IMLS Climate Change Toolkit
FINAL Report

Submitted September 24, 2010

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Table of Contents

Please cite as:
Phillips, T. 2010. IMLS Climate Change Toolkit Final Report. Ithaca, NY.

Acknowledgements

Without the help of many people, this evaluation would not have been possible. Special thanks to:

- Alberto Lopez Torres, Museum Educator, Ithaca Sciencenter
- Janet Huie, Grants Project Manager, Ithaca Sciencenter
- Julie Van Buren, Education Intern, Ithaca College
- Katie Levedahl, Manager of Education, Ithaca Sciencenter and the rest of the *Climate Change Toolkit* team for their help and support throughout this evaluation.

Main entrance to the Sciencenter, located in Ithaca, NY

I. Executive Summary

Overview

A summative evaluation of the Climate Change Toolkit, an IMLS funded project, developed by the Sciencenter located in Ithaca, NY was conducted during the spring and summer of 2010, by independent evaluator, Tina Phillips. The Sciencenter is a moderately sized facility incorporating approximately 150 exhibits, 20 of which are located outside the building walls. Annually, the Sciencenter receives roughly 100,000 visitors; monthly visitation rates vary between from 5,000 to 13,000 during the summer.

The Climate Change Toolkit consists of four different elements: Hands on Cart Activities, Four Portable Discovery Kits, an Interactive Public Forum, and a Museum Field Trip Program. Each of these exhibits were designed with the goal of empowering participants to make changes to reduce energy use and climate change, and to learn more about energy and the causes and effects of climate change. A secondary goal is to help visitors explore their curiosity in a current science topic.

This final evaluation report synthesizes key analyses and findings from three of the four activities, it does not include results from the Museum Field Trip Program, which was considered a separate evaluation. The majority of the data come from survey feedback and some observations from the evaluator. Although most of the activities are appropriate for a wide range of ages, they were developed to specifically target 8-12 year olds and their families.

Evaluation Questions

The following questions were considered high priority for the evaluation.

1. How effective are each of the three activities to impact participant learning about causes and effects of climate change, pros and cons of different energy sources, and behavioral changes required to reduce energy use?
2. How effective is the interactive public presentation format in affecting the ways people regard their role in addressing climate change?
3. How effective is the active learning technique for museum public presentations on a current science topic?
4. What are the strengths and weaknesses of the activities?

Results

Analysis of results shows that visitor interest in, connection to, and knowledge about climate change has increased. In general, these findings demonstrate that all three activities were effective in meeting the educational objectives of impacting participant learning about causes and effects of climate change, pros and cons of different energy sources, and behavioral changes required to reduce energy use. However, it appears that some of the activities were better able to address these objectives than others. Visitors exploring the Hands-on Cart Activities and the Discovery Kits demonstrated extremely high engagement

and these activities can be easily integrated into the existing array of Sciencenter exhibits. Across all three activities, there was a definite cognitive gain in self reported knowledge, with respondents naming either general or specific items they learned, including facts related to the role of CO2, the origin of fossil fuels and descriptions of phantom power. Perhaps most importantly, each of the activities, but particularly the interactive forum, showed evidence for effectively empowering people to make personal choices that positively effect climate change. Future longitudinal research may help determine how long such learning and interest persists, and whether personal actions to reduce climate change have been implemented into the daily lives of Sciencenter visitors.

Recommendations

Future iterations of the Hands-on Cart activities should emphasize the causes and effects of climate change and other behaviors that help to conserve energy. Every effort should be made to keep the subject matter of the interactive forums focused on one or two big ideas and to keep the presentations to around 20 minutes. Spinning the presentation with a positive angle is also recommended as it minimized the feelings of helplessness. Also, the clickers worked very well but should only be used to extract useful information rather than as a reason to use the clickers. Audience interest in the forum will be enhanced with the addition of short (less than one minute) demonstrations as well as inclusion of data displaying evidence of climate change. Lastly, better marketing for the forums may increase the number of members and the diversity of information collected using the clickers. The Discovery Kits should be labeled for a recommended age group or as an activity requiring adult guidance for younger children. Efforts should also be made to update the Ocean Discovery Kit and draw more specific connections to every day behaviors. All four kits would be enhanced with an activity or scavenger puzzle that provides cohesion or emphasizes a central take home message within each kit.

II. Program Description

Overview

The Climate Change Toolkit project developed by the Sciencenter of Ithaca (hereafter, the Sciencenter) and funded through the Institute of Museum Library Services was created to support the educational activities of the Sciencenter in order to raise awareness of the science and issues related to global climate change. While public concern for global climate change is high, knowledge of issues surrounding global climate change is surprisingly low. According to the National Environmental Education and Training Foundation (NEETF), 70 percent of Americans say that they know a fair amount about environmental issues and problems, but only one in three can pass a straightforward environmental quiz (Coyle, 2004). Perhaps most worrisome, a recent poll from the Pew Research Center (The Pew Research Center, 2010), revealed that global climate change received the lowest governmental priority rating by the American public. Many have argued that this lack of environmental knowledge and concern may have serious implications for the natural environment and ultimately, the future health of all living things (Leigh, 2005; Louv, 2005)

While researching trends for a recent strategic planning process, the Sciencenter determined that educating the public on the science of sustainability (and global climate change in particular), at both the local and international levels, was the most important way to apply their resources for the immediate future. IMLS funding would allow the Sciencenter to:

1. Build the capacity to create new educational activities that address current public issues in science and encourage visitors to explore their curiosity on current science topics.
2. Build the capacity to apply the field of "active learning" to the amphitheater and public lecture presentations.
3. Purchase and incorporate low-cost anonymous polling devices ("clickers") and state-of-the-art radio frequency (RF) receiver technology into the amphitheater presentations.

Collectively these activities would result in broad impacts such as deeper museum experiences for visitors, growth of the Sciencenter audience, deeper engagement of group learners, enhanced educational efforts through the use of emerging technology, and most importantly, empowering participants to make changes to reduce energy use and climate change and to learn more about energy and the causes and effects of climate change. A logic model illustrating the Climate Change Toolkit and relationship between the resources, activities, outputs, outcomes and impacts is illustrated in Figure 1.

Figure 1: Logic Model for Climate Change Toolkit

INPUTS	ACTIVITIES	OUTPUTS	OUTCOMES	IMPACTS
• Sciencenter Project Leaders, volunteers, staff • IMLS funding • Sciencenter visitors	• Develop and deliver climate change activities targeted at families and 8-12 year old children • Develop and deliver new interactive public forum • Pilot test all three activities, refine where necessary • Disseminate materials widely	• 10 new Hands-on Cart activities • 4 new Discovery Kit sets • Newly tested and refined interactive public forum • Number of participating Sciencenter visitors exposed to activities and forums	• Increase visitor understanding of different energy sources, the causes and effects of climate change, and ways to reduce energy use • Increase visitors' interest in current science topic. • Engage participants in discussion of climate change	• Increased capacity for Sciencenter to engage audiences in interactive public presentations • Empower participants to make changes to reduce energy use • Empower participants to seek out information and talk to others about climate change

Setting and Audience

The Sciencenter operates within the city of Ithaca, which has a population of 30,000 people, not including students from Cornell University and Ithaca College. It is located within Tompkins County an otherwise rural county, with a population of 100,000. Known for its math, science, and engineering programs, and located just 2 miles away, Cornell University provides a diverse population that is highly interested in science and technology. The regional audience of the Sciencenter is 89% Caucasian, 7% African American, 3% Latino, and 1% other ethnicities. The staff closely reflects these regional demographics: 88% Caucasian, 6% African American, 6% Latino. The museum audience segments by age are 55% under 12 years old; 45% between 25 to 45 years old; 5% teens; and 5% over 45 and seniors.

The Climate Change Toolkit was designed to serve families visiting the Sciencenter with children under the age of 12, which constitute nearly 90% of Sciencenter visitors. The Sciencenter is a moderately sized facility incorporating approximately 150 exhibits, 20 of which are located outside the building walls. Annually, the Sciencenter receives roughly 100,000 visitors; monthly visitation rates vary between from 5,000 to 13,000 during the summer.

Project Deliverables

This evaluation presents information on three of the four funded activities. The Field Trip Program, a 45-minute field trip designed for children to learn about climate change and renewable energy, was evaluated separately through the Kids Discover the Trail program.

Deliverable 1: Hands-on Cart Activities

Ten cart-type science activities were developed to engage children and families with the science of climate change and global climate change. Some of the activities emphasized the science behind climate change, while others emphasized the actions that individuals could take to reduce climate change. Individual activities included:

1) Energy And The Carbon Cycle: Carbon, Carbon, Everywhere!
2) Albedo: The Earth Absorbs And Reflects!
3) Melting Glaciers: Positive Feedback Not Always Good…
4) Heat Trapping Molecules: What Makes A Greenhouse Gas?
5) Energy From Hydrogen: The Science Of Electrolysis!
6) Fossil Fuels From the Forest: The Story of Coal
7) Draft Detectives: Track Down and Stop Sneaky Drafts!
8) Refrigerators, Clothes Dryers, and CFL Lights: What's a Watt?
9) Wind Works
10) The Flip Side of CO2.!

