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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INTRODUCTION

This report presents the findings from a 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). This evaluation is the first of two rounds of formative evaluation being conducted for this program. Data for this study were collected in November 2011 by Randi Korn & Associates, Inc. (RK&A), including observations of six *Sphere Corps* programs and interviews with 18 visitor groups.

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

SUMMARY OF FINDINGS

PROGRAM STRENGTHS

- Interviews show that the majority of participants spoke positively of the program, saying it was informative, interesting, and educational.
- About one-third of interviewees found the program personally relevant, and about one-quarter also gained new knowledge (or a new way to think about existing knowledge).
- Participants highly enjoyed the sphere, describing it as visually pleasing, which mirrors findings demonstrated by other studies of Science on a Sphere programs and exhibitions.
- Participants enjoyed the program's interactivity but it also posed challenges (see below); they liked actively participating in the program using the iClicker and seeing the group's collective response to questions.
- Participants found visualizations that were personally relevant or surprising, or provided new information or ways to understand existing information the most memorable; this finding also mirrors other studies of Science on a Sphere programs and exhibitions.
- Few participants arrived late, and nearly all stayed the entire length of the program, remaining passively focused and attentive.
- Older child and adult participants seemed to recognize that the data on the sphere came from satellites and buoys and/or were interested to discover this through the program.

PROGRAM CHALLENGES

- The amount of technology required to deliver the program posed challenges for educators and participants, impeding question and response sequences between the two.
- The large number and types of questions asked during the program disrupted the program's flow and diminished participants' level of engagement (e.g., close-ended iClicker questions did not pose a significant enough challenge for older children and adults).

- The program did not allow for wait time which would have encouraged dialogue between the educator and participants; similarly, participants were rarely verbally encouraged to ask questions during or after the program.
- Background noise from neighboring exhibits, low lighting, and limited viewing of the sphere when seated detracted from participants' experience and ability to participate verbally.
- Participants made few connections between the program experience and the rest of the Museum; those connections participants did forge were superficial.
- Close observations of the sphere were minimal; observations show that some questions did not require close-looking but rather prior knowledge and/or considerable background information from the educator to answer.
- Younger children were challenged by using the iClickers and certain content and terminology.

RECOMMENDATIONS

- Not surprisingly, findings show the sphere to be the primary strength of the program; consider shifting the focus of the program to more heavily include observation of the sphere rather than emphasizing technology that competes with the sphere.
- Consider shortening the program script and reducing the number of iClicker questions so that educators have sufficient time to acknowledge participants' responses and questions and build on these interactions to create a more active educator-participant dialogue.
- Provide training in inquiry and other strategies to engage audiences (e.g., using appropriate wait time after questions, making eye contact with participants in order to encourage verbal responses, building on direct observations of the sphere and personally relevant responses to visual stimuli, etc.).
- Consider beginning the script by clarifying expectations about speaking aloud during the program (e.g., tell participants that answering questions aloud is encouraged, state whether participants should raise hands, etc.), especially for the benefit of child participants.
- Allow adequate time in the script for educators to rotate the sphere so that all participants can see the visualizations being discussed regardless of which side of the room they sit on.
- Consider sound proofing the Science on a Sphere program area to reduce background noise that impedes inquiry-based interaction between the educators and participants.
- Consider creating more challenging iClicker questions that more directly relate to observations of sphere visualizations, rather than questions that rely on prior knowledge of climate change.
- Notify visitors that the program is best suited for children ages 10 and older. Consider creating a version of the program for younger children that focuses on sphere visualizations (rather than iClicker polls) and uses age-appropriate terminology.
- If helping visitors forge connections between the program and the rest of the Museum is important, emphasize these connections throughout the program where they naturally exist.
- Because of its connection to everyday life, the topic of environmentally-friendly behaviors lends itself more readily to open-ended questions and discussion rather than an iClicker poll question with all correct answers. One suggestion is to present an environmentally-friendly behavior that has both economic and "green" benefits (e.g., switching to compact fluorescent light bulbs) for consideration by participants using props and/or examples.

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 in collaboration between RK&A and SMV in March 2011.[1] The matrix outlines the program's intended visitor outcomes and indicators of achievement (see Appendix A).

METHODOLOGY

All data were collected in November 2011 by RK&A staff and trained data collectors.

SCIENCE ON A SPHERE OBSERVATIONS AND PARTICIPANT INTERVIEWS

RK&A conducted six observations of the same *Sphere Corps* program about climate change; RK&A conducted these observations on Friday, Saturday, and Sunday, November 11-13, 2011. 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 field notes describing interactions between the educators and participants during the program using an observation guide to focus the observations (see Appendix C).

Trained data collectors conducted interviews with participants following the conclusion of the 20-minute program. Two to five participants were interviewed after each program. An interview guide was used to focus the interviews (Appendix D), although data collectors probed interviewees about their experiences as necessary.

DATA ANALYSIS AND REPORTING METHOD

All data were analyzed qualitatively. That is, the evaluator studied the data for meaningful patterns and, as patterns and trends emerged, grouped similar responses or behaviors. Trends and themes within the data are presented in descending order, starting with the most-frequently occurring.

Trends from participants' interviews are reported using verbatim quotations (edited for clarity) to give the reader the flavor of participants' experiences and to illustrate their ideas as fully as possible. Within quotations, the interviewer's comments appear in parentheses. Findings are organized around the following two areas:

[1] An important step for the evaluation was to clarify the intended impact of SMV's *Sphere Corps* program. In March 2011, RK&A worked with SMV to define impact statements so that they more closely matched the programs being developed (and target audiences), including a focus on specific content areas and the inquiry approach. Further, RK&A and SMV identified concrete indicators to make the impact statements observable and measureable. This resulted in an Impact Matrix, which can be found in Appendix A.

SECTIONS OF THE REPORT:

1. Interviews
2. Observations

PRINCIPAL FINDINGS: INTERVIEWS

INTRODUCTION

RK&A conducted observations of six *Sphere Corps* programs about climate change on Friday, Saturday and Sunday, November 11-13, 2011. Following each program, trained data collectors conducted interviews with participants immediately after the conclusion of the 20-minute program. Two to five participants were interviewed after each program for a total of 18 interviews. Several interviews included more than one interviewee, such as a couple or a parent and child; thus, approximately 28 individuals' perceptions are represented in the interview data. An interview guide was used to focus the interviews (Appendix D), although data collectors probed interviewees about their experiences as necessary.

SAMPLE DESCRIPTION

Interviewees volunteered to participate in the interview at the end of the program. Interviewees ranged in age. The majority of interviewees were adults between the ages of 22 and 56 years old. A few young children participated during the interview with their parent, and a few children between the ages of 9 and 12 years old participated independently. For about one-half of interviewees, it was their first time visiting the Science Museum of Virginia. Only a few interviewees said they are frequent visitors to the Museum.

