and satellites used to collect data. A couple said they learned about the amount of air traffic on any given day and about electricity usage in different cities (see the second quotation). One interviewee each said that the program taught them about tornados, volcanoes, and the Northwest Passage. A few interviewees also said they learned about the importance of conservation (see the third quotation).

[I learned] just how rapidly the glaciers are [melting] at this point, because I didn't realize how fast they had disappeared. [female 25]

I did really like seeing the globe at night. (And did that help you get a new understanding about that?) I think so. Once you were seeing it, you could really compare America to other countries [where there] may be one or two big cities all lit up. But all across the United States [there were] all sorts of highways and just a bunch of cities lit up. [female 24]

I thought [the program] dealt with conservation of the Earth's resources whether it be energy [or] other natural resources. . . . Just being aware that once we lose something, if it's gone, you can't get it back. [female 52]

A few remaining interviewees said they thought the program put too much emphasis on human causes of climate change while ignoring other, natural causes of climate change (see the quotation below).

> I don't buy into it [that humans are the main cause of global warming] as much as some might. I know there is global warming, but the concept that I'm equal to the volcano doesn't cut it with me. What I saw was a blatant effort to convince [us] that global warming is equally [caused by nature and humans]; they didn't differentiate between the causes. [male 79]

NEW KNOWLEDGE OR CHANGED PERSPECTIVES

Interviewees were asked how, if at all, their perspective, opinion, or understanding changed as a result of the program. About one-half said that the program emphasized or reinforced their existing knowledge by visually presenting the effects of climate change (see the first and second quotations below). A few noted one or two specific facts or concepts that they learned or were reminded about through the program, such as the buoys used to collect data or the rapidity of ice caps melting (see the third quotation). A few said that the program did not significantly change their perspective or understanding in any way. The remaining interviewees did not answer the question.

> It really isn't different [than] the things that I already knew. It just provided visual factual information to back up what we've already heard for most of our adult lives. [male 52]

> I didn't have much knowledge or any photo imagery like that [to show] what it looked like. [It] was all talk and conceptual up until all that. [male 40]

> I knew that some of those things [buoys] existed. I had no idea that there were that many different types and that [number] of buoys [in position]. [male 31]

RELEVANCE TO EVERYDAY LIFE

Interviewees were asked how the information presented in the program is relevant to their everyday life, and about one-half said the content of the program reminded them that they can actually make a difference by conserving energy, with many citing specific examples of things that can be done to conserve energy (see the first and second quotations below). A few said they were already doing a great deal to conserve energy and therefore the information in the program reinforced their current actions. A few said that the program is relevant to everyday life because it covers weather-related phenomena that may or may not be intensified by climate change, and weather affects everyone (see the third quotation). A couple of interviewees provided examples of relevant information based on the visualizations presented (e.g., the effect of sea level rise on the coast), and one interviewee each said it was good to know what was going on in the world around you, and it is important for children to understand different viewpoints of climate change (see the fourth quotation). Several interviewees said the information presented in the program was not relevant.

> It is relevant because I want to do more than I'm currently doing to try to preserve fossil fuels and decrease my carbon footprint. [female 43]

> We just need to be careful about the environment, and recycling, reusing and that kind of thing. And that we need to be responsible stewards of our Earth. [female 66]

> In terms of the global warming, there's [going to] be more violent weather. [female 40]

I have kids in school right now who are learning about all sorts of topics, and it's definitely relevant for them to understand not only that point of view, but the alternate point of view as well. [male 43]

SOURCE OF INFORMATION

Interviewees were asked where they think the data on the Sphere comes from. About one-quarter of interviewees said the data came from satellites, buoys or the National Oceanic and Atmospheric Administration (NOAA). A few said it came from the National Weather Service. The remaining responses varied. A few mentioned other government agencies such as the National Aeronautics and Space Administration (NASA), the North American Aerospace Defense Command (NORAD), or the United States Geological Survey (USGS). One interviewee each mentioned personal observations, universities, weather stations, meteorologists and the Hurricane Warning Center. One interviewee was not certain where the information came from.

CURIOSITY TO EXPLORE FURTHER

Interviewees were asked whether the program piqued their interest to explore anything further. More than one-half said the program did not pique their interest. For example, several of these interviewees said that climate change was a topic in which they were already interested, and therefore they have already explored the topic (see the first and second quotations below). Less than one-quarter referenced specific visualizations that piqued their curiosity. For example, a couple said the Accumulative Hurricane Tracks 1950-2005 and other weather-related visualizations encouraged them to learn more about weather (see the third quotation). And, one interviewee each mentioned World Wide Buoy Locations, X-ray Sun, Volcanic Eruptions, Ocean Temperatures, Greenland, and the Northwest Passage as something they were interested in exploring further (see the fourth quotation).

