Evaluation of "Heliostat: The Sun Live - Heat from Sunlight"

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December 7, 2007

1 Background

Heat from Sunlight is a component of the larger exhibit, "Heliostat: The Sun Live," currently in development at The Museum of Science and Industry (MSI). In this exhibit, it is proposed that visitors will interact with sunlight directed from a central heliostat (a device that tracks the sun, focusing the light onto a target) to smaller exhibit which will demonstrate that heat is a form of energy that is produced by sunlight. The original concept for visitor interaction was to direct the sunlight onto a tank of water. Using an Infrared (IR) Camera, visitors may observe convection currents in the water as it heats.

2 Goals

MSI has an IR camera installed in the museum. Visitors stand in front of the camera and see a false color image of themselves projected onto a large screen. Darker colors (black/blue) indicate colder regions and lighter colors (red,yellow) indicate hotter regions. Use of the IR camera was an integral part of the original exhibit concept. Thus, as it was necessary to determine the effectiveness of the camera in a heat from sunlight context, we focused on learning whether visitors understand the image produced by the camera. The goal of this evaluation was to develop a demonstration that would allow us to gather answers to the following questions:

1 Do visitors understand the connection between color and temperature as shown by