PROGRAM PERCEPTIONS

Interviewees were asked what they thought of the program, and nearly all had positive things to say, often referencing more than one aspect of the program in their response. More than one-half of interviewees said that the program was good, very good, or that they enjoyed it. More than one-third said that it was informative, interesting, or educational, with a couple of interviewees saying that it presented a good learning opportunity for kids (see the quotation below). A couple gave generally positive responses about the visual impact and impressiveness of the sphere, a couple praised the program for being brief, and one interviewee each said that it was excellent, amazing, cool, or energetic.

> It was very good. Very interesting. I wanted my daughter to learn something, so I told her she had to come and sit [for] fifteen minutes to learn something.

Some interviewees elaborated on these sentiments and described specific elements of the program they enjoyed, such as the interactivity, the visual imagery, or the technology, in order of frequency (see the quotations below).

> I thought it was really very interesting. He did a really good job explaining things. I liked it being interactive with the voting and stuff like that. It was very good.

> [It was] quite a good show. . . . [I like] the way it's presented on the globe. You feel the whole world. It's a small world, and you feel engulfed.

> I think it is absolutely amazing. This is the first time I've seen this sort of technology. . . . It's so educational.

A few interviewees discussed the program in the context of child audiences, and their perspectives differed significantly. As noted above, a couple of interviewees spoke positively about the learning opportunity for children provided by the program. A couple of other interviewees reiterated the appropriateness of the program for children, but intimated that this might be a drawback for adults because the program is simplified (see the first and second quotations below). However, one parent said that the fast speed of the program was better suited to upper-elementary or early-middle school age children (see the third quotation).

> It was okay. It was much simpler. I think it was designed for kids.

> I thought [the educators] did a really good job being energetic and making the program really interesting, especially for children. As an adult, I already knew most of this stuff. But, as a child, I would have been pretty excited to see this.

> I wish it had been a little slower and more kid-friendly. . . . It really wasn't aimed at [8- to 9-year-olds] to the extent that I hoped it might have been. . . . It probably would have been very good for a fifth grader, early middle school. If the [educator] had spoken slower, explained things a little more, I think it might have been more engaging.

MOST ENGAGING ASPECTS

When asked what they found most interesting about the program, more than one-half of interviewees said that the visualizations and/or the sphere itself was most interesting, either because of the imagery or how the imagery helped them understand concepts related to climate change (see the first and second quotations below). Many interviewees described one or more specific visualizations that they found most interesting. About one-third of interviewees said they found the temperature visualization interesting because they could see the temperature change over time (see the third quotation). A couple of interviewees liked the satellite imagery, and one interviewee each liked the visualizations about weather, flight paths, water currents, volcanoes, and comparison of energy usage in different countries (see the fourth and fifth quotations).

> Visually, it's very attractive, and when I first sat down, I told my husband, 'There's something about looking at the sphere that makes me feel good about the planet.'

> It [the sphere] helped [me] visualize so many aspects of climate change. And, it helped [me] visualize the effect that we're having on our planet.

> I thought the pictures were beautiful. I couldn't get past it. . . . I thought the visuals really helped tie things together. . . . I liked how the colors correlated to the temperature of the planet and how that changed between 1880 and the present. I thought that was the most powerful one for me.

> I liked the [visualizations] with the hurricanes. (Why did you like those the best?) It showed where they come from and the path they take, and that was interesting.

> The satellites were very interesting. I didn't know that there were satellites spinning around all the time. I thought they were just staying up there.

Other responses to the question varied. A couple of interviewees said they were most interested in the opportunity to expose their children to environmental issues. A couple said that learning about the rise in temperature was the most interesting part of the program, and a couple of interviewees said the interactive components were most interesting (see the first and second quotations below). One interviewee each stated that learning about the need to protect the Earth, energy conservation, or climate change in general was most interesting to them.

> [Learning] that the Earth temperature has risen two degrees over a hundred years [was most interesting] because I didn't know that before, and if it keeps rising, all the ice is going to melt.

> I liked how it was interactive, where it asked you questions. You know, it presented facts. I thought it was especially well geared towards middle or high school-age children.

LEAST ENGAGING ASPECTS

When asked what they found least interesting about the program, more than one-third of interviewees said that there was nothing they found uninteresting. About one-fifth of interviewees said that the airplane or air traffic visualizations were least interesting to them, either because they were not clearly explained or because the topic itself did not seem like a compelling illustration of climate change (see the two quotations below).

> [It was least interesting] when they showed all those jets pass. . . . They showed it for quite a while, and they didn't really explain what we were seeing. I didn't know what we were seeing until the [educator] made a passing remark at the end.

> The little airplanes [were least interesting to me]. I thought there were other facts that he could have [used instead]. I know that he was trying to [discuss] the congestion and carbon dioxide. But, I thought he could have used other things [to demonstrate that].

A few interviewees, both children and adults, said that the iClicker questions were the least interesting part of the program, for varying reasons including that the questions are confusing or simply uninteresting (see the first quotation below). The remaining responses were idiosyncratic (e.g., the least interesting parts of the program were the visualization about ice at the poles, the temperature visualization, that it was difficult to see the sphere from certain angles, or the parts of the program that seemed geared towards children) (see the second and third quotations).

> I [was] a little underwhelmed by the questionnaires. I think that's probably [my] main [complaint]. (What kinds of questions would have been better?) [It] would have been far more effective to [discuss the] technology like the Facebook piece.

> I think if [the program] had a quicker flow to it, [it would have been more interesting]. Sometimes, it was like, 'Well, here's this,' and then you look at it for a little bit, and then you move on to the next thing.

> I found all of it interesting, but the kids have a very finite attention span, so actually something a little bit shorter [would have been more interesting to them]. Because my son, and even my 3-year-old, were engaged a little bit in the beginning, but then as it continued, they lost interest.

CHALLENGES

Interviewees were also asked what, if anything, they found challenging about the program. About one-half of interviewees responded by saying that nothing was challenging, with a few clarifying that this may not be or was not the case for children (see the first quotation below). About one-fifth of interviewees said that some aspects of the program content were challenging for their children or "above their heads," including some of the abstract visualizations and/or iClicker questions (see the second and third quotations). One of these interviewees reiterated that the program went too fast for elementary-age children.

> I didn't find anything challenging. But, I think it's a challenge to a lot of children.
>
> Me? No. My 6-year-old? Maybe the hurricane stuff [was challenging]. I mean, while I found it really interesting to watch Katrina, it was just a bunch of swirling clouds to them. So, that was probably a little bit over even my 6-year-old's head.
>
> The satellites. Those were kind of hard to understand. He said something like, 'The white satellite is special from the others,' and I forgot what it is. And, also, the questions are kind of hard to understand, especially since I'm only nine.

A few interviewees said that the iClicker questions were challenging because they were hard to see on the screen, too detailed, too long, and/or confusing (see the first quotation below). One interviewee said that the topic of saving energy is challenging in general (see the second quotation), and another interviewee said that it was challenging to see sets of data that had not been cited (see the third quotation).