Sciencenter visitors exploring one of ten Hands-on Cart Activities

Deliverable 2: Portable self-guided Discovery Kits

The four Discovery Kits were housed in sturdy wooden boxes, and each contained four self-guided activities, that were packaged in a 1-gallon mesh bag inside the box. Each of the 4 kits focused on how climate change is affecting a different environment: the forest, ocean, urban, and atmosphere. Each kit also had a game map to help guide visitors through the 4 hands on activities within the boxes. The boxes were designed to encourage active participation by individuals and adults with younger children. Examples of the activities within each box and the main concepts of each activity are presented in Table 1.

Visitors actively engaged with one of the four Discovery Kit boxes.

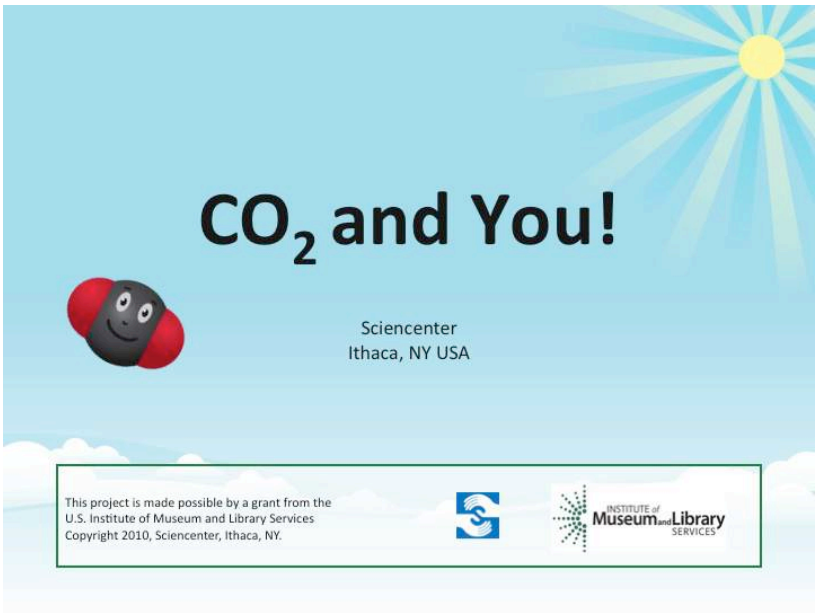
Table 1. Discovery Kit Contents

Discovery Kit	Activity	Main Concept
Ocean	Build A Shell	Ocean acidification occurs when too much CO_2 is dissolved in seawater, triggering a chemical reaction that creates more carbonic acid. Carbonic acid is harmful to animals with shells such as snails, corals, and crabs.
	Earth Reflects	Albedo, the amount of heat reflected from a surface, is partly determined by color. High albedo areas, such as the polar ice caps, reflect a lot of heat while lower albedo areas like the oceans absorbs more heat. Albedo plays an important role with the rates of melting in the Arctic.
	How Fast Will It Melt?	As icebergs and glaciers melt the replacement of reflective ice with the darker colored ocean encourages more melting which then contributes to the positive feedback loop.
	Plankton, Polar Bears and People!	The polar bear, a keystone species important for maintaining ecosystem balance in the Arctic habitat, is currently being affected by climate change. As the climate warms, sea ice breaks up earlier requiring the polar bear to swim longer distances to hunt.
Atmosphere	Cloud Conundrum	Climate scientists are still relatively uncertain about the impacts of clouds on the climate system. Although we can observe that different types of clouds have different short-term effects, sophisticated climate models are needed to determine the long term role of various types of clouds.
	Molecule Building	Greenhouse gases are comprised of three or more atoms and have the ability to absorb and trap heat. Carbon Dioxide (CO_2), Water Vapor (H_2O) and Methane (CH_4) are examples of common greenhouse gases.
	The Invisible Gas	CO_2 levels in the air can be measured using infrared light and a device (CO_2 monitor) to detect light reflected by the CO_2 molecules. Direct measurements of CO_2 levels in the atmosphere are crucial information used by scientists to predict future climate changes.
	CO2 Tips the Climate Scales	Since the 1950's carbon dioxide (CO_2) levels have been increasing at an alarming rate. Only recently have scientists been able to measure the amount of CO_2 in the atmosphere and how quickly the rate is increasing.
Urban	Hand Crank Generator	Different light sources require different amounts of energy. Traditional incandescent bulbs use a lot more energy than CFL or LED bulbs.
	What's a Watt?	The amount of power, or the number of watts needed to use an appliance, varies greatly different types of appliances. *Standby* or *vampire power* is the power appliances use when they turned "off" but still plugged in.
	Is it Really Trash?	The creation of greenhouse gases associated with sending trash to the landfill contributes to climate change. Recycling, Composting, and Reusing materials reduces the amount of trash sent to landfills
	Solar Power Cooling	Solar technology such as PV cells have an enormous potential to address our energy needs. In one year more solar energy will reach the surface of the planet than will ever be obtained from all of the Earth's non-renewable resources combined!
Forest	The Puzzling Golden Toad	The effect of climate change on species is still unknown and widely debated. Scientists believe that factors such as increased droughts and the spread of a fungus may have led to the demise of the Golden Toad.
	Fossil Fuels From the Forest	Coal is made from ancient plants that were put under extreme heat and pressure for long periods of time. Carbon dioxide is removed from the atmosphere by plants. Burning coal for electricity, releases this carbon into the atmosphere, contributing to climate change.
	Trees: Long Term CO_2 Storage	Trees take up CO_2 through photosynthesis, converting it into the building blocks of wood, lignin and cellulose. Trees can live thousands of years without returning CO_2 back into the atmosphere, making them important players in the climate crisis.
	Tree Ring Science	Tree rings provide clues to long term weather patterns, or climate, up to thousands of years ago. Wider rings indicate warmer temperatures and/or more water availability.

Deliverable 3: Interactive Public Forum

The interactive public forums provide visitors with a lecture-style presentation on global climate change, moderated by museum educators in the Sciencenter amphitheater. Rather than focusing on the "doom and gloom" angle of climate change, the Sciencenter staff decided to instead promote the positive side of addressing global change. The forums employed "active learning" techniques through the use of interactive clickers, a technique adopted from university settings that facilitates thought-provoking questions and audience small-group discussion of issues, through low-cost remote polling devices. Participants are asked questions during the presentation to which they can anonymously vote on issues and see real-time histograms of their collective responses on a PowerPoint slide. The forums were intended to be 20 minutes in length and provide a venue to empower people to address their role in energy use and climate change. The evaluation was designed to measure the effectiveness of the public presentation format in affecting the ways people regard their role in addressing climate change. A secondary goal was to evaluate the effectiveness of this active learning technique for museum public presentations on a current science topic.

Type of interactive clicker used in the forum



Interactive forum "CO2 and You" title slide

III. Evaluation Methodology

Data for all three deliverables were collected at the Sciencenter in Ithaca, NY during the spring and summer of 2010. Multiple methods of data collection were employed including observations, adult and youth surveys, and interviews with staff. By using multiple data collection methods, the evaluator was able to develop a more complete picture of how visitors used and learned from the three different deliverables. However, due to time constraints and changes to the evaluation plan, the evaluator was not able to collect in-depth interviews from participants.

Table 2 presents the evaluation plan how the data were collected, the instruments used and the timing of evaluation activities. For each of the three deliverables we used a purposeful sample that was considered representative of the Sciencenter audience (Patton, 2002). We specifically targeted families that appeared to have children between the ages of 8-12. As incentive, all adults who participated in the evaluation received a free one-day family pass to the Sciencenter. Participating Children were able to choose a small prize from the treasure box.

Table 2. Evaluation Plan for the Climate Change Toolkit

Activity	*Instrument & Method*	*Data Collection Dates*	*Timing*
Hands-on Cart Activities	• Ithaca College surveys, unless otherwise noted	May, 2010	Post only
Discovery Kits	• In-house formative testing • Discovery Kit survey • Observations • Staff interviews	August 10 – 20, 2010	Pre & post
Public Forum	• Surveys from adults and youth • Observations • Staff interviews	May 22, 2010 June 26, 2010	Post test only Post test with comparison group

It should be noted that the evaluator, Tina Phillips was not hired onto the project until May, after Ithaca College students and Ithaca Sciencenter staff had already developed and administered the one-page posttest survey for the Hands-on Cart activities. The analysis of the cart activities are therefore limited by the fact that the evaluator was not involved in the development or administration of the survey instruments. See Appendix A for the instrument used in the Hands-on Cart activity.