[Climate change] is something I've always been interested in and I read quite a bit about it. . . . It's definitely relevant and something that I am very interested in. [female 21]

These are areas that I actually do have [an] interest in, so this is one more little thing to tuck in my bag of tricks. [male 65]

I would definitely say yes, [it piqued my interest]. It did lead to a conversation [with] my 5-year-old. I think he's really interested in weather, and how storms develop and travel in particular. [female 42]

I think it would be interesting to do a little bit more exploration into the buoys and the information that they're collecting. [My son] loves stuff like that, so [I] think it would be interesting to study a little bit further into that. [female 39]

Other responses varied. A few interviewees said they were curious to explore personal actions they could take to address climate change (see the first quotation below). The remaining responses were idiosyncratic (e.g., the visitor was interested in exploring how to get a job at NOAA, how to share the presentation with others, or spending more time at the Museum (see the second and third quotations).

What else can we do to lower our carbon footprint? [female 45]

I'd love to have a job working [at NOAA]. . . . I would like to be on a shift where you actually go out and maintain the buoys and whatnot; that'd be right up my alley. [male 31]

> The organization that I'm a part of. . . . I'm planning on talking to them about the Sphere program that [the Museum has]. [I'm interested in] seeing if we can do [an] event and show them the images that I saw. [female 21]

Interviewees who said the program piqued their interest to explore something further also were asked how they might follow up on these interests. More than two-thirds said generally that they would do research on their topic of interest, using media such as books, articles, the Internet, and maps. One-half said that they would explore Museum programs and exhibitions (see the first quotation below). A few said they would look into personal actions that could be taken (see the second quotation). A couple mentioned traveling to different places to see the affects of climate change (see the third quotation). A couple also mentioned watching programs on television related to climate change.

> Anywhere we go, we usually go to science museums, [and] that's how [we learn more about climate change]. [female 50]

> Doing more to temperature control the house, driving PVs [plug-in vehicles] and really focus[ing] on buying local products. [male 48]

> I will follow up on the Alaskan glaciers because that's where I was, that's what got me into global warming. So, I'll probably follow up in Alaska, [but] not the actual Northwest Passage. [female 25]

APPENDICES

APPENDIX A: OUTCOMES MATRIX

Target Audience = Walk-in adult visitors and visitors with children ages 10 & older							
Outcome Outcome = Intended result	**1 – Visitors are engaged in the program experience.**	**2 – Visitors perceive the program experience as personally relevant.**	3 – Visitors connect the program experience with other experiences in the Museum.	**4 – Visitors use critical thinking in the program and recognize these skills as things they do in everyday life.**	**5 – Visitors gain content knowledge about climate change.**	**6 – Visitors are aware of the scientific process as it relates to Sphere data.**	**7 – Visitors consider making an environmentally-friendly behavior change.**
Indicators Indicators = concrete evidence of the achievement of an outcome	***Visitors participate in the program by asking questions and responding to iClicker polls.** *Visitors express surprise or delight during or after their program experience (e.g., describe an "ah-ha" moment). ***Visitors stay for the entire program.** *Visitors engage in program-relevant group interaction (e.g., discussion). ***Some visitors remain after programs to look at the Sphere or ask questions.**	***Visitors ask questions explicitly related to Sphere visualizations that have implications for their own life (e.g., agriculture or farming)** ***Visitors recognize ways that climate change affects their lives.** *Visitors say or ask something that relates to prior knowledge.	*Visitors say they went to a related exhibit based on the suggestion of a program facilitator. *Visitors connect their program experience to another experience in the Museum and explain how the two relate.	***Visitors make close observations of the Sphere during the program by describing, in detail, what they see.** ***Visitors ask questions during and after the program that reference what they see on Sphere visualizations (e.g., "How do scientists collect data about sea levels?").** ***Visitors interpret what they see on the Sphere and provide visual evidence that supports their interpretations (e.g., "The United States seems to use more energy than Europe because the United States is covered in more lights.")**	***Visitors report learning something they did not know before (e.g., weather vs. climate, local-global connection, etc.).** ***Visitors express that the program cleared up a misconception.** *Visitors do not state misconceptions they learned during the program.	***Visitors know that Sphere data is real and collected by scientists.** ***Visitors name specific ways scientists collect data (e.g., satellites)** ***Visitors recognize that Sphere visualizations represent data, not real life (e.g., colors represent numbers not the actual phenomena)**	***Visitors express an interest in knowing more about what they can do (e.g., recycle).** *Visitors explore information about what they can do after their program visit (e.g., carpool).