> The questions were too detailed. They should be shorter. . . . And, we couldn't see [the screen] from here. I'm wearing glasses, and I still couldn't read it. There were just too many words. It should be a little bit shorter and more to the point. Maybe [fewer] options.
>
> How you can save energy. . . . It's easier said than done.
>
> There was not as much of an emphasis on how they got their data sets. And sometimes [the educator] made generalizations which, while I believe they're true, were not [supported by] a thorough explanation of where [they are] coming from.

PROGRAM FORMAT

Interviewees were asked to share their perceptions of the program format and discuss whether or not they participated or interacted during the program.

PERCEPTIONS OF PROGRAM FORMAT

About one-half of interviewees said they liked the interactive or participatory components of the program format (see the first and second quotations below). Most of these interviewees elaborated, saying they liked using the iClicker to answer questions, and a few noted specific elements of this process that they liked, such as the anonymity of voting or the opportunity to expose their children to new technology (see the third and fourth quotations). While discussing the iClickers, one interviewee said that fewer questions, and less interactivity, would have been better (see the fourth quotation). About one-third of interviewees gave general positive feedback about the program format (e.g., "it was good").

> I liked [the program format]. It was very interactive. I liked the clickers, and then seeing the graphs of how everyone did. That was very informative.

> I thought [the program format] was good [be]cause we actually participated in it. It wasn't just a lecture.
>
> The clicker, for [the children], is a great thing. (Why do you think it's good for them?) Well, we're moving into the age of new technology, and it teaches them, the format is good for standardized testing. With the clicker, instead of putting up your hand and shouting out the answer, they were able to feel like they were all participating without competing. So, I think that part is good for little children.
>
> [The clickers are] anonymous and time saving. It's a good idea. *Yeah, [but] maybe [there] should be [fewer] questions because we need to know something new [but] it's just too much interaction.

A few interviewees said that the screen with questions was difficult to see (see the first quotation below), and some provided suggestions for improving this, such as projecting the questions in larger [print] or reducing the number of answer options. A couple of interviewees also commented that the educator's narration was helpful for addressing this issue (see the first quotation). Similarly, one interviewee said that the number of different things to look at, including the educator, screen, and sphere, was challenging. Other responses were idiosyncratic, including that some of the questions were too difficult, too many questions took the focus away from the sphere, or they would have liked the opportunity to request certain visualizations or angles on the sphere.

> At first I didn't notice that there was a screen there. I think, for people with visual problems, it might be difficult to read the questions. But, [the educator] did a good job pointing at the screen, making sure people know it's there, and then reading the questions and the answers out loud.

LEVEL OF PARTICIPATION

Interviewees were asked if they participated or interacted during the program, and many said they did. When asked to clarify how they participated, nearly all said they participated by using the iClicker to vote in the question polls (see the first quotation below). Of those that did not participate, most explained that they did not receive an iClicker, usually because they entered the program late and therefore could not or did not know how to participate. Several parent interviewees said they shared the iClicker with their child or that their children had to share an iClicker (see the first and second quotations). A few interviewees said they and/or their children enjoyed using the iClicker despite occasional challenges (see the second and third quotations). One child suggested that using the iClicker was a fun museum activity because you could directly participate (see the fourth quotation).

> We participated together on one clicker. For questions I thought [my daughter] would know the answer to, I would ask her.
>
> We had only one [clicker even though we had] two children. But they loved it. Yes, [my daughter] used it, and then they had to share, so it wasn't accurate, but the clicker, for them, is a great thing.
>
> I liked the clicker part. (Did you and your two children all participate with the clickers?) I helped them. But I don't know if they learned through it. I mean, since I was helping them, I don't know how much they learned because they can't really read, but they heard the questions.

> That was pretty cool. I haven't used a clicker in any museums before. (What do you like about it?) That you could actually fill [in] your own answers.

When probed about whether or not they participated verbally, a few interviewees said they did, usually explaining that they responded to one or two of the educator's questions (see the first quotation below). None of the interviewees said that they asked the educator a question. After discussing the fact that her children tried to call out answers and raise their hands without being called on, one parent interviewee suggested that the educator clarify whether or not verbal answers and/or hand-raising is encouraged, because this was unclear (see the second quotation).

> (Did you participate in any other way, like by asking questions or responding verbally to questions that he posed?) Not really. (Did you feel like you had the opportunity to do that?) Only when he was showing the clip of Hurricane Irene, I did say, 'Oh! That's Hurricane Irene.' I remember that. But that was pretty much it.

> If you're looking for people to blurt out answers, then [the educator should] encourage that at the beginning, so that a 6-year-old would know [whether] he's allowed to shout out an answer or he has to raise his hand.

UNDERSTANDING OF PROGRAM CONTENT

SEEING AND UNDERSTANDING THE SPHERE

Interviewees were asked if they were able to see or understand everything that was shown on the sphere, and more than one-third said that it was difficult to see the sphere from certain angles. Some interviewees elaborated, saying that they were sitting on the opposite side of the room from what was being discussed on the sphere, that the sphere visualization changed or rotated too quickly, and/or that they wanted to see a certain country or region on the sphere that was not in their range of view (see the first and second quotations below).

> One thing I didn't really get is how [the educator is] looking from that angle, and I was looking from over here, so I didn't actually see what he was talking about.

> [The educator] kept rotating [the sphere] around. So, sometimes you didn't see the U.S. and sometimes you did.

One-third of interviewees said they were able to see and understand everything that was shown on the sphere. A couple of interviewees said they could see the sphere, but they could not see the screen with questions (see the first quotation below). Other responses were idiosyncratic (e.g., it was difficult to understand the time differences on the sphere, the visualization showing the ice at two poles, the temperature change visualization, or the clicker buttons) (see the second and third quotations).

> The sphere is good, but that screen is too far. Maybe the materials should be kind of pushed all together and the screen [moved] closer.

> The only thing that was confusing was the thing with the ice where I was trying to figure out if it's going backwards in time or forward in time. That was the only thing that I would make more clear.

> There are some difficult things you're trying to understand. (Like what?) Well, the one about the differences in the temperature over time. And he tried to explain it.

PROGRAM TAKEAWAYS

Interviewees were asked what they learned or took away from the program. About one-third of interviewees explained that they already knew most of the information presented in the program, but some of them clarified that the program reinforced what they already knew, offered interesting new ways to visualize aspects of what they already knew, or helped impart new knowledge to their children (see the first and second quotations below). Several interviewees said that the program taught people, especially children, how to conserve energy in simple but important ways (see the second and third quotations).

> I don't think I really took anything away that I didn't already know because I understand the basics behind climate change. [But], I thought some of the stuff was just really cool, like where they showed all the flight paths of every plane in the world in a given day. I thought that was really cool. It was cool to visualize something like that.