The Discovery Kits were formatively tested several times by Ithaca Sciencenter staff in an effort to develop the kits to be age-appropriate, fun, and educational. In addition, the evaluator conducted a few formative tests and provided feedback to staff. Once the kits

were considered sufficiently ready, pre surveys were administered to Sciencenter visitors just prior to exploring the discovery kits. Immediately after they were done with the kits, they were asked to take a post survey. Knowledge questions regarding climate change were generated the educator activity guides developed for each kit. Opinion questions regarding views on climate change were adapted from the recent Yale Climate Change report (Maibach, Roser-Renouf, & Leiserowitz, 2009). See Appendix B for this survey instrument.

Two Interactive Public Forums were conducted. The first on May 22nd was considered a formative assessment used to inform the final presentation on June 26th. We felt it necessary to treat the first presentation as a formative assessment because the staff was not familiar with the technology. Immediately following both public forums, audience members that appeared to be older than eight years of age were asked to fill out a one-page survey. During the second presentation however, we opted to also include a comparison group. During the actual presentation, Sciencenter volunteers actively sought the participation of visitors who were wandering around the Sciencenter but not taking part in the forum. In this way we were able to compare outcomes for participants taking part in the forum with those that were not part of the forum. Initially the evaluator intended to analyze the data for significant differences using t-tests, however given the small sample sizes, this was not possible.

The evaluator made observations during both forums as well as the practice forum conducted in early May where Sciencenter staff and volunteers provided feedback on the presentation as well as the pilot survey. To control for potential sources of variation, each of the forums were led by the same museum educator. See Appendix C for a sample of the instrument used and Appendix D for a copy of the Participant Consent Form.

IV. Findings & Results

The evaluation was intended to answer the following questions:

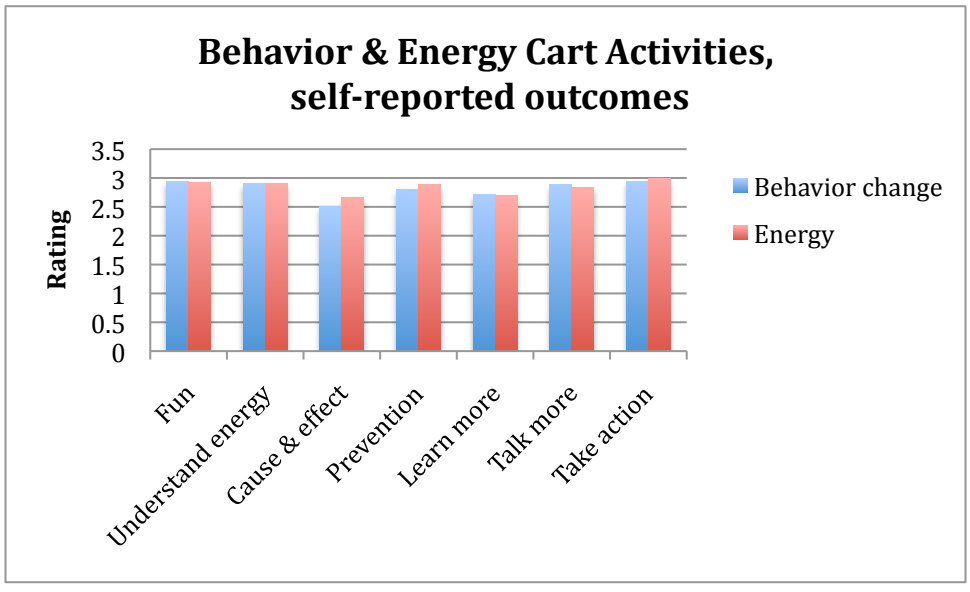
1. How effective are each of the three activities to impact participant learning about causes and effects of climate change, pros and cons of different energy sources, and behavioral changes required to reduce energy use?
2. How effective is the interactive public presentation format in affecting the ways people regard their role in addressing climate change?
3. How effective is the active learning technique for museum public presentations on a current science topic?
4. What are the strengths and weaknesses of the activities?

The results from the data collection and analysis for all three deliverables are presented below. All of the data were compiled and analyzed by the evaluator, Tina Phillips. Each deliverable is presented separately.

Hands-on Cart Activities: Behavior Change and Energy

The sample size for these activities was 13, and the average age was 8.6 years. According to Figure 2, below, both the Behavior Change and Energy activities were very well received with relatively high approvals. In general, the Energy activities had slightly higher ratings than the Behavior Change activities, but these differences do not appear significant. For both sets of activities however, understanding of the causes and effects of climate change was the least understood.

Figure 2: Respondent rating of Behavior Change and Energy activities. Responses were coded in the following way: happy face = 3, neutral = 2, sad face = 1.



Participants using the Hands-on Carts were also asked to write in what they learned from the activity. From Table 3 below, the most important take home message received by 50% of respondents was the phantom power message. A few respondents mentioned that heating produces energy and a few noted the influence of coal.

Table 3: Tabulation of open-ended responses to the question: "One thing I learned about energy or climate change."

	Number (n=13)	**Percentage**
Appliances use power even when turned off (phantom)	8/16	50%
Heating things uses more energy/electricity	3/16	19%
Coal is hard/destructive to get from the earth	3/16	19%
Energy is made from plants	1/16	6%
Different bulbs use different amounts of energy	1/16	6%

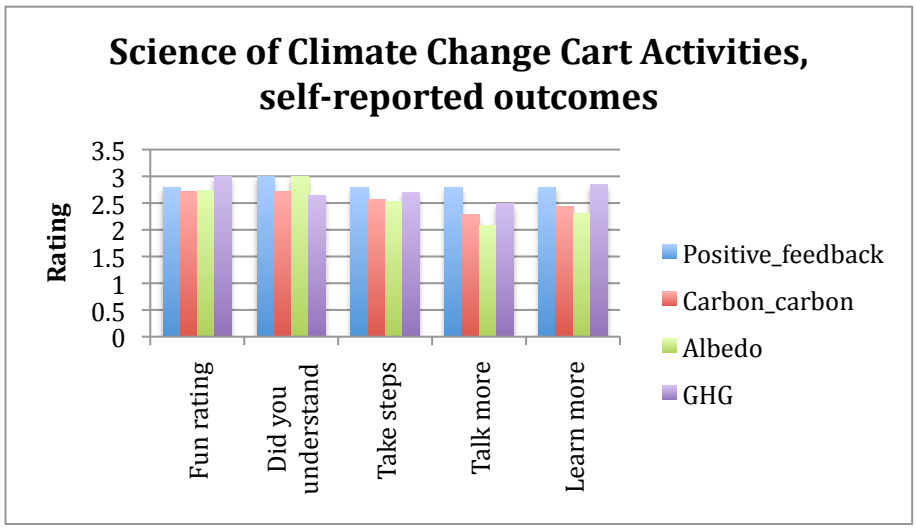
Hands-on Cart Activities: The Science of Climate Change

The Science of Climate Change activities consisted of four separate activities listed below, along with the corresponding sample sizes and average age for each activity:

- Carbon Carbon (CC) – average age: 7.6 (n=7)
- Positive Feedback (PF) – average age: 14.4 (n=5)
- Albedo (AL) – average age: 7.2 (n=15)
- Greenhouse Gases – (GHG) – average age: 7.9 (n=11)

All of the Science of Climate Change activities were perceived as fun, with GHG being the most fun, and Carbon-Carbon the least fun, but these differences were very slight (Figure 3). The respondents seemed to have very high understanding for all four activities, particularly Positive Feedback and Albedo. The Positive Feedback activity seemed to inspire the most number of respondents to take steps to reduce energy use and talk more about energy use. The Albedo activity inspired the least amount of respondent willingness to talk more about energy use. Both the GHG and the Positive Feedback activities had very high ratings for inspiring people to learn more about climate change. The average age for the Positive feedback was twice that of the rest of the activities, which may explain higher levels of understanding and willingness to talk and learn more about climate change. It should be noted however that this activity had the smallest sample size.

Figure 3: Respondent rating of Science of Climate Change activities. Responses were coded in the following way: happy face = 3, neutral = 2, sad face = 1.



Participants were also asked to write what they learned as a result of the activities (Table 4). The major take home messages from each of the activities were that of positive feedback and melting ice (PF), the types of molecules in the air (GHG), that energy is made by wind, water, sun, oil, and coal (CC), and the role of forests in helping to reflect light (AL).

Table 4: Tabulation of open-ended responses to the question: "One thing I learned about energy or climate change" from the Science of Climate Change activities.

	Number (n=16)	**Percentage**	**Activity**
We breathe out carbon monoxide	1 /7	14%	CC
Energy is made by wind, water, sun, oil, coal	2 /7	28%	CC
Air has oxygen	1/7	14%	CC
Turn the water off	1/5	20%	PF
Turn off lights when you leave the room	1/5	20%	PF
There is positive feedback that continues to melt the ice	3/5	60%	PF
Darker things get hotter by the sun than lighter stuff	6/15	26%	AL
It helps to plant a tree because forests reflect light and keep polar caps intact	4/15	26%	AL
The earth is getting hot and warm	2/15	13%	AL
Molecules/oxygen/The kinds of stuff in the air	4/11	36%	GHG
Climate change is happening by global warming and when you burn gases	3/11	27%	GHG
That we are starting to produce too much	1/11	9%	GHG
That we should take a shorter bath	1/11	9%	GHG

Participants were also asked to jot down one thing they can do to prevent climate change. Table 5 summarizes these responses. For three of the four activities, (GHG, PF, CC), "turning off lights" was the most commonly stated behavior to prevent climate change. Planting a tree was the most common response for the Albedo activity. Riding a bike was also mentioned in a few of the activities (GHG, CC).