***The outcomes and indicators in bold are those that SMV staff kept upon reflection on the evaluation findings.**

Implementation Indicators Implementation Indicator = program elements that are necessary for the achievement of outcomes	**Key Aspects of Facilitation** a. Educators demonstrate enthusiasm about the Museum, content, and program. b. Educators clearly state program length at the beginning of the program. c. At the beginning of the program, educators clearly state an intention to answer questions after the program. **Educators end each program by directing visitors to other relevant Museum experiences.** d. Educators intentionally select data sets that are relevant to visitors (e.g., locally-based), aligned with content goals, and visually rich e. Educators ask questions that encourage connections between visitors' prior knowledge and experiences and Sphere visualizations, especially as a way for visitors to enter into the program experience ("What do you know about X?"; "Where are you from?"; collectively poll visitors, display results) f. Educators encourage questions, observations, and interpretations grounded in the Sphere visualization (i.e., "What do you think is going on here?" and "What do you *see* that makes you ask that/say that/know that?"). g. Educators deliver content through a dialogue with entire group, eliciting responses from multiple visitors (does not lecture). h. Educators use compare/contrast methods to encourage close looking i. Educators use guiding, open-ended questions that elicit multiple responses and a dialogue. j. Educators scaffold (i.e., use data sets as prompts and clues to help support visitor reflection, reiterate and restate visitors' observations building on their comments). k. Educators use tools to focus visitors' attention on the Sphere (e.g., laser pointer). l. Educators continually assess visitors' understanding throughout the program m. Educators are grounded in the appropriate knowledge to confidently facilitate discussion and answer questions n. Educators use language and vocabulary appropriate to the audience o. Educators ask "How do we know X?" to encourage visitor reflection about the ways data is collected and interpreted p. Educators use data sets that reveal ways scientists gather data (e.g., satellites, buoys, etc.) q. Educators show Sphere visualizations that relate to human-caused impacts. r. Educators encourage visitors to reflect on what they can do (i.e., this is something you can do locally and it will have this impact) **s.** Educators use polling to demonstrate what environmentally-friendly behaviors visitors practice to encourage visitor reflection **Considerations for Sphere Set-up, Design, and Scripts** • The SMV Sphere experience is always facilitated • Small visitor group size creates optimum opportunity to facilitate guided inquiry (when possible) • Considerations may need to be made for poor acoustics in the Sphere presentation area • Bleacher seating so all visitors can clearly see the Sphere visualizations • Program length accounts for visitor attention span (15-20 minutes) • Scripts place emphasis on local and relevant connections (e.g., using Sphere as a rapid response tool) • Scripts encourage consistency among facilitators while allowing opportunities for flexibility

***The implementation strategy in bold was removed upon reflection on the evaluation findings since it related to Outcome 3 which was also removed.**

APPENDIX B: PROGRAM SCRIPT

VERSION A (USED DURING ROUND TWO EVALUATION)

SOS Climate Change – revised February 16, 2012

Science Museum of Virginia
Science on a Sphere – Dr. Maurakis' Climate Change Program

Materials

Science On a Sphere – Climate Change playlist
iClicker System – big screen monitor, computer, presenter and iClickers

Sources

NOAA Science on a Sphere website – http://sos.noaa.gov

Demonstration

Welcome to the Science Museum of Virginia! My name is ___ and today we are going to explore some parameters and events that shape Earth's weather and climate using the Science on a Sphere (SOS)! *Quickly* review some details on SOS equipment and system.

The images you will see are put together from data collected from organizations such as NASA and NOAA, like this image of the Earth from space. The presentation will last 15 to 20 minutes and was developed for ages 10 years and up. We will also be using these, iClickers! Please turn on your iClickers, you should see a blue light at the top of the remote.

Dataset: Blue Marble

We recognize our planet Earth with visual light images of light brown/green land masses and blue water covering almost 73% of the surface. Approximately 97% of Earth's water is salty leaving only 3% fresh water behind. Of that 3% approximately 2% is locked up in ice, leaving about 1% liquid fresh water for our needs. The sphere image indicates how most of the ice on the planet is concentrated at the poles (rotate the sphere around).

Here's our first iClicker question. Don't be alarmed, it's an easy one:

iClicker Question 1:

What happens to ice when the air temperature rises above freezing?

A. No change
B. Changes to a gas
C. Changes to a liquid
D. Changes to a solid
E. Turns into carbon dioxide

As most of you correctly answered ice will change into a liquid, or mel.t

Dataset: Snow and Ice Cover Real-time

This dataset is updated on a daily basis in near real-time. The seasonal variations are very clear as we look at North America. Snow and ice cover moves south in the winter and regresses in the summer. However please take note beginning in August of 2011. For the first time in modern history, or at least since Europeans have been landing here, beginning in 2007 you can now make water passage through an area known as the Northwest Passage. Point out the track of open water with the laser pointer.

Let's refer back to the iClicker screen and compare and contrast a few images from around the world. The photographs were taken from the same angle, day and month but the noted years apart.

iClicker image: Muir Glacier, Alaska: 1941 and 2004

iClicker image: Grinnell Glacier, Montana: 1940 and 2006

iClicker image: Mt. Kilimanjaro, Africa: February 1993 and 2000

iClicker image: The Matterhorn, Switzerland: August 1960 and 2005

Dataset: Impact of 1 Meter Sea Level Rise

There is a lot of scientific evidence to suggest global temperatures have been rising over the last century. Scientists have also observed a rise in global sea levels. What if the oceans rose 1 meter or just over 3 feet from their current levels? Would world populations be affected? All the areas you see in red would be underwater.