> Well, I think for my level, I already understand. But for the children, I think it's more valuable. (What do you think your son might have learned?) To turn the light off. Shut the door. Yeah, to turn things off.

> [I took away from the program the need] to recycle, reuse, and reduce our waste. Decrease our temperature in our homes. Little things can actually make a difference.

One-quarter of interviewees said that the program or visualizations helped illustrate that climate change affects the earth and/or that humans have an impact on this (see the first quotation below). One-quarter of interviewees said they learned about the rising temperatures on the earth, and a few noted that this was a scary or urgent issue (see the first three quotations). A few interviewees each said they learned about the number or amount of volcanoes, air traffic, and/or hurricanes through the program (see the fourth quotation). One interviewee each said that the program taught them about buoys, the difference between climate and weather, how weather is forecasted, or about electricity usage in different cities (see the fifth quotation).

> I think knowing that we're having an impact [is important], but seeing it [through] the airplanes and Facebook [visualizations], those sorts of things really bring it home. It really brings home how small and fragile our planet is.

> [I learned] that the Earth's temperature has risen two degrees over a hundred years. . . . I didn't know that before, and I didn't know that, if it keeps rising, all the ice is going to melt.

> It was stated, of course, how warm the world is getting. And that kind of stuff is kind of scary.

> I had no idea how many volcanoes there were. That was pretty surprising to me. But, the air traffic was definitely eye opening.

> I thought it was great, because [my daughter] always asks me [about] the weather. And, actually, I thought that weather and climate [were] the same. I didn't know they are totally different from each other. Like that climate is the total of thirty years or something, and that the weather is just a daily event.

EVIDENCE OF 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-quarter said that the program emphasized or reinforced their existing knowledge in a new way, and some said this motivates them to get more involved in energy conservation (see the first quotation below). About one-quarter said that the program did not significantly change their perspective or understanding in any way (see the second quotation). A couple of interviewees said the program helped motivate their children to conserve energy, and a couple said they were affected by the opportunity to visually see the effects of climate change on the sphere (see the third quotation). As discussed above, several interviewees noted one or two specific facts or concepts that they learned or were reminded about through the program, such as where energy comes from or that satellites are constantly moving (see the fourth quotation).

> I think it was more of an emphasis, 'Hey. This is a wake-up call.' You kind of know it. You just have to do it. . . . I have to get my kids more involved. You know? Let's [turn off] the light. If you leave the room, shut the light off.

> No. I agreed with all the stuff before, and I still agree with it.

> [With] global warming, it's one thing to talk about it and acknowledge that it exists, but it's another to actually see the red areas and how it is changing.

> [The program] brought back the idea about energy and where it comes from. I got that one [question] wrong.

THE PROGRAM IN A BROADER CONTEXT

RELEVANCE TO EVERYDAY LIFE

Interviewees were asked how the information presented in the program is relevant to their everyday life. About one-quarter of interviewees said that the program is relevant to their life because their behavior affects climate change and/or they can actually make a difference by conserving energy (see the first and second quotations below). Similarly, about one-fifth of interviewees discussed an imperative to conserve energy, saying that we need to protect the earth, change our energy usage behavior, teach young people about energy conservation or something similar (see the third quotation).

> [The program shows] what we're doing to the Earth and how we can change it or how we are changing it. So, what we need to do to reverse those changes.

> Yes, [the program is relevant]. Anytime you can remind us [about] the best ways to save energy and our energy consumption, that's really important.

> Well, we need to make sure that we protect the Earth, or else, for future generations, because it affects them.

About one-quarter of interviewees said that the program is relevant to everyday life because it covers weather-related phenomena that are intensified by climate change (see the first quotation below). Several interviewees generally stated that the program is relevant to everyday life, and a couple provided examples from the program (see the second quotation).

It is relevant to watch the weather everyday and get a sense of what's going on, especially the changes in El Nino, El Nina . . . how's that going to affect the hurricane season in my part of the world?

Oh, [the program] is really relevant! (Can you give an example?) Because satellites [involve] everything to us these days.

PERCEPTIONS OF PROGRAM GOALS

When asked why they thought the Museum was doing this program, about one-half of interviewees said they thought the Museum was offering the program to educate or create awareness (see the first three quotations below). The remaining responses varied, with a couple of interviewees each saying that the Museum was offering the program because it is a popular or timely topic, to motivate visitors to make a difference in their energy usage, or because climate change is a science-related topic (see the fourth quotation).

I think the Science Museum is here primarily as an educational device. I think more parents should bring their kids to museums.

To educate people [about] information [about] climate change, and I think it's also important to get the information from an unbiased source as opposed to politicians or media.

Probably the mission [of the program is] to expand people's knowledge about science and how science is used to track changes in temperature and weather conditions.

I think the show tried to make people involved, to [make them] think about the whole planet. And what we can do. . . . We all can make a difference.

A couple of interviewees said that the goal of the program was probably to attract more visitors through exciting technology (see the quotation below).

Frankly, it seems a really cool bit of technology here, and it's a good way to market and bring people in. I understand the Museum is a non-profit, but they still want to bring people in through the doors. [The Museum must] come up with something new and exciting every few years to get people to come back.

BROADER MUSEUM CONNECTIONS

Interviewees were asked if they saw any connections between the program and the rest of the Museum. About one-quarter of interviewees said they had not yet seen the rest of the Museum (see the first quotation below). Several interviewees said they saw one or more connections between the program and the rest of the Museum, with a couple discussing energy and one interviewee each mentioning connections such as astronomy, weather, living things, evolution, and climate change (see the second quotation). Many of these connections were superficial, perhaps because it was the end of the interview.

We just walked in for the first time, and I've been here for about ten minutes before we came here, so I'm not entirely sure.

Yes, because the rest of the Museum [has] planets and weather. And this [the sphere] represents weather.

PRINCIPAL FINDINGS: OBSERVATIONS

INTRODUCTION

RK&A observed six *Sphere Corps* programs about climate change between November 11 and November 13, 2011. Since all six programs followed the same script, data for program observations were analyzed together (rather than by program). Four programs were observed between November 11 and November 12, and two were observed on November 13. Findings in this section of the report are based on observations conducted on-site.

SPHERE CORPS PROGRAM

An average of 16 participants (9 adults and 7 children) attended each program, with the largest program attended by 32 people (18 adults and 14 children) and the smallest program attended by 5 people (3 adults and 2 children). Participants were evenly distributed in terms of gender. The adult participants ranged in age, although most with children were estimated to be in their thirties. Approximately two-thirds of the 40 children in attendance were under the age of 10. All programs lasted approximately 20 minutes, often running a few minutes longer.

ENGAGEMENT IN PROGRAM EXPERIENCE

Participant engagement in the program experience was focused but reserved. Most participants watched the presentation closely, shifting their attention between the educator, the sphere, the iClicker, and the plasma screen. Participants made very few comments and asked no questions during the programs. Observations suggest this is likely due to the number and intensity of visual stimuli, the fact that participants were not explicitly encouraged to ask questions, and the fast pace of the program.