Table 5: Tabulation of open-ended responses to the question: "One thing you can do to prevent climate change" from the Science of Climate Change activities.

	Number (n=16)	**Percentage**	**Activity**
Walk	1 /7	14%	CC
Plant more trees	1 /7	14%	CC
Ride my bike or walk instead of driving	1/7	14%	CC
You can use solar panels	1/7	14%	CC
I do not know	1/7	14%	CC
Turn off lights when not using them	2/7	28%	CC
Turn off lights when not using them	2/5	26%	PF
I do not know	1/5	26%	PF
Conserve energy	1/5	13%	PF
Plant a tree	7/15	47%	AL
Do not do climate change	1/15	7%	AL
I don't know	3/15	20%	AL
Recycle	2/15	14%	AL
Turn off lights	4/11	36%	GHG
Ride a bike	3/11	27%	GHG
Take shorter showers	1/11	9%	GHG

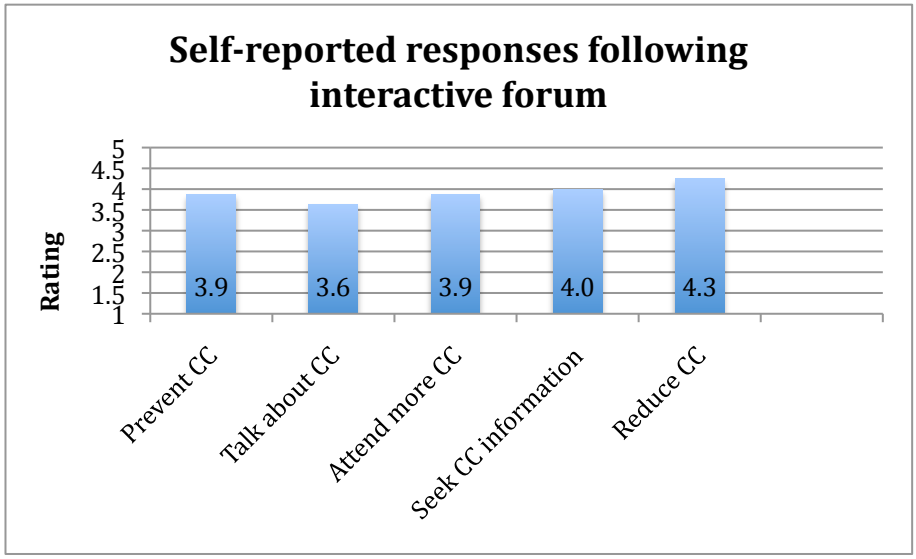
Interactive Public Presentation (Formative Data)

Although the presentation was meant to be about 20 minutes, the first presentation delivered on May 22nd, was nearly 45 minutes. There was clear evidence that this was too long for the audience: half way through the show about half the audience had left. Therefore the sample size for the participants that stayed for the entire show and filled out the posttest questionnaire is small (n=8). Following the forum, the evaluator and staff went through the slide show to remove extraneous information in an effort to cut the talk in half.

Despite the small sample size and duration of the talk, those that stayed did provide very positive feedback about the forum's organization, the preparedness of the presenter, assistance by the staff, and the forum's value. Nearly all participants strongly agreed that they thought the clickers were fun and engaging and that they would recommend the forum to a friend.

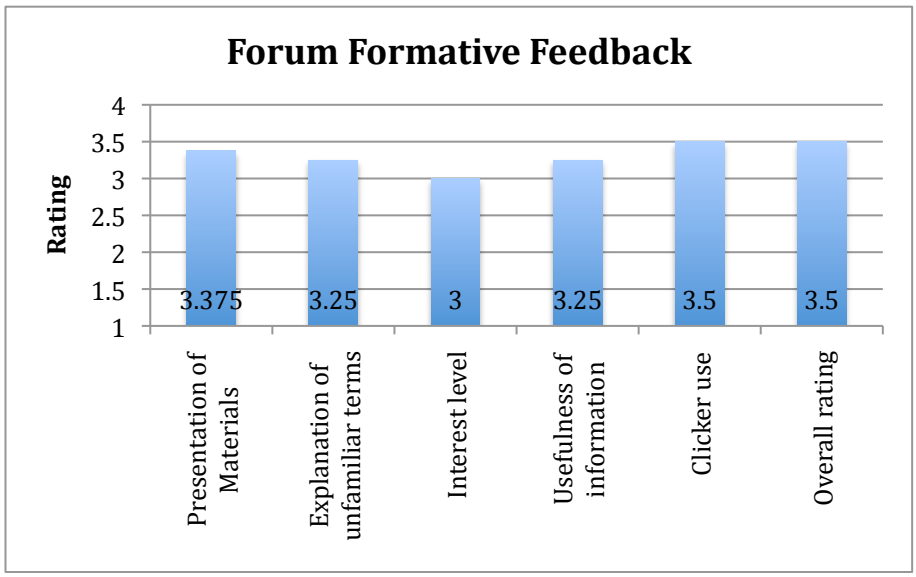
In general, most audience members stated that as a result of the forum, they are more likely to take steps to reduce climate change, seek out information about climate change, and attend more events on climate change. They also reported to having a better understanding of what to do to prevent climate change (Figure 4).

Figure 4: Respondents opinions of the presentation, each item beginning with the statement "As a result of the interactive public forum…" Responses *ranged from 1 (strongly disagree) to 5 (strongly agree) with 3 serving as a neutral response.*



According to Figure 5, audience members rated the use of technology quite high, and overall, gave the forum a very high rating of either good to excellent. Presentation of materials and explanation of unfamiliar terms rated well and the information was rated as useful to the participants. Interest level earned the lowest score, but still averaging at 3, or "good." This last finding is likely a result of the duration (45 minutes) of the forum.

Figure 5: Respondents were asked to complete six sentences about the forum. Responses ranged from 1 (poor); 2 (fair); 3 (good); to 4(excellent).



Observations of the audience during the forum suggested that the factory diagram within the slide show was very engaging as was the heat blanket activity and the clicker voting opportunities. The tree diagram demonstration appeared to have less engagement for the audience.

Participants were also asked to write in what they learned from the interactive forum. Several audience members wrote in comments such as "what I can do to help." A few members wrote about CO2. For example, one person wrote: "how to reduce CO2 on a personal level," and another wrote, "what CO2 really is." These statements demonstrate that the forum did reach some of its goals of empowering people to understand what they can do on a personal level to reduce CO2. Also, the references to CO2 provide evidence that at least some audience members walked away with a better understanding of the role of CO2 in the science of climate change.

The survey also asked audience members to suggest ways to improve the forum, one member wrote, "the length of the presentation was too long and could be reduced and condensed to maintain audience interest." This appears to be a major area for improvement for future presentations. Other members commented that they would have liked to see more demonstrations and more evidence for climate change in the form of data.

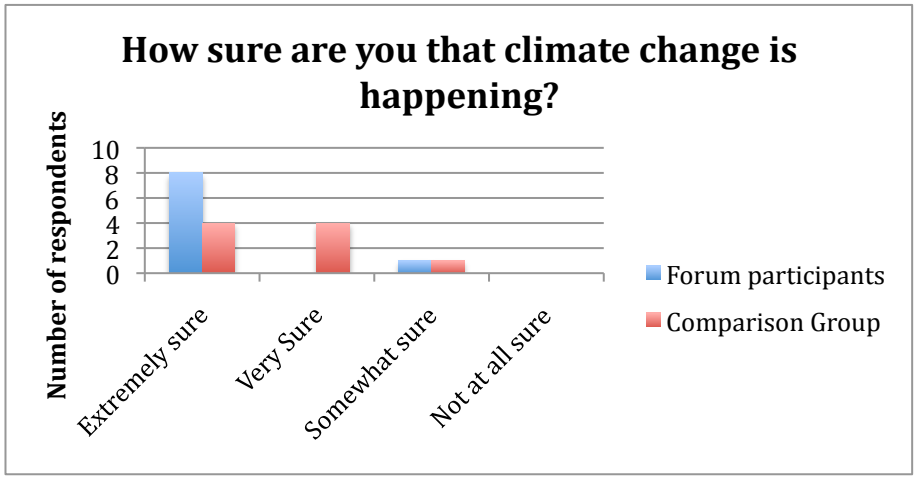
Interactive Public Presentation (Summative Data)

Based on observations and findings from the formative presentation on May 22nd, the second presentation on June 26th was conducted in under 30 minutes. Only one family left early and this was likely due to the fact that they had very small children (ages 2 and 4, approximately). Posttest surveys were received by nine members of the treatment group

taking part in the forum, and nine in the comparison group that were not in the amphitheater but in the Sciencenter during the same time frame. Average age for the treatment group was 38; comparison group average age was 44. Although the ages between the groups are fairly similar, the gender skew was not. In the treatment (forum) group, there were six males and three females. In the comparison group, all nine respondents were female. Additionally, whereas 88% of the forum participants were also Sciencenter members (7/9), in contrast only 22% (2/9) of the comparison group were members. These differences present some limitations to our findings in that we can only speculate whether perceived differences exist because of the forum intervention or because of pre-existing differences between the two groups.