We often hear the terms weather and climate being used in discussion, so it's important we understand what each term refers to.

iClicker Question 2:

Weather can be defined as,

A. tornadoes and hurricanes
B. daily temperature, precipitation and wind events
C. solar energy in the atmosphere
D. a seven day forecast
E. the force that produces tides

iClicker image: Definitions of weather and climate

Weather is a daily or near daily occurrence of events: how warm or cold it will be, any precipitation, sunshine, wind. Climate is a long-term, minimum 30-year average of weather events. Let's look at a couple of sphere images and determine if we're looking at weather or climate data.

Dataset: Linear IR Satellite

We're now looking at the last 30 days of cloud cover over the planet up to 7 hours ago with constant updates to the computer every 2 hours. Obviously a weather related dataset. From this dataset extreme weather events like hurricanes can be seen and have been captured for viewing.

Dataset – ty-cyc-hur

Hurricanes, cyclones and typhoons are all the same type of large, low pressure, high wind and precipitation storms. The name refers to the area on Earth where they occur.

Hurricane:	Gulf of Mexico, Atlantic Ocean, eastern Pacific Ocean
Typhoon:	western Pacific Ocean
Cyclone:	Bay of Bengal, Indian Ocean, around Australia

Hurricanes begin as large low pressure systems then build into tropical depressions (winds up to 38 mph), tropical storms (39 – 73 mph) and full-blown hurricanes with sustained winds of at least 74 miles per hour). The U.S. east coast has an active hurricane season between June 1 and November 30. Due to the Coriolis Effect or Force - created by the Earth spinning counter-clockwise as you look down from the northern hemisphere - winds in these storms turn counter-clockwise above the equator, and clockwise below. Where do hurricanes come from and how do they form?

Dataset: Accumulative Hurricane Tracks: 1950 – 2005

Here's a dataset that has tracked hurricanes, typhoons, and cyclones over a 55 year period. Does this image reflect a change in weather or climate? This dataset is a reflection of climate change. Let's position the eastern United States into your view and go to our next iClicker question.

iClicker Question 3:

Hurricanes that affect Virginia usually start as tropical depressions,

A. in the Chesapeake Bay
B. in the Pacific Ocean
C. in the Great Lakes
D. off the tip of western Africa
E. off the coast of Peru

The data indicates most hurricanes that have affected the eastern U.S. formed off the tip of western Africa in the Atlantic Ocean, or at least that's the best selection from the choices. Often a hurricane won't start building strength until it moves further west into the Atlantic Ocean, or even the Caribbean.

Dataset: Hurricane Irene August 23, 2012

Virginia's most recent hurricane tracked from the east somewhere in Atlantic Ocean.

Dataset: 5-Year Average Global Temperature Anomalies from 1888 – 2008

For any report, particularly in science, it's very important one understands how data is collected, interpreted, and presented. This dataset shows a 110 year anomaly or departure from a 30 year norm or mean temperature between 1950 and 1980. Are we looking at weather or climate data? Correct, specific climate changes over a 110 year period. Position North America towards the audience and stop the animation at 2008. Notice that the temperature is at least 2 degrees warmer in the Arctic region than the 30 year norm.

How do we know what we know? How do meteorologists, climatologists and scientists in general obtain information about weather and climate?

Dataset – All Satellites

This data set shows the positions of seven geostationary satellites, the tracks of several polar orbiting satellites, and the location of the white International Space Station on February 15, 2007. Geostationary satellites travel at the same rate as the Earth rotates so each can collect continuous data from one area. They're positioned approximately 22,300 miles from Earth (to scale about the distance to the tinted windows of the sphere room) and travelling about 7,000 miles per hour. Polar orbiting satellites are located about 500 miles from Earth (less than 2 inches from the sphere) and travel at almost 17,000 miles per hour, orbiting the Earth about once every 100 minutes. At that speed polar orbiting satellites cover the entire Earth in less than one day.

Dataset – World Wide Buoys

There are over 3,000 buoys collecting data from the world's major bodies of water: temperature, salinity, and water chemistry, currents including those for El Nino and La Nina, and tsunami warning systems. The data can be used to create the following:

Datasets (back to back) – NASA Sea Currents and Sea Surface Temperatures

Sea currents highlighted where lime green is moving faster than blue. Surface sea temperatures between August 2005 and October 2006 where red is the warmest and blue the coldest temperatures. The shift of warmer water north and south over a year reflects the changing seasons as the sun's more direct sunrays move between the Tropics of Cancer and Capricorn. Highlight the warm water current moving north along the eastern shore of the United States. It's the Gulf Stream!

The planet's weather and long term climate patterns are ever changing. A tremendous amount of energy is needed for these daily global events, moving heat and water vapor around the planet. Let's step back for a second and recognize the driving force for our weather.

iClicker Question 4:

Where does almost all the energy on Earth come from?