AUDIENCE RESPONSE TO QUESTIONS

The educators asked the audience many questions throughout the program, at least one-half of which were questions read aloud from the iClicker poll screen. See below for more details on the audience's response to iClicker polls.

- Non-iClicker poll questions were rhetorical in nature; little time was built in for the audience to respond to questions, and educators often did not indicate through eye contact or body language that they were seeking audience responses.
- Verbal responses to questions were minimal. Occasionally, audience members attempted to answer by speaking aloud or raising a hand, but usually went unnoticed.
- The program environment, which included low lighting, intense technological demands, and considerable background noise from nearby exhibits, was not conducive to verbal dialogue between the educator and audience.
- Occasionally, verbal responses to non-iClicker questions were directly acknowledged by the educator, but the script did not provide time for or encourage follow-up discussion between audience and educator.
- Educator wait time after non-iClicker questions decreased considerably as the program progressed to accommodate the script. Often educators paused only briefly after asking a question before providing the answer or making further remarks.

- Many of the non-iClicker questions asked by the educators were close-ended, further limiting possible responses from the audience. Additionally, these questions occasionally required prior knowledge, as opposed to observation, to answer.
  - The program frequently prompts audiences with "either-or" questions, such as "Is the Earth getting warmer or cooler?" as well as questions with only one correct response, such as "What surrounds our planet and traps the gasses?"
- A few times, educators built on responses from participants with follow-up questions that required close observation of the sphere.
  - The educator said, "What do you notice about this? What does all that blue represent?" A few soft voices responded by saying "water." The educator acknowledged this by saying, "What phase of matter is that water in? It's a liquid, right? Is it always a liquid?" The audience answered "No!" The educator built on this by saying, "Yes, what's that white stuff at the top?"

ICLICKER POLLS

Most visitors participated in the iClicker polls, with the exception of 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 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 older children (ages 9 and up) who participated in the iClicker polls enjoyed the experience.
  - A 9-year-old girl smiled and looked proud after each poll, suggesting that she selected the correct answer and enjoyed participating.
- Older children (ages 5 and up) seemed very interested in the iClicker, but occasionally were distracted or limited by the hand-held device. In some instances, they looked at the device instead of looking at the sphere after the iClicker poll had ended, and occasionally they had trouble operating the device.
- Occasionally the participants' selected responses were slow to appear on the screen, and the educator had to ask the audience more than once to select a response, representing either a delayed audience reaction or a delay in the technology.
- Most participant 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 rather than observation of the sphere.
- In some programs, iClicker poll participation dwindled slightly towards the end of the program.

EXPRESSIONS OF SURPRISE OR DELIGHT

- Occasionally participants reacted to sphere visualizations with audible expressions of surprise or delight.
  - Participants gasped or softly said, "Oh my gosh!" or "Wow!" in response to certain visualizations, such as the flight path or electricity usage image.
  - One 7-year-old boy exclaimed "Whoa!" when the sphere changed color. He consistently expressed delight and excitement in response to the sphere visualizations.

- Several adult participants laughed quietly at jokes made by the educator.
  - Some adults laughed when the educator pointed out that no one had selected option "C. Walk or ride a bicycle instead of a car for short trips" in response to the iClicker poll about environmentally-friendly behavior choices.
- Adults in the audience frequently nodded throughout educator remarks, indicating their understanding and engagement.
- Some parents pointed to the sphere or whispered to explain visualizations to their children, occasionally expressing awe or fascination.
  - In response to the sphere visualization, one mother said quietly to her daughter, "That is how God sees the Earth," and later, "Oooh, that's the Sun."

LENGTH OF STAY AND DISTRACTIONS

Most participants stayed for the entire program. Of the few people who left in the middle, most appeared to do so in order to tend to the needs of a child or infant. Usually, at least two people entered the program after it had begun, sometimes standing in the doorway and watching a portion of the program while passing by.

In most programs, no one stayed to talk to the educator or learn more about the sphere. In the one case when a few participants did linger after the program, the educator had indicated at the beginning that participants could do so (this was the only case of educators encouraging stay afterward).

- Body language and quiet conversations showed that young children and their parents were occasionally distracted during the program.
  - Several younger children began swinging their feet or turning away from the center of the room as the program progressed. Some children squirmed or rolled on the floor.
  - Occasionally there were quiet side conversations between children and their parents throughout the programs, and although most did not seem to be for the purpose of disciplining, it was unclear if the conversation was on topic.
- For younger children (ages 4 and under), the sphere seemed to hold their attention more than the plasma screen.
  - A 3-year-old boy who shouted out answers in response to the visualizations disengaged and put his head in his mother's lap each time the educator shifted from the sphere to the polling screen.
- Most adults alternated between paying close attention to the program and tending to younger children as needed. Adults looked more closely at the sphere visualizations than they did at the educator, iClicker, or plasma screen.
- Adults' body language indicated that they were rarely distracted or disengaged by something other than their children.
  - A couple of times, an adult checked their cell phone, yawned, or turned away from the presentation.

PRIOR KNOWLEDGE AND PERSONAL RELEVANCE

- Correct responses to several questions from the script indicated that the audience had some prior knowledge about climate change.

    - Participants were able to answer the following questions that required prior knowledge: "What is around our Earth that moderates temperatures?" "Where do we get most of our data about the Earth?" and "Where does all our energy come from?"
- It is unclear from observations whether the program held personal relevance for participants. The only topic that clearly elicited a personal response was the sphere visualization showing Hurricane Irene.
- In some cases, educators mentioned topics that could have personal relevance; however, educators did not elicit any follow-up response from the audience, even when a question was asked.
    - One educator showed the visualization of sea levels rising, and then pointed out Virginia and asked the audience what the rising sea level means for people living in Virginia. No one responded. The educator said that the sea levels rose "three meters," which may have been hard to visualize for the younger children in the audience.

MUSEUM CONNECTIONS

No comments or questions by participants or educators made connections between the program and other experiences in the Museum.

INQUIRY AND CRITICAL THINKING

EVIDENCE OF CLOSE OBSERVATION

- Body language showed that most participants looked closely at the sphere and plasma screen throughout the program; however, very few called out responses about the visualizations, making it difficult to know exactly how closely they were observing.
    - Some adults sat very straight or leaned forward in their chairs, indicating that they were trying to get a better view.
    - Some adults pointed to the sphere, indicating that they noticed something about the visualization.
- Occasional commentary and audience responses to questions indicated that close observation was taking place.
    - A 7-year-old boy pointed to the sphere and exclaimed, "Whoa! It's even whiter!" referencing one of the glacier visualizations. He looked back and forth between the sphere and his iClicker and listened intently to the educator.
    - The educator asked "Where have most of our hurricanes originated?" In one program, a 10-year-old boy answered "Africa" because he could see the trail on the visualization.