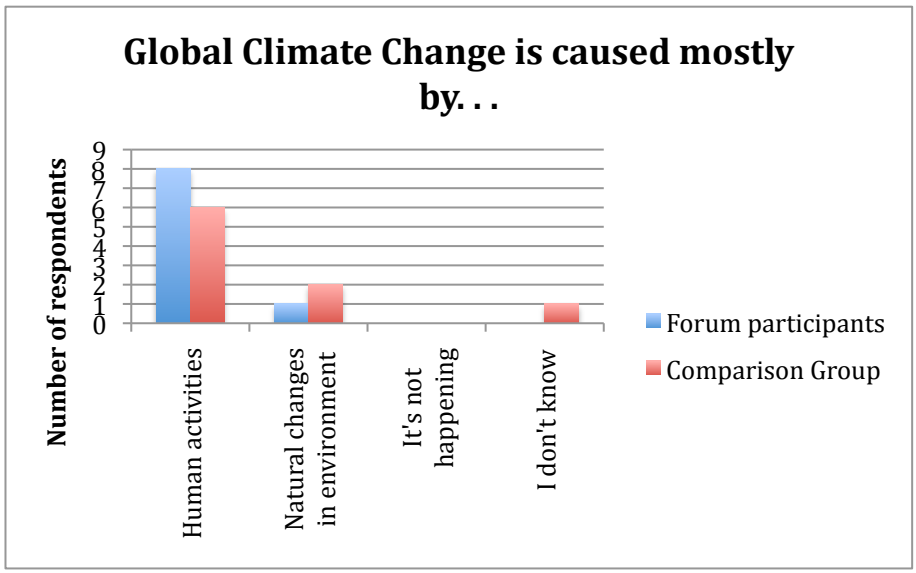
Nonetheless, the data presented below do provide some evidence for the effectiveness of the program. For example, the vast majority of forum participants (88%) are extremely sure that climate change is happening, compared to only 44% of the comparison group (Figure 6).

Figure 6: *Respondent answers to the question "How sure are you that global climate change is or is not happening?"*



When asked what the causes of climate change are, 88% of forum participants chose the response "human activities," compared with 66% of the comparison group (Figure 7).

Figure 7: *Respondent answers to the question "If global climate change is happening, do you think it is caused by . .*



In general, both the forum and comparison group had fairly sophisticated answers to the question: "What can you do to prevent climate change?" However, forum respondents appeared more able to describe specific individual and feasible behaviors that they could accomplish. The comparison group responses while still accurate, were presented in less specific terms and in some cases were not behaviors that could be easily enacted (e.g., wind and solar energy) on an individual basis. Below are the written responses between the groups.

Forum responses:

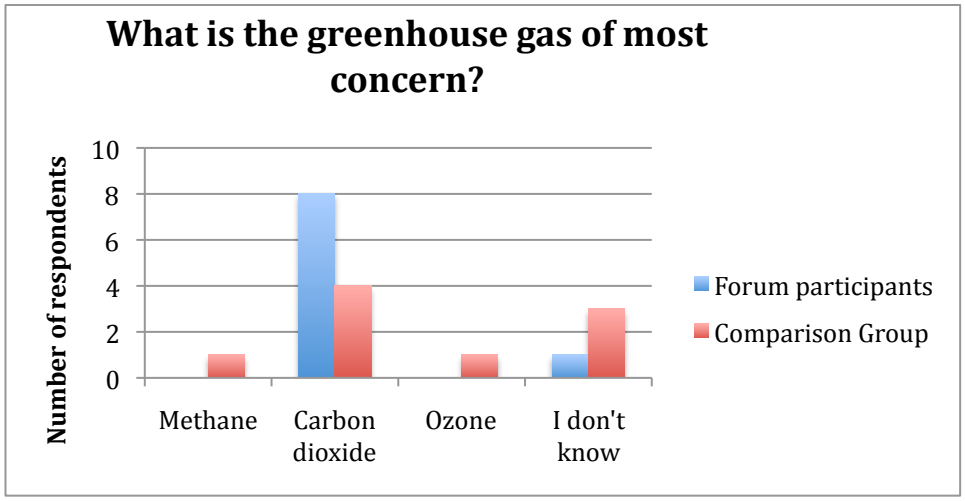
- increase thermostat in winter, decrease in summer
- 5 min shower; turn off lights, buy local
- turn off lights, buy local, turn down heat
- use less energy that is created through sources that emit CO2, less energy to heat, light power homes, buildings
- change to CFLs, talk to businesses, politicians, turn off lights
- reduce shower time, use smart strips, use CFL lights, use energy saving bulbs, buy local food, turn off lights, turn thermostat down, drive less
- drive less, take fewer plane trips, turn off lights

Comparison group responses:

- recycle, alternative energy sources, smaller footprint
- reduce emissions, increase plant growth (don't eliminate forests)
- drive electric car, sustainable living, no aerosols
- smaller carbon footprint
- reduce, reuse, recycle
- less fossil fuels, solar energy, wind energy
- reduce waste, compost more, drive less, hybrid car
- reduce amount of petrochemicals used and carboflourans, recycle, buy local, buy organic, teach future generations environmentally friendly habits

In Figure 8, the data show clear differences in factual understanding of the role that CO2 plays in global climate change. Of the forum participants, 88% correctly chose CO2 as the greenhouse gas of most concern, compared with 44% of comparison group members.

Figure 8: Respondent answers to the question: "Which of the following is the greenhouse gas of most concern from a global climate change point of view?"

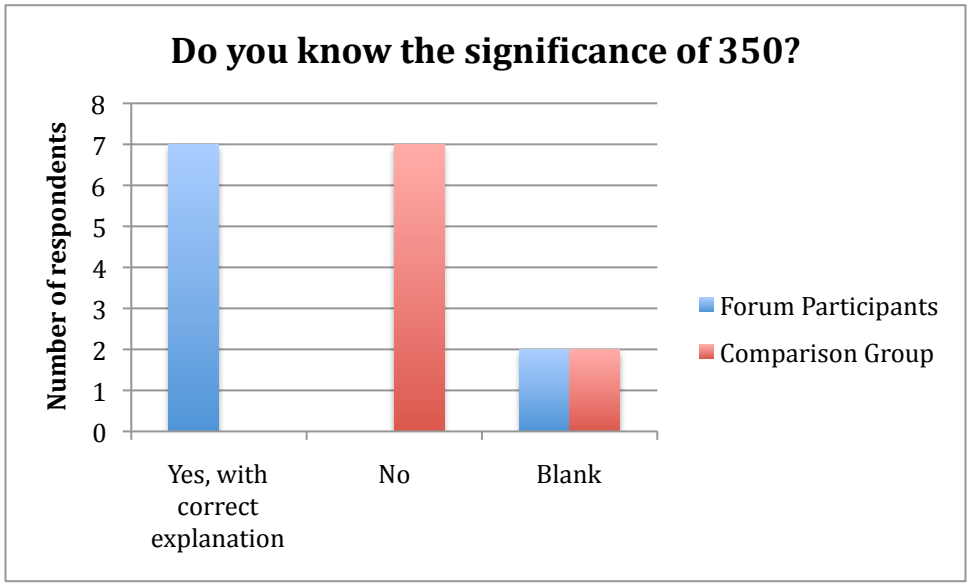


Perhaps the most compelling piece of evidence regarding gains in knowledge from the forum are the extremely different responses to the question: "Do you know what the significance of the number '350' means as it relates to climate change? If so, please describe below." Every participant in the forum who answered this question (77%) was able to provide a correct explanation of the significance of 350 (Figure 9). This is in sharp contrast to the comparison group where not a single correct response was formulated.