A. The Sun
B. The Milky Way
C. Burning fossil fuels
D. The Earth's mantle
E. The Earth's magnetic field

Dataset: Real-time STEREO/SDO Sun Observations

Launched in 2006 the Solar Terrestrial Relations Observatory STEREO consists of two satellites on a path similar to Earth's orbit around the sun. At present each satellite is located approximately ninety degrees to the left and right of Earth with each heading towards the back side where they'll cross in 2015. This real time data set features brighter areas of stronger magnetic force and where solar storms may originate.

Nuclear fusion reactions occurring deep within the sun results in the release of the entire electromagnetic spectrum of energy (radio, microwave, infrared, light, UV, gamma, alpha, beta, etc.) into space at the speed of light. Because the sun is about 93 million miles away the energy reaches our planet in about 8 ½ minutes. Some of the energy is in the form of infrared or heat energy. Our atmosphere contains gases that help keep heat energy from escaping back into space, particularly in the lowest layer, or troposphere. These heat trapping gases include carbon dioxide, methane, nitrous oxide and water vapor.

Dataset: IPCC GFDL b1 Temp Change 1870-2100

This dataset compares carbon dioxide concentrations in the air in parts per billion (ppb) to surface temperature from 1870 to a projected year of 2100. Carbon dioxide concentrations were gathered as scientific data from among other sources Mauna Loa emissions and ice cores. Corresponding temperatures are the response to a computer model, however, actual surface temperatures were researched to justify, check or confirm the model results.

Position North America towards the audience and stop the simulation before or at this year. If you go beyond emphasis the data observed is a model projection, not actual data. What can we see from the data? Over time as carbon dioxide concentrations have increased so has surface temperature.

Where do Earth's heat trapping gasses come from?

iClicker Question 5

Heat trapping gases in our atmosphere originate from,

A. volcanic eruptions
B. burning fossil fuels
C. living and dead organisms
D. exhaust fumes
E. all of the above

Heat trapping gases are the result of both natural and human activities

Dataset: Volcanic Eruptions

The red triangles indicate locations of at least 400 active volcanoes of significant past eruptions. Heat trapping gasses are often released to the atmosphere from any type of volcanic activity to reach the surface, from a slowly seeping vent to an explosive eruption.

iClicker image: photographic of explosive volcanic eruption

iClicker image: people and dog exhaling

Each time an organism respires carbon dioxide is released to the atmosphere. There are many, many forms of life on the planet taking in oxygen and releasing carbon dioxide gas, including the 7 billion plus people at last count. However, since the late 1880s what has man been engaged in that has been adding additional heat trapping gasses to the atmosphere?

iClicker images: smokestacks, cars

Dataset: Earth at Night

Since the Industrial Revolution burning fossil fuels including coal, wood, natural gas and oil-based products has generated heat trapping gases like carbon dioxide. An ever increasing population needs electricity, clean water, sanitary facilities, the ability to heat and cool dwellings, and a means of transportation. The sphere gives us a relatively recent composite image of Earth at night with all the light energy one could see from space. Currently how is most of the electricity produced not only around the world but in the United States? By burning fossil fuels, predominately coal.

Dataset: Air Traffic

The same fossil fuels used to move commercial airlines flying around Earth on a typical day.

There are alternatives to producing energy without adding nearly as many heat trap gasses to the atmosphere: nuclear, hydro, wind and solar to name a few. Every method of producing energy has

its positives and negatives. As individuals, can we do anything in our day to day lives to reduce the amount of heat trapping gasses being added to the atmosphere?

iClicker Images: classroom, hallway, color-coded energy audit cards

This group of 5th grade students at Greenbrier Elementary School in Tidewater, Virginia thought so. They conducted a month-long energy audit checking each classroom to see which teachers were leaving computers and other electrical devices on, and who left doors open designed to keep in heat energy in or out. Students hung red cards on the doors of "energy hogs" meaning they left 3 or more items on, and a checklist of what the teacher could do to reduce energy consumption. Yellow cards denoted fewer violations and green cards to teachers who did not waste electricity by turning off devices when not in the room.

After a month most teachers had green cards affixed to their doors. In the end, the school used less energy and saved over $10,000 on their power bill.

We can all make a difference in reducing the amount of heat trapping gasses being added to the atmosphere. Starting today, what could you do?

iClicker Question 6:

What are you more likely to do?

A. **Adjust home thermostat by 2 degrees or more**
B. **Turn off lights when you leave a room**
C. **Walk or ride a bicycle**
D. **Bring your own bag(s) or backpack for groceries**
E. **Refill your cup or water bottle**

Last iClicker image: For everything in your life: reduce, reuse and recycle

Thank You!

VERSION B (DEVELOPED POST-EVALUATION)

SOS SCRIPT – CLIMATE CHANGE

Revised: 6/14/12

(Datasets, PIPS and iClicker images/questions are in bold)

Welcome to the Science Museum of Virginia! My name is _____. Today we'll be investigating Earth's climate using Science on a Sphere.