USE OF VISUAL EVIDENCE TO SUPPORT INTERPRETATIONS

- Several questions asked by the educators required a combination of close looking at the sphere and applying prior knowledge; however, educators often provided the answers to these questions before allowing ample time for participants to look closely and attempt to answer.
    - The educator said "How many people are on the planet? 7 billion! What's all that white stuff? That's just the lights we use! Where does it come from? Burning fossil fuels!" These answers were provided quickly in succession, with little wait time.

TECHNOLOGY AS AN IMPEDIMENT TO INTERACTION

- In some instances, the iClicker polls prevented the audience and educator from having a direct exchange.
  - In response to an iClicker question read aloud by the educator, an 8-year-old girl enthusiastically responded by jumping up and down with both hands raised, and the educator called on her. The girl responded with the correct answer; however, the educator focused on having her input her response using the iClicker instead of acknowledging the response and/or engaging her in further dialogue about it.

- Occasionally, the educator was unable to engage directly with the audience due to technology-related distractions required to run the program.
  - The technology impeded the educator from inputting the correct dates for the temperature visualization. He asked, "What did you notice about the temperature in 2008?" Two children responded but the educator did not hear them due to distractions caused by operating the remote control.

CONTENT KNOWLEDGE ABOUT CLIMATE CHANGE

- Due to the reserved nature of the audiences, there was not much 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.

AWARENESS OF SCIENTIFIC PROCESS AS IT RELATES TO SPHERE DATA

- The educators made connections to the tools and processes used by scientists and meteorologists as part of an explanation of the difference between weather and climate.
  - After pointing out the glaciers melting (plasma screen) and temperature changes (sphere visualization), the educator made connections to broader scientific processes by saying, "We are doing basic science . . . observing, forming hypotheses, and looking at data." He then moved on to define the terms "weather" and "climate."
- Explanations of the tools used by scientists were somewhat rushed and incorporated terminology, such as "satellites" and "buoys," that might not have been understandable to the younger children in the audience.
- Among the older children and adults, participants seemed to recognize that the data on the sphere came from satellites and buoys.
  - The educator said, "I've been showing you a lot of cool stuff. Where is all this data coming from?" In response, a 10-year-old boy called out "satellites."

CONSIDERATION OF ENVIRONMENTALLY-FRIENDLY BEHAVIOR CHANGE

The educators addressed environmentally-friendly behavior changes through the middle school case study and an iClicker poll question. Even though all the multiple-choice options provided could have been correct, participants were not given the option to choose multiple answers or provide answers of their own. They were not encouraged to discuss their choices nor was there any follow-up interaction around the topic of behavioral changes. The program ended shortly thereafter, sometimes with one more sphere visualization of flight paths, without much explanation.

APPENDICES

APPENDIX A: IMPACT MATRIX

Target Audience = Walk-in adult visitors and visitors with children ages 10 & older							
Impact <u>Impact</u> = 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.
Impact Indicators <u>Impact Indicators</u> = concrete evidence of the achievement of an impact	*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). *Visitors remain after programs to look at the Sphere or ask questions. *Visitors refrain from irrelevant side conversations and cell phone use.	*Visitors ask questions about the implications for their own life (e.g., gardening) *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 are connected.	*Visitors make close observations during the program by providing a detailed description of what they see. *Visitors ask questions that reference Sphere visualizations (e.g., "I see polar ice caps. Does that mean there is climate on Mars?"). *Visitors provide visual evidence from Sphere visualizations that support their interpretations.	*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 more information about what they can do after their program visit (e.g., carpool).

Implementation Indicators <u>Implementation Indicator</u> = program elements that are necessary for the achievement of impacts	**Key Aspects of Facilitation** • Educators demonstrate enthusiasm about the Museum, content, and program. • Educators clearly state program length at the beginning of the program. • 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. • Educators intentionally select data sets that are relevant to visitors (e.g., locally-based), aligned with content goals, and visually rich. • 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). • 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?"). • Educators deliver content through a dialogue with entire group, eliciting responses from multiple visitors (does not lecture). • Educators use compare/contrast methods to encourage close looking. • Educators use guiding, open-ended questions that elicit multiple responses and a dialogue. • 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). • Educators use tools to focus visitors' attention on the Sphere (e.g., laser pointer). • Educators continually assess visitors' understanding throughout the program • Educators are grounded in the appropriate knowledge to confidently facilitate discussion and answer questions. • Educators use language and vocabulary appropriate to the audience. • Educators ask "How do we know X?" to encourage visitor reflection about the ways data is collected and interpreted. • Educators use data sets that reveal ways scientists gather data (e.g., satellites, buoys, etc.). • Educators show Sphere visualizations that relate to human-caused impacts. • 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). • 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) • Bleacher seating so all visitors can clearly see the Sphere visualizations • Program length that 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

APPENDIX B: PROGRAM SCRIPT

SOS Weather and Climate – revised November 9, 2011

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

Materials

Science On a Sphere – Earth Science Program playlist
iClicker System – television, computer, presenter and audience iClickers, astronomy program

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! This technology uses four projectors to place pictures onto a white round screen. All of the images that you will see today are from data collected from organizations such as NASA and NOAA, like this image of the Earth from space. Quickly review some details on SOS, image, etc.
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 light brown and green land masses, blue water covering almost 75% of the surface and often cloud cover as seen from space. But if we remove the clouds depending on the seasons we observe areas towards the poles covered with snow and ice.

Dataset: Earth Topography and Density – highlight snow and ice capped regions. Here's our first iClicker question

iClicker Question 1:

What happens to ice when the air temperature rises above 32°F or 0°C?

A. No change
B. Instantly changes to water vapor
C. Changes to a liquid
D. Changes to a solid
E. Turns into carbon dioxide

Of course, the ice changes to a liquid or melts! We have all experienced ice melting. You have just used your past experiences with, and observations of, ice to make a prediction - that the ice in this picture will also melt when the air temperature around it rises. This is what scientists do. They observe events and make predictions, called hypotheses, to understand the natural world. So, let's apply what we just did. Make some observations of the following photographs and hypothesize what is happening in these photos.

iClicker Image: This is the Muir Glacier in Alaska in 1941. Describe what you see.

Good observations! You described this picture in words.
Now take a look at this photo of the Muir Glacier in 2004. Is this the same location as the previous photo? Compare and contrast the two - same location, but in different years. (Show Muir Glacier in 2000) Can you find the matching land forms? Other than one photo being in B&W and the other in color - what changes do you observe between the two photos? Now, let's travel to a place closer to home - in the continental United States.

iClicker Image: This is the Grinnell Glacier in Montana in 1940.