Below are examples of some of the written responses from the forum participants:

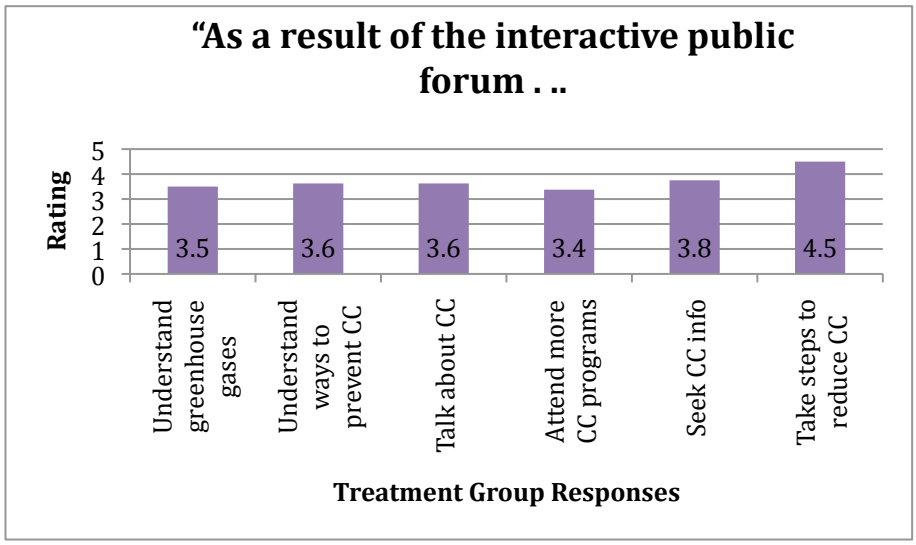
- *350 CO2 molecules in 1 million particles of air*
- *It is the level of CO2 in the atmosphere we are trying to reach*
- *350 ppm of CO2 is the threshold amount of CO2 for the environment before catastrophe*
- *It's the parts per million of CO2*
- *Reduce CO2 concentrations to less than 350 ppm*
- *350 PPM CO2 in the atmosphere would be a safe level*

Figure 9: Respondent answers to the question: "Do you know what the significance of the number '350' means as it relates to climate change?"



Finally, similar to the first public forum, respondents were asked what they got out of the presentation (Figure 10). A fair number of respondents maintained a neutral position, the rest either replied with "agree" or "strongly agree." Nearly everyone agreed or strongly agreed that the forum would help them to take steps to reduce climate change. While the forum may not have influenced everyone in a positive direction on all questions, it did influence about half the participants. Importantly, no one responded with "disagree" or "strongly disagree."

Figure 10: Respondent's opinions of the forum, each item beginning with the statement "As a result of the interactive public forum…" Responses *ranged from 1 (strongly disagree) to 5 (strongly agree) with 3 serving as a neutral response.*

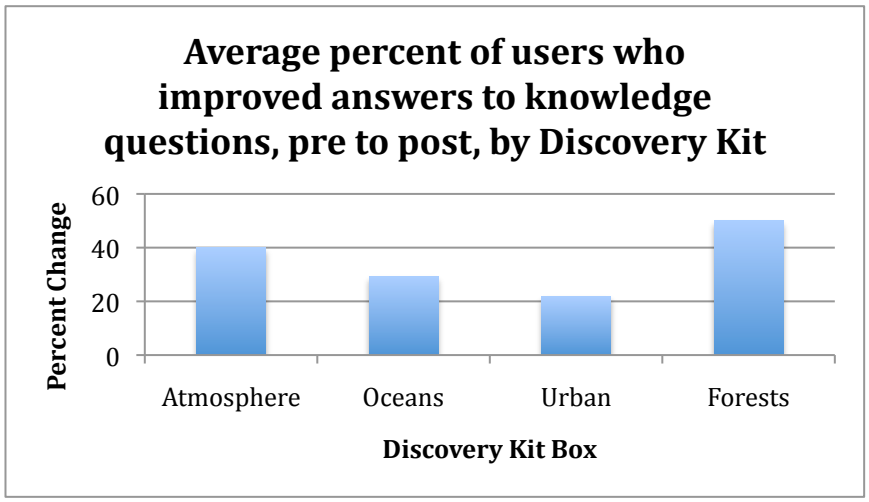


DISCOVERY KITS

In all, we collected 27 completed Discovery Kit pre-post surveys from museum visitors. We did not include six other surveys, which were from very young respondents who had a difficult time understanding the survey and had trouble reading the information contained within the kits. Several of the respondents used more than one kit, so it is difficult to know the exact number of individuals, however we estimate that based on unique age and gender characteristics, there were 20 unique individuals. Of the 27 surveys received 16 were from females (60%). The average age across all four kits ranged between 14.5 and 17 years of age. However, in this case mean age was not the best measure to use because for each of the kits there was an adult that skewed the average upward. The mode and the median were better indicators of age, both of which were 11, the exact target age for these kits.

For the sake of analytical brevity, the results for the kits were averaged together so that comparisons could be made across kits. Each of the surveys included between 3-5 knowledge questions in both the pre and posttest. Figure 11 illustrates the percentage of users who changed either from an incorrect or "I don't know" responses in the pre test to a correct response in the posttest. The values ranged from a low of 20% for the Urban box, to 50% of respondents in the Forest box. This does not necessarily imply that the Urban box was not effective at influencing understanding of the topic. It is likely that respondents may have had more prior familiarity with the content of the Urban box, which dealt with everyday tangible issues such as appliances, light bulbs, and trash. In contrast, the Forest box dealt with sources of energy, the role of trees in carbon storing, and the origination of fossil fuels, all concepts that typically would not be associated with "every day living."

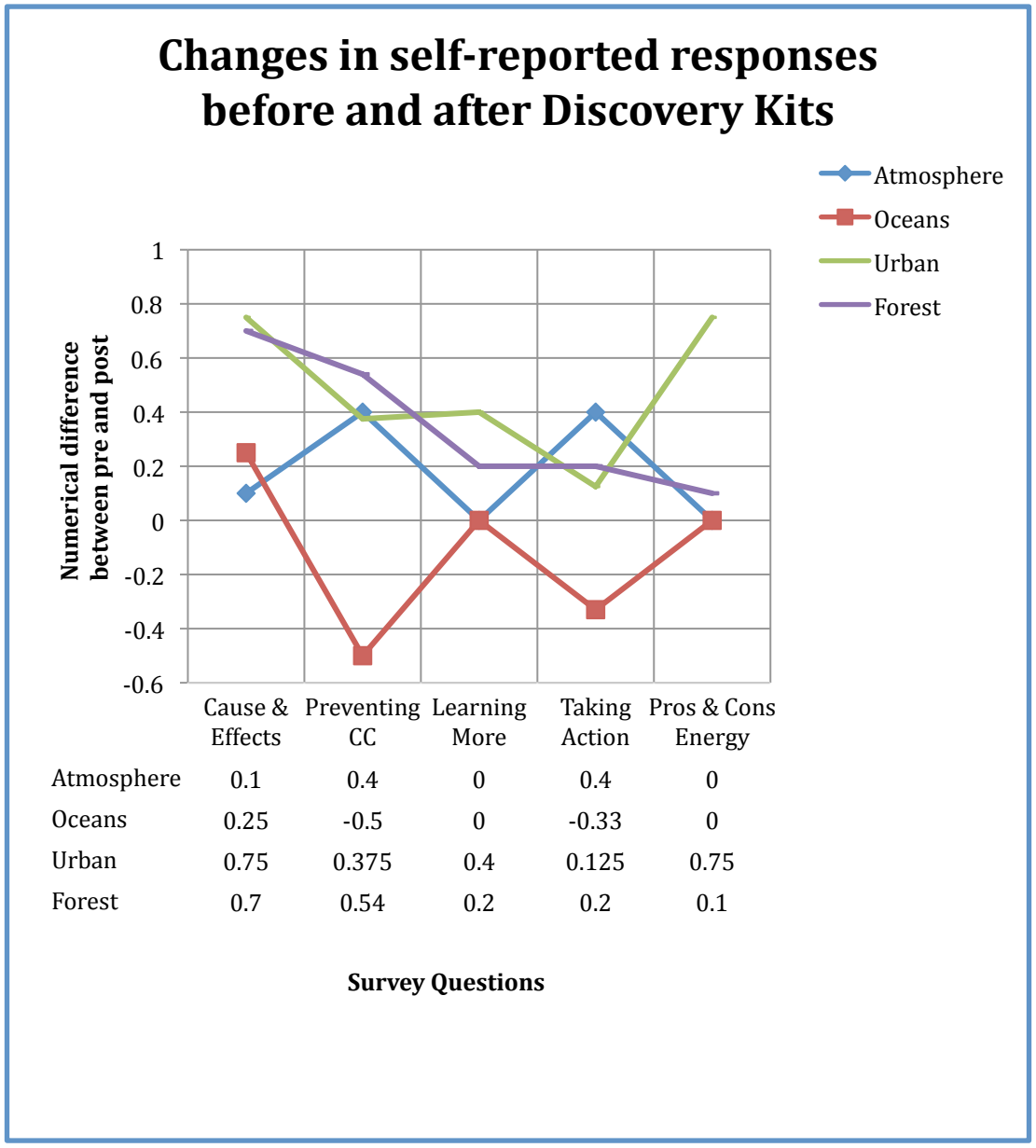
Figure 11: Respondent's changes from either incorrect or "I don't know" responses to correct responses for each kit.