The sphere in front of you is not moving, there are four projectors, one in each of the columns around the room which project the images onto a lightweight sphere about six feet in diameter.

The images you will see are put together from data collected by organizations such as NASA and NOAA, the National Oceanic and Atmospheric Administration. Our exploration should last 15-20 minutes. I'm going to need your help in investigating so please interact out loud as well as using your iClickers, which you may go ahead and turn on now.

Dataset: The Blue Marble

Depending on age range of audience, vary questions to introduce the sphere and poles.

Our first image is beautiful planet Earth! What do you notice is the predominant color on the sphere right now? Participants answer verbally Blue! You're right- 73% of the earth is covered with water. 97% of Earth's water is salty, and of the remaining 3% that is fresh water, 2% of it is locked up in ice. Do you find ice when you go east to Virginia Beach? No way, so where is most of the ice on our planet? Participants answer verbally. The poles. *Show poles.*

It's time for our first iClicker question; turn your attention to the flat screen to your right. We're starting with an easy one, what happens to ice when the air temperature rises above freezing? *Polling time, discussion of response*

iClicker Question 1

What happens to ice when the air temperature rises above freezing?

a. No Change
b. Changes to a gas
c. changes to a liquid
d. changes to a solid
e. turns into carbon dioxide

"Then and Now" Images of Glaciers

Keep this fact in mind as we view the photographs on the screen.

This is the Muir Glacier in Glacier Bay National Park and Preserve in Alaska. The first photo was taken in 1941, what do you notice? Now take a look at a photograph taken from the same angle in the same month 63 years later in 2004. What differences do you see? Participants answer verbally

- **Muir** (Glacier Bay National Park & Preserve, Alaska) 1941 2004
- **Grinnell** (Glacier National Park, Montana) 1940 2006
- **Mt. Kilimanjaro** (inactive volcano in Tanzania, Africa; highest mountain in Africa and tallest freestanding mountain in the world) 1993 2000
- **Matterhorn** (mountain in the Pennine Alps, bordering Switzerland and Italy) 1960 2005

What do you think is happening in each of these locations? Participants answer verbally What must be happening to the temperature in each location? Participants answer verbally

Reach the conclusion that the glaciers are not as large now because it is too warm for the ice to grow or maintain size.

Are these four locations isolated incidents of temperature change or do they point to a broader trend? Participants answer verbally; they have no basis of knowing what the right answer is, but say these reflect a broader trend.

Let's find out by looking at scientific data!

Five Year Average Global Temperature Anomalies 1884-2011

This dataset shows us if locations have become cooler or warmer since the late 1800's based on deviation from a 30 year temperature average. The orange-red colors indicate areas where the average temperature has increased, as opposed to blue which indicates a decrease in temperature.

What observations can you make about this dataset? Participants answer verbally. If we watch the color changes starting in 1980 up to 2011, what color appears on North America? What color do you see at the North Pole? Participants answer verbally What does that mean? There is a rapid warming trend observed over the past 30 years, and the greatest warming is taking place in the Arctic.

Impact of 1 Meter Sea Level Rise

Ice cannot survive at temperatures above freezing. Warmer temperatures on Earth cause ice to melt and ocean surface temperatures to rise. When sea temperatures increase, the water expands. Thermal expansion and the introduction of melted ice to the planet's oceans cause the global sea level to rise. Our next dataset shows us what would happen if there was a 1 meter rise in sea level.

What areas are at the greatest risk? Participants answer verbally *Coastline*

New Point Comfort Lighthouse PIP, video

It might be hard to imagine sea level rise by looking at the entire planet. This is New Point Comfort Lighthouse in the Chesapeake Bay. On this 2011 map you can see it all by itself. It hasn't always looked this way, though. As we look at maps from the past, we can see changes in the land surrounding the lighthouse. Here it is in 1964, and 1948, and all the way back to

1917- the lighthouse used to be surrounded by land. Sea level rise, major storms, and the sinking of the east coast severed the connection between the lighthouse and the mainland.

[It might be hard to imagine what sea level rise really means by looking at the entire planet. This is a photo of New Point Comfort Lighthouse in the Chesapeake Bay taken in 1950. It has land surrounding it; however that land does not extend to the mainland. In 1917, as you can see on this map, that connection was still there. By 1948 you can already see a big difference (*pointer)* This 1964 map shows us that the lighthouse now stands alone. In 2011, we see it completely surrounded by water (*pointing then switch to CLIP.)* Because of sea level rise, hurricanes and the sinking of the east coast, the connection between New Point Comfort Lighthouse and the mainland has been severed. (*use pointer with maps)]* This clip gives us recent view of the lighthouse as it stands alone. [Thanks to the New Point Comfort Lighthouse Preservation Task Force for the clip]. (7 inch- sea level increase over past century)

We have seen here the effects of sea level rise and earlier we observed an increase in global temperature. Does this warming trend mean that we won't experience any cool days this summer or a warm day next January?