And now here is a photo of the Grinnell Glacier in 2006.
What changes do you observe between the two photos?

iClicker Image: Now, let's go to the continent of Africa. Does anyone know the name of the highest mountain in Africa?
Mt. Kilimanjaro. Very good. This is a photo of Mt. Kilimanjaro in Feb. of 1993. Observe how far the snow and ice extend down from the top of the mountain.
Now here is a photo of Mt. Kilimanjaro taken in the same month, FEBRUARY, but this time in the year 2000. What changes do you observe between the two photos?

iClicker Image: Let's go to Europe! Anyone know the name of the tallest mountain on this continent? **The Matterhorn**, correct! This is a photo of the Matterhorn in Switzerland in August, 1960, about 50 years ago. Observe how far the snow and ice extend from the top of the mountain.

Here is another photo of the Matterhorn in August, but this time in the year 2005. What changes do you observe between the two photos?
Now reflect on all of these images, and tell me what is common to them all? How are these locations changing? Are they all changing in a similar way? What do these changes indicate?

Think back to our discussion about ice melting when temperature increases.

iClicker Question 2:

Which of the following statements help us to explain the changes we observe in each pair of images?

A. The sizes of glaciers have not changed over time even though air temperature has increased globally.
B. The sizes of glaciers have shrunk over time as air temperature has increased globally.
C. The sizes of glacier have become large over time as air temperatures have increased globally.

Many of you have responded with choice B. Let's see if we can present some data to support or refute the statement often in the news regarding temperature change over the last 100 years.

Dataset: 5-year Average Global Temperature Anomalies from 1880 – 2008

In any study it's very important to understand how data is collected, interpreted, presented and reported. This dataset shows the anomaly or departure from normal, for temperature from 1884 through 2008. In this case, normal is the 1951 - 1980 mean temperature. Do you notice any trends over time? The warmest year in this record is 2005. 2007 tied 1998 for the second warmest year in a century. Over the past 30 years, there has been a rapid warming trend. In fact, eight of the warmest years have been recorded since 1998. The greatest warming has been observed in the arctic. Areas that are dark red indicate the greatest warming, while dark blue areas indicate the greatest cooling.

Can you find North America? The orange-red colors indicate areas where the average air temperature is increasing, as opposed to blue which indicate areas that are cooling. So, train your eyes to focus on the orange-red colors - that's the data we are looking for. Notice that at the bottom of the sphere we can see the year's passing from 1880-2010.

This data shows us that some locations are becoming cooler on earth whereas other areas are becoming warmer over the past 130 years.
Do you observe a pattern? Are more locations increasing or decreasing in air temperature?

iClicker Question 2:

Does this set of scientific information support the statement glaciers are melting because the overall air temperature of Earth is increasing over time?

A. Yes
B. No
C. I don't know

When we think about air temperatures – weather, climate and seasons may all come to mind. Let's focus on weather for just a minute.

iClicker Question 3:

Weather can be defined as

A. A prediction of how many tornadoes and hurricanes will hit Virginia
B. A daily temperature, precipitation and/or wind event.
C. A seven day forecast
D. Last month's rain totals
E. Next winter's ski report

Weather is a daily event. When we talk about "weather," we are talking about the temperature outside, or if it's raining or snowing, sunny or windy on a particular day. So if weather is a daily event, then what is climate?

iClicker Image: Definitions of climate and weather. In contrast to weather, a daily event, climate is the long-term 30-year average of weather events. Click back to **5-year Average Global Temperature Anomalies from 1880 – 2008** to illustrate climate change data.

An example of extreme weather is a hurricane, like Hurricane Katrina in 2005.

Dataset: Hurricane Katrina

With 28 named storms, 15 hurricanes, seven major hurricanes, and four category 5 hurricanes, the 2005 hurricane season certainly blew the records away. It was also the first season in which four major hurricanes hit the U.S. Watch Hurricane Katrina start to really form just east of Puerto Rico, move between Cuba and Florida then pick up more warm water in the Gulf of Mexico (August 2005) to become a very large category 5 storm. The eye is very visible before the leading edge of the storm slams into the Louisiana and Mississippi coastal areas.

Dataset: Accumulative Hurricane Tracks 1950 – 2005

Even though hurricanes are considered extreme weather events we use long term data to study them such as this dataset showing hurricane tracks between 1950 and 2005. According to this dataset most of the hurricanes that have affected Central and North America began as tropical depressions or storms off the western tip of Africa and west across the Atlantic Ocean.

Data set – ty-cyc-hur

Hurricanes, cyclones and typhoons are all the same type of large, low pressure, high wind and precipitation storms. The name depends on what area of the globe they occur in.

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

The formation of hurricanes, also known as typhoons and cyclones in other parts of the world, are climate events

Understanding climate is critical to observing and tracking patterns and changes in the natural world - such as the changes that we just observed in the photos of the glaciers. But how do we know what we know about climate? How do we know climate is changing and air temperatures are increasing? The answer is in making observations and collecting and analyzing data - as we have just shown with the set of data on global air temperatures from 1880-2010.

How do scientists collect information that tells us there is an increase in air temperature over the past 130 years? Here is one example of real-time data that scientists use. "Real-time" means that we can capture the data as it is happening.

Dataset – Linear IR Satellite – depicts the last 30 days of cloud cover on the planet up to @ 7 hours ago with constant data updates every 2 hours. The computer creates cloud images from heat energy reflected off cooler cloud surfaces.

iClicker Question 4:

Where do you think the information for this data was collected from?
A. UFOs
B. The Farmer's Almanac
C. Satellites, ocean buoys, airplanes and ice cores
D. Bill Nye the Science Guy
E. Wickopedia

Dataset – All Satellites

Satellites are a key tool for scientists to monitor and observe the Earth's atmosphere from space. Geostationary satellites travel at the same rate as the Earth rotates keeping allowing them to collect a continuous stream of data for one location. The satellites are positioned 22,300 miles above the

Earth's surface in order to view the Earth's full disk and travel about 7,000 mph in order to maintain their geostationary orbit. In addition to geostationary satellites, scientists also use polar orbiting satellites. These satellites circle the Earth, crossing the poles on each orbit. Typically, polar orbiting satellites are about 500 miles above the Earth's surface. The satellites travel at almost 17,000mph, allowing them to orbit the Earth in roughly 100 minutes. A polar orbiting satellite is able to cover the whole Earth in less than one day.

There are hundreds of scientific satellites orbiting the Earth. This dataset shows the positions of seven geostationary satellites and the tracks of several polar orbiting satellites, plus the location of the International Space Station over one day, February 15, 2007. The day/night terminator is also included in this dataset. Each of the polar orbiting satellites travel at slightly different heights, allowing them to pass by one another without crashing.

Let me show you the Polar Orbiting Earth Satellites. We call them the POES. Watch how the POES travel around Earth over the poles, collecting and transmitting data as they go.

If satellites send us information on the atmosphere, then how do scientists gather data about the oceans (the hydrosphere)?