In addition to the knowledge questions, each pre and post survey asked for self reported understanding of the causes and effects of climate change, understanding of what they could do to prevent climate change, the pros and cons of different energy sources (only for urban and forest) and interest in learning more about climate change and taking action (Figure 12). For each question the item responses were averaged together and then the differences between average pre and average post scores were calculated to measure change. In three of the boxes - Atmosphere, Urban, and Forest, all statements showed positive increases from pre to post, with the exception of one Atmosphere statement (Learning more), which showed no change. The Urban box in particular seemed to show very strong gains pre to post. This is likely due to the relevant subject matter (home energy use, composting, trash reduction) that most people are familiar with.

The Ocean box stood out from the other three boxes, showing only a slight positive increase for understanding of the causes and effects of climate change, pre to post and no change or declines for other questions. Specifically, users of the Ocean box showed a negative trend in understanding how to prevent climate change and in taking action. There was no overall change in interest in learning more. There may be several reasons why this particular box seemed to present difficulty from pre to post. First, it may be that respondents assume they know more about a certain topic in the pretest than they actually do. Once confronted with some of the knowledge questions, they may have realized that in fact they did not know very much to begin with. Another reason may be that the activities within the Ocean Discovery Kit may have been too far removed from tangible actions that could be undertaken. This is inferred by the negative trends in the two-action/behavior statements regarding their understanding of what they can do to prevent climate change and their interest in taking action as a result of using the kit. This is also apparent in the written comments asking what they can do to prevent climate change (Table 6). Many responses from the other three boxes alluded to box activities, this was not the case for the Ocean Kit.

Figure 12: Changes in self reported responses (from 1 strongly disagree, to 5 strongly agree) before and after use of the Discovery Kits. For each statement, data points above zero indicate positive changes in responses from pre to post; Data points below zero indicate negative changes from pre to post. Data points at zero indicate no change. The table below the graph provides the average change within each kit and by each question.



	Cause & Effects	Preventing CC	Learning More	Taking Action	Pros & Cons Energy
Atmosphere	0.1	0.4	0	0.4	0
Oceans	0.25	-0.5	0	-0.33	0
Urban	0.75	0.375	0.4	0.125	0.75
Forest	0.7	0.54	0.2	0.2	0.1

Table 6: Responses to the question: "What are three things you can do to prevent climate change?" prior to and after using the Discovery Kits.

Kit	Pre Response	Post Response
Atmosphere	Turn off appliances, visit informative websites to reduce carbon footprint; walk, bike, bus, carpool	Reuse, recycle, compost; become a citizen scientist and share data; plant trees and protect forests
Urban	Recycle; solar power; hybrid cars	CFL instead of incandescent; solar; recycle, reuse, compost
Forest	Vegetable oil powered car; recycle; compost	Not use coal; walk or bike; plant lots of trees
Ocean	Stop pollution; ride bike	Don't use as much electricity

Lastly, Discovery Kit users were asked what was the most surprising thing they learned as a result of testing the Discovery Kits. The responses highlight many conceptual knowledge gains regarding the role of CO2 in the atmosphere, the ways in which appliances consume energy, different sources of renewable energy, and the link between fossil fuels and carbon. Below are some of the responses with the corresponding Discovery Kit in parentheses.

Responses to "The most surprising thing I learned was . . ."

- That CO2 causes climate change and that the ocean absorbs the excess gas (oceans)
- As of 2010, there are 393 ppm. of CO2 in the atmosphere (atmosphere)
- How rapidly the CO2 rose through the years (atmosphere)
- When appliances are kept plugged in even after being turned off the energy they consume is called vampire energy (urban)
- Energy from the sun made the fan move (urban)
- Trees store carbon which is good for the environment (forest)
- That coal is made from ancient plants (forest)
- So many frogs and toads died - I love frogs and toads! (forest)

V. Discussion & Recommendations

In general, these findings demonstrate that all three activities were effective in meeting the educational objectives of impacting participant learning about causes and effects of climate change, pros and cons of different energy sources, and behavioral changes required to reduce energy use. However, it appears that some of the activities were better able to address these objectives than others.

The Hands-on cart activities were very effective at bringing awareness to phantom power used when appliances are turned off but still plugged in. The cart activities were less effective at addressing the causes and effects of climate change. And while each of the cart activities had high overall understanding, the Positive Feedback activity showed the most promise in terms of changing behavior and talking to others about energy use (keeping in mind the small sample size). Across all four activities, turning off lights was the behavior that seemed to resonate most with intended future behavior changes, followed by planting a tree. Importantly, each of these activities were regarded as fun while also being educational, an important criteria for engaging visitors in a science museum.

The results from the Hand-on Cart activities are limited by the fact that the surveys had been developed and evaluations had already taken place by Ithaca College students prior to the arrival of the independent evaluator, Tina Phillips. However, in future iterations of the Hands-on Cart activities, efforts should be made to emphasize the causes and effects of climate change and other behaviors that help to conserve energy.

Evaluation of the Interactive Forum was meant to determine the effectiveness of the active learning technique and use of the clickers as well as the effectiveness of the presentation to affect the ways people regard their role in addressing climate change. The clickers were very well received and observations of the audience demonstrated engagement with the clickers by nearly everyone. The presentation received fairly good ratings but in both presentations, the overall interest level of the audience could have been better. The survey findings showed that compared to the comparison group, the audience members were able to successfully articulate the role of CO2 and what they can do on a personal level to reduce climate change. These findings demonstrate the ability of the forum to empower people to make personal choices that positively effect climate change.

The forum findings are limited by the use of a comparison group rather than a control. The initial plan was to use a control group with similar characteristics as the treatment. The small sample size resulted in two groups that were fairly diverse, limiting the ability to control for extraneous variables such as age, gender, and Sciencenter membership. It is likely that the Sciencenter will continue to develop interactive programming, and if so, every effort should be made to keep the subject matter focused to one or two big ideas and to keep the presentations to around 20 minutes. Spinning the presentation with a positive angle is also recommended as it minimized the feelings of helplessness. In conjunction with the behavioral changes discussed in the forum, audience members were presented feasible ways to improve their self-efficacy around what is an otherwise daunting

phenomenon to consider on an individual level. Also, the clickers worked very well but should only be used to extract useful information rather than as a reason to use the clickers. Audience interest in the forum will be enhanced with the addition of short (less than one minute) demonstrations as well as inclusion of data displaying evidence of climate change. Lastly, better marketing for the forums may increase the number of members and the diversity of information collected using the clickers. Perhaps signs that say something like "Come join our interactive forum and tell us what you think about Climate Change using real-time polling devices" may help draw more visitors into the amphitheater.

Observations of the Discovery Kits showed extremely high engagement with the box contents. In generally, the average time spent exploring any singly box was between 20-30 minutes. Multiple people used the kits simultaneously. The kits were designed to be used in groups, and in the case of families, parents facilitated discussion and engagement with the activities. While children under the age of eight did use the boxes, they were unable to demonstrate signs of conceptual understanding when probed. Children between the ages of 10-15 seemed to be most engaged with the boxes and enjoyed working together through the activities. As the results showed, the Forest box demonstrated high conceptual knowledge change from pre to post answers. The Urban box demonstrated the greatest gains in empowerment to change behavior from pre to post. This appears logical given the relevance of the subject matter within the Urban kit. The kit showing the least effect to impact understanding and empowerment was the Ocean Kit. It appears that the messaging within the activities did not provide enough relevance for individuals to make the connection between the Ocean activities and ways to prevent climate change or willingness to take action.

Discovery Kit findings may be limited by a potential mismatch between the way the kits were used and the data collection technique administered. As mentioned, visitors used the kits together as part of a group, but the data were collected from each individual. A focus group with visitors after using the kits may have yielded more useful information about particular strengths and weaknesses of individual activities within the kits. Also visitors may have overestimated how much they thought they knew about climate change prior to using the kits, resulting in negative changes after using the Urban Kit. One way to deal with this problem is to conduct a retrospective post rather than a pre-post, and have respondents answer questions after the activity and self rate how they would have answered prior to the activity. Nevertheless, efforts should be made to update the Ocean box and draw more specific connections to every day behaviors. The kits should be labeled for a recommended age group or as an activity requiring adult guidance for younger children. Lastly, observations by the evaluator suggest that collectively the activities within each kit were lacking cohesion, or a central take home message. The inclusion of a scavenger hunt or word puzzle to complete a "mystery phrase" indicative of a conceptual take home message, could be an effective way of tying all the individual components of each kit together.

Overall the findings illustrate that the suite of activities within the Climate Change Toolkit are successful in peaking interest about climate change. Both the Hands-on Cart and Discovery Kit activities were extremely effective at engaging visitors of all ages and

backgrounds, with activities that can be easily integrated into the existing array of Sciencenter exhibits. Participants gained conceptual knowledge about complex concepts and perhaps most important, they learned what they can do as individuals to reduce climate change. Future longitudinal research may help determine how long such learning and interest persists, and whether personal actions to reduce climate change have been implemented into the daily lives of Sciencenter visitors.

VI. References

Coyle, K. J. (2004). *Understanding Environmental Literacy in America: And Making it a Reality*. Washington D.C. : National Environmental Education and Training Foundation.