No. Here we must consider the difference between climate and weather. The next iClicker question asks how to define weather.

iClicker Question 2

Weather can be defined as,

a. Tornadoes and hurricanes
b. Daily temperature, precipitation and wind events
c. Solar energy in the atmosphere
d. A seven day forecast
e. The force that produces tides

Weather describes a daily event, whereas climate describes a pattern of weather for a location over 30 years or more.

Real-Time Color Enhanced Infrared Satellite

This dataset shows us the last 30 days of cloud cover on the planet up to 2 hours ago! Are we looking at weather of climate information? Weather is exactly right! Meteorologists study satellite images similar to this to make weather predictions. What do you observe? Participants answer verbally Let's look at North America. What is going on near Virginia? Participants answer verbally

Accumulative Hurricane Tracks 1950-2005

When we take lots of weather data and put it together, it can be studied for climate patterns. This dataset shows hurricane and tropical storm tracks between 1950 and 2005. What do you notice about hurricanes that affected Virginia, where do they originate? *Orient audience with locations*

Use that observation to answer our next iClicker question.

iClicker Question 3

Hurricanes that affect Virginia usually start as tropical depressions,

a. In the Chesapeake Bay
b. In the Pacific Ocean
c. In the Great Lakes
d. Off the tip of western Africa
e. Off the coast of Peru

Hurricanes that affect Virginia usually start as tropical depressions off the tip of western Africa and gain strength as they traverse warm water.

We've looked at a lot of valuable information so far, but how is this information collected? Where do these images come from? How do scientists collect data on temperature, sea level, and air pollution? Sometimes participants answer verbally before intern shows satellites.

Satellites and buoys provide scientists with important information.

NOAA Polar-Orbiting Operational Environmental Satellites

On the sphere you can see the location of NASA and NOAA satellites orbiting the Earth. Those that appear stationary are traveling at the same speed the earth rotates, to collect continuous data from one location. These satellites are 22,300 miles from Earth, if the sphere were the earth; geostationary satellites would be at the tinted windows. The satellites traveling faster are orbiting at 17,000 miles per hour and are only 500 miles from Earth or 2 inches from the sphere.

Argo Buoy Tracks

Just as satellites monitor from the atmosphere, buoys monitor the oceans. This dataset shows a global array of 3000 free-drifting floats, or buoys, that measure the temperature, salinity and movement of the ocean (upper 2000 m). [The red are tsunami warning systems and the purple monitor for El Nino and La Nina. (Unusually warm/cool sea surface temperatures in the equatorial Pacific Ocean.)] Participants spontaneously ask what the different color buoys represent, and interns answer.

Information from these scientific instruments helps scientists to track and collect data over a period of time. Analyzing this data is how we know what we know!

What we've discovered today, by your observations, is that our climate is changing. Global sea level is rising and temperatures are going up! How can we explain these trends? It all starts with energy! Earth relies on a very important source of energy. Do you know what it is? Go ahead and input your answer now for the fourth iClicker question. *Read question*

iClicker Question 4

Where does almost all the energy on Earth come from?

a. The sun
b. The Milky Way
c. Burning fossil fuels
d. The earth's mantle
e. The Earth's magnetic field

Real-time STEREO/SDO Sun Observations

You got it- the sun. These are Real-time images, the most recent of which shows the sun only five days ago. [The bright spots are where magnetic forces are strongest and solar storms are likely to originate.] Nuclear fusion, occurring deep within the sun, results in the release of the entire electromagnetic spectrum of energy. [Because the sun is about 93 million miles away, that energy reaches our planet in about 8.5 minutes.] Infrared or heat energy gets trapped in our atmosphere by heat trapping gases like carbon dioxide, methane, nitrous oxide and water vapor.

IPCC GFDL b1 Temp Change 1870-2100

This dataset models temperature change beginning in 1870. It also provides the concentration of carbon dioxide, a heat trapping gas, in the atmosphere. (*use pointer to indicate carbon dioxide concentration)* When you see yellow and green, there has been a temperature increase.

What do you notice about temperature? Participants answer verbally with the color change.What about the CO_2 concentration? Participants answer verbally that the number increases, some say it almost doubles. Over time, as carbon dioxide concentrations have increased, temperatures have also. An increase in heat trapping gases does just that, traps more heat!

Where are the heat trapping gases coming from? Can you think of an example?

Test your knowledge with the next iClicker question

iClicker Question 5

Heat trapping gases in our atmosphere originate from,

a. Volcanic eruptions
b. Burning fossil fuels
c. Living and dead organism
d. Exhaust fumes
e. All of the above

These are all sources of heat trapping gases.