Dataset: World Wide Buoy Locations

You're right! There are over 3,000 buoys collecting data - water temperature, salinity, water currents. Buoys with the ability to collect data are scattered throughout the world's oceans in order to gain a better understanding of how the oceans work and how they are changing. The data is being used for monitoring chemical levels in the oceans, garnering accurate ocean temperatures and change in temperature, and many other endless uses.

Each dot on this visualization represents a buoy, and each color indicates the use of the buoy. The green colored dots are buoys in the Argo network. These deep-water buoys record continuous data from over 6,500ft below sea level up to the surface. The yellow and blue dots are maintained by NOAA. These buoys and stations record parameters such as wind speed and direction, wave height, pressure, air temperature, and sea surface temperature. The red dots are buoys in the Deep Ocean Assessment and Reporting of Tsunamis (DART) Project, which is an ongoing effort to maintain and improve the capability for the early detection and real-time reporting of tsunamis in the open ocean. Finally, the purple dots are buoys used in the Tropical Atmosphere Ocean, TAO/TRITON, project. This project is dedicated to El Nino and La Nina.

Some of these buoys gather data on the direction of the movement of ocean water.

Datasets: NASA Sea Currents, FSU QuickSCAT Ocean Surface Vector Winds

Data gathered from buoys and other instruments allows us to map the location, direction and velocity of major sea currents. Do you see any currents that you recognize? GULF STREAM Analyzing this data is how we know what we know.

Let's step back for a second and recognize the driving force, the source of energy to give us weather.

iClicker Question 4:

Where does almost all energy on Earth come from?

A. Earth's magnetic field
B. Fossil fuels
C. Heat from the Earth's core
D. Exploding stars and black holes
E. Energy from the Sun

Dataset: X-ray Sun

Our weather is ultimately the end result of the distribution of heat energy and water vapor around the planet particularly in the troposphere, the lower part of the atmosphere where most of our weather occurs. In the **X-ray Sun** image the lightest features are solar flares, violent explosions on the surface of the sun. Solar flares can emit radiation which interferes with satellites near Earth. The origin of solar flares is usually near sunspots.

Components of the Earth's atmosphere help retain heat energy in our lower atmosphere, or keep it from escaping back into space, in a process known as the greenhouse effect. Carbon dioxide is a known heat trapping gas in our atmosphere. Here's a question:

iClicker Question 4:

If you increase the amount of carbon dioxide in the atmosphere, what happens to air temperature over time?

A. No significant change
B. Decrease
C. Increase

As carbon dioxide increases in our atmosphere, more heat will be trapped and air temperature will increase.

So, what could be causing all of these changes that we're observing, like the melting glaciers we saw earlier, or the earlier migrations of birds and the earlier flowering of some plants? Let's look at data scientists have collected related to carbon dioxide and methane, another known heat trapping gas released from decaying matter and landfills

iClicker Question 5:

Are these changes that we're observing, whether the ones you've mentioned or like the melting glaciers we talked about earlier--- are they natural, human influenced or both?

A. Naturally influenced climate change
B. Human influenced climate change
  C. Both A and B

Dataset: Carbon Tracker (2004 Plumes)

Greenhouse gas concentrations in the atmosphere fluctuate naturally, but has man recently affected those levels?

The large variations in CO_2 concentration from season to season are due to the plant life. During the winter season, plants and trees respire CO_2 as they shed leaves and stop growing or decay, adding much CO_2 to the atmosphere. This process reverses during spring and summer, when they have plenty of access to sunlight and grow leaves and flowers, or increase their size substantially. This time of year is very well visible in the movie: in July the NH shows intense blue colors especially over the mid-latitude regions where forests and crops are soaking up CO_2 in great amounts. The large change in CO_2 between the seasons caused by plant activity is sometimes referred to as the 'breathing' of the planet. In the tropics, intense red areas are visible especially during July, August and September. This is due to the burning of biomass. Some of this is natural, such as dry grasses on the savannas burning

iClicker Images: Volcanic eruptions Volcanic eruptions are one example of how heat trapping gasses are naturally added to the atmosphere. Some of the daily functions of living organisms other than man and the decay of organic matter release those gases as well

What is the basis of the name "Industrial Revolution"? How would you describe the Industrial Revolution?
What types of activities did humans begin engaging in during this time to release so much carbon dioxide in the atmosphere?

iClicker Images: smoke stacks, cars, over 7 billion people on Earth Volcanic eruptions are one example of how heat trapping gasses are naturally added to the atmosphere.

These are examples of human activities that continue to release large amounts of carbon dioxide into the atmosphere. When you burn fuels such as coal, wood, and oil, you generate heat and heat trapping gases, one of which is carbon dioxide. Most the electricity produced on this planet is still made by burning the fossil fuel coal.

SHOW Earth at Night and airplane dataset, which gives a great idea of just how many people there are on the planet using energy and releasing carbon dioxide.

TRANSITION: (Use laser pointer to feature the highest concentration of carbon dioxide on the chart) This is the concentration of carbon dioxide now.

So, maybe you're asking yourselves - Are we going to change this? Can we make a difference? Is it doable? Or do we just "hope it away"?
Hope is not a strategy. It is up to you , you and you to make better choices. Each of us has the power to make better choices. And when we all make better choices, we make a huge impact. And it's the little changes that can make the biggest difference. Working together, we can make a positive change! Let me give you an example.

A group of 5th grade students at Greenbrier Elementary School in Tidewater conducted a month long energy audit. On Friday afternoons, these students checked each classroom to see which teachers were wasting energy by leaving on computers, lights, heater, printers, and other electrical devices when they were not in their classroom after school. Students hung red cards on doors of teachers who were "Energy Hogs" meaning that they left three or more items on. The red card had a checklist of what the teacher could do to reduce energy consumption. Yellow cards were issued to teachers who left one or two devices on. Green cards were given to teachers who did not waste electricity and turned off all electrical devices when not in the room. After a month, most teachers had green cards. And guess what? The students and teachers reduced their school's electric power bill over $ 10,000. So, a few simple steps can make big differences.

We can all make a huge difference in reducing the amount of Carbon dioxide in the atmosphere by the following. On this question, these are all things that have an impact, what are YOU willing to do to reduce the amount of CO2?

iClicker: ***Starting today*** what can ***you do*** reduce the amount of carbon dioxide emitted to the atmosphere?

A. Adjust your home thermostat by at least 2 degrees
B. Turn off lights when you leave a room
C. Walk or ride a bicycle instead of a car for short trips
D. Phase out traditional (incandescent light bulbs) and replace with energy saving bulbs
E. Paper or plastic? Neither. Bring a cloth bag or backpack for groceries
F. Refill your ceramic mug or glass; don't use paper, plastic or styrofoam cups made with large amounts of energy.

For everything in your life: Reduce, reuse, and recycle

APPENDIX C: OBSERVATION GUIDE

APPENDIX D: INTERVIEW GUIDE

REMOVED FOR PROPRIETARY PURPOSES