Leigh, P. (2005). The ecological crisis, the human condition, and community-based restoration as an instrument for its cure. *Ethics in Science and Environmental Politics*, 3-15.

Louv, R. (2005). *Last Child in the Woods: Saving Our Children from Nature Deficit Disorder*. Chapel Hill: NC: Algonquin Books of Chapel Hill.

Maibach, E. W., Roser-Renouf, C., & Leiserowitz, A. (2009). 2009. Global warming's Six Americas 2009. An audience segmentation analysis. http://environment.yale.edu/uploads/6Americas2009.pdf. Viewed 10 Sep 2010.

Patton, M. Q. (2002). *Qualitative research and Evaluation Methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.

The Pew Research Center. (2010). Public's Priorities for 2010: Economy, Jobs, Terrorism. Retrieved September 3, 2010 from http://people-press.org/report/584/policy-priorities-2010

APPENDIX A: HANDS ON CART ACTIVITY

TELL US WHAT YOU THINK!!

IMLS Global Warming Toolkit – Climate Change Education Activities

This work is funded through a grant from the Institute of Museum and Library Services (IMLS).

1. Your age(s) _____

yes I don't know no

2. Was the activity fun?

3. Did you understand what to do?

4. What is one thing you learned today about energy or climate change?

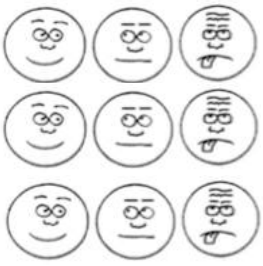
5. What is one thing you can do to prevent climate change?

6. *These activities make me want to…*

… take steps to reduce energy use.

… talk more about energy use.

…learn more about climate change.



Sciencenter

Appendix B: CLIMATE CHANGE PUBLIC FORUM FEEDBACK

The forum is made possible through a grant from the Institute of Museum Library Services (IMLS) in an effort to develop public engagement activities on climate science. The survey includes questions regarding your knowledge and attitudes related to climate change. Your feedback is very important to help us improve our programs. Please answer these items as honestly as possible. The results of the survey are confidential and anonymous. Thank you for your time.

1. Year you were born: _____

2. Gender: ☐ Male ☐ Female

3. Who else was in your group today (excluding yourself)?

A. Number of Adults: Male ____ Female____ B. Number of Children: Male ____ Female____

4.Please list the ages (in years) for up to six children in your group today.

Child 1:_____ Child 2:_____ Child 3:_____ Child 4:_____ Child 5:_____ Child 6:____

5. Are you a member of the Sciencenter (circle one)? No Yes If so ___# years as a member

YOUR OPINION ABOUT CLIMATE CHANGE (Please circle one choice)

Global climate change refers to the idea that the world's average temperature has been increasing over the past 150 years, may be increasing in the future, and that the world's climate may change as a result.

6. What do you think? Do you think that global climate change is happening?

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

7. How sure are you that global climate change is or is not happening?

A. Extremely sure
B. Very sure
C. Somewhat sure
D. D. Not at all sure

8. If global climate change is happening, do you think it is . . .

A. Caused mostly by human activities
B. Caused mostly by natural changes in the environment
C. None of the above because global climate change isn't happening
D. I don't know

9. Which of the following statements comes closest to your view?

A. Global climate change isn't happening
B. Humans can't reduce global climate change, even if it is happening
C. Humans could reduce global climate change, but people aren't willing to change their behavior
D. Humans could reduce global climate change, but it's unclear if we will do what's needed
E. Humans could reduce global climate change, and we are starting to take steps towards that goal

YOUR KNOWLEDGE OF CLIMATE CHANGE. Please answer the following questions to the best of your ability – if you don't know the answer, choose or write "I don't know" rather than guessing.

10. Which of the following is the greenhouse gas of most concern from a global climate change point of view?

A. oxygen (O2)
B. water vapor (H2O)
C. methane(CH4)
D. carbon dioxide (CO2)
E. ozone (O3)
F. I don't know

11. Do you know what the significance of the number '350' means as it relates to climate change? If so, please describe below.

_____

_____

_____

12. Can you describe three things that you can do to help prevent climate change?

_____

_____

_____

A FEW LAST QUESTIONS ABOUT THE FORUM

13. Please circle a number to rate your level of agreement with the following statements, each starting with *"As a result of the interactive public forum . . ."*

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I have a better understanding of the role of greenhouse gases in climate change	1	2	3	4	5
I have a better understanding of what I can do to prevent climate change.	1	2	3	4	5
I am more likely to talk about climate change with others.	1	2	3	4	5
I will plan to attend other events related to climate change.	1	2	3	4	5
I am more likely to seek out information about climate change.	1	2	3	4	5
I will take steps to reduce climate change.	1	2	3	4	5

14. How if at all, did the forum influence your views on global climate change?

_____

_____

_____

THANK YOU FOR YOUR TIME!

STAFF: PLEASE COMPLETE THIS SECTION BEFORE PHOTOCOPYING:
Event:_____ Date(s):_____

APPENDIX C: SCIENCE OF CLIMATE CHANGE DISCOVERY KITS – POST

These discovery boxes are made possible through a grant from the Institute of Museum Library Services (IMLS) in an effort to develop public engagement activities on climate science. Your feedback is very important to us. Please answer these items as honestly as possible. The results of the survey are confidential and anonymous. Thank you for your time.

1. Year you were born: _____ **2. Gender: ☐ Male ☐ Female**

3. Who else was in your group today (excluding yourself)?

A. Number of Adults: Male ___ Female___ B. Number of Children: Male ___ Female___

4.Please list the ages (in years) for up to six children in your group today.

Child 1:____ Child 2:____ Child 3:____ Child 4:____ Child 5:____ Child 6:____

5. Are you a member of the Sciencenter (circle one)? No Yes If yes, ____# years as a member

6. Which Discovery Kit(s) did you use today? Circle all that apply.

a. Arctic & Oceans b. Atmosphere c. Forests d. Urban

7. Please circle "true," "false," or "not sure" regarding the following statements.

Oceans can absorb excess carbon dioxide and help reduce climate change.	**True**	**False**	**Not Sure**
Dark colored objects tend to absorb more heat than light colored objects.	**True**	**False**	**Not Sure**
Scientists don't know what will happen if all the icebergs and glaciers melt.	**True**	**False**	**Not Sure**
With less sea ice, polar bears will be able to find food more easily.	**True**	**False**	**Not Sure**
Scientists don't fully understand the effects of clouds on climate change.	**True**	**False**	**Not Sure**
Water vapor (H2O) is a greenhouse gas.	**True**	**False**	**Not Sure**
Scientists measure the amount of carbon dioxide (CO2) using infrared light.	**True**	**False**	**Not Sure**

8. Can you describe three things that you can do to help prevent climate change?

_____

_____

_____

9. Please circle a number to rate your level of agreement with the following statements

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
I have a very good understanding of the causes and effects of climate change	1	2	3	4	5
I have a very good understanding of what I can do to prevent climate change.	1	2	3	4	5
I am interested in learning more about climate change	1	2	3	4	5
I am interested in taking action to reduce the effects of climate change	1	2	3	4	5

10. "What was the most surprising thing you learned while using the discovery box?"

_____

APPENDIX D: CONSENT TO PARTICIPATE IN A DISCUSSION GROUP

Dear Parent or Guardian:

You and your child's opinions of the Sciencenter climate change presentation are important to us. We would like to assess the effectiveness of the presentation by asking you to take a quick 5-10 minute survey. While you are taking the survey, we would like to hold a discussion group with the children that also were part of the presentation. If you give permission for your son/daughter to participate, please check the appropriate box below and return this form to one of the Sciencenter staff.

PARTICIPANTS: Parents and their children who participated in the climate change presentation.

PROCEDURES: On May 22, 2010, from 2:30 to 2:45 pm in the Sciencenter amphitheater approximately fifteen to twenty children will meet with a discussion group leader while the parents are taking a quick survey. The group will discuss their opinions about the climate change presentation and should take only about 5 minutes.

BENEFITS: Participants will not benefit directly from this discussion. However, you and your child's participation will help the project directors improve the interactive presentation.

CONFIDENTIALITY: Students' names or other personal information will not be collected by the discussion group leader. Participation will be anonymous. All information that is collected will remain strictly confidential.

IF YOU HAVE QUESTIONS: Contact the project evaluator, Tina Phillips, (607) 254-2482.

VOLUNTARY PARTICIPATION: Participation in this discussion group is voluntary. You and your child may decline to answer any question or discontinue involvement at any time without penalty.

Please sign the bottom of this letter indicating consent and return it to the staff at the Sciencenter.

__ I consent to my participation in the climate change presentation survey.

__ I do NOT wish to participate in the climate change presentation survey.

__ I consent to my child participating in the climate change presentation discussion group.

__ I do NOT consent to my child participating in the climate change presentation discussion group.

_____ _____

Parent's/Guardian's Name Parent's/Guardian's Signature Date