Volcanic Eruptions

The red triangles indicate locations of at least 400 active volcanoes. Heat trapping gases are released from any type of volcanic activity from a slowly seeping vent to an explosive eruption.

iClicker Image: volcanic eruption

iClicker Image: people and dog exhaling

When organisms exhale, they release carbon dioxide into the air. With a little over 7 billion people on the planet, that is a lot of carbon dioxide! Volcanoes and exhalation are of course natural events. However, humans have been contributing additional heat trapping gases since the Industrial Revolution began in the late 1800s.

iClicker Image: smokestacks, cars

Burning fossil fuels including coal, natural gas and oil-based products has generated heat trapping gases like carbon dioxide. We use these methods to in factories and electricity generation as well as when we drive our cars.

Earth at Night

Now take a look at Earth at night. What are all those white dots? Participants answer verbally *Bring the US into view* Those are lights, correct. These lights show us high concentrations of electricity generation, the largest source of carbon dioxide emissions in the United States (EPA 2006).

The increasing concentrations of heat trapping gases in our atmosphere are correlated with rises in global temperature and sea level. The observations you've made today match those agreed upon by scientists. Although natural events contribute heat trapping gases to the atmosphere, humans have played an increasingly larger role. Because we have contributed, we also have the power to make a positive change.

Can you think of ways to alter our use of electricity and transportation, the two biggest contributors of heat trapping gases?

This leads us to the final iClicker question- one with no wrong answers!

iClicker Question 6

What are you more likely to do?

a. Adjust home thermostat by 2 degrees or more
b. Walk or ride a bicycle rather than drive a gasoline powered vehicle
c. Bring your own bag(s) for groceries
d. Refill your ceramic cup or stainless steel water bottle
e. Tell a friend

Thank you so much for participating today! Please stick around if you have any questions!

Docents ask if there are other questions. Participants ask a host of questions from I want to see other images, see previous datasets (e.g. the one on volcano occurrences, the hurricane tracks), or in-depth questions like " How do heat trapping gases trap the heat (from a 6-year old girl).

APPENDIX C: OBSERVATION GUIDE

Removed for proprietary purposes.

APPENDIX D: TELEPHONE RECRUITMENT FORM AND TELEPHONE NUMBER COLLECTION PROTOCOL

Removed for proprietary purposes.

APPENDIX E: INTERVIEW GUIDE

Removed for proprietary purposes.

APPENDIX F: "MINI-PROGRAM" BRAINSTORM

GROUP ONE

Program Idea	Audience	Outcomes	Implementation Indicators
Weather + Climate – delineation of weather and climate; trends in temperature (just because it is hot doesn't equal climate change, just because it is cold doesn't mean the earth is getting colder; these changes need to happen over a number of years for it to be climate)	General museum	1,4,5	e,f,h,i
Scientific Data – how satellites and buoys measure data, perfect opportunity to show someone on a boat collecting a sample (personalize it, make it more concrete) – range of ways data is collected	General museum	1,4,6	d,f,i,o,p
Then & Now – Similar to the beginning of the existing program when we use the photographs of glaciers. Based on Dr. Roser-Renouf's suggestion to incorporate more "disaster" photos to show what is happening now (e.g., lighthouse in the bay of Virginia). Around the world, there are places buying land, islands that are disappearing. Before & After pictures – focus on water rising, etc. Long term changes, before and after. Preface with glass of water, to relate it to prior knowledge. Also relate it to the changes in the Northwest Passage. Can provide examples of actions people are taking by providing examples such as the classroom who conducted the energy audit. Also provide examples of actions people took "then" as opposed to "now"; "then" – resource issues facilitated WWII scrap metal drives; "Now" – there has been an increase in bicycle usage in the last # of years, reduced traffic.	General museum	1,2, maybe 5	d,f,h,i,q
Energy – Focus on heat trapping gases. Comes from the fact that we use energy generated from fossil fuels. Most people don't think about where they get their energy from – Earth at Night visualization (where is the energy coming from?); airplanes (burn fossil fuels) – make general public aware that how you use your energy is changing our atmosphere – where is your energy coming from? These are things you can do now to lower energy usage/save money, etc.	General museum	2,7	d,f,i,j,r,s

GROUP TWO

Program Idea	Audience	Outcomes	Indicators
Is Climate Change Occurring? – Use some of the "Then and Now" material, some of the temperature information. Focus on "is climate change actually occurring?"	Earth Science & Adults	5,6	5.1
Measuring Earth's Temperature – scientific processes used by satellites and buoys (infra-red, heat energy reflected, etc.) – is there an everyday association you can use to help show people (make it relatable)? [Heat loss from windows in buildings, goggles worn in video games such as Call of Duty]	Earth Science & Adults	5,6	6.2, 6.3
Heat Trapping Gases – focus on science, understanding that sunlight comes through the atmosphere, reflects off of surfaces [Car in parking lot in summer – gets warm because glass traps the heat energy]	High school and older	5,6	5.1, 5.2, 6.2
How does Climate Change affect me? What can I do? – eco-centric audience, aligns with standards of learning at that age range – challenging to get nuance exactly right	4^{th}, 5^{th}, 6^{th}	2,7	2.1, 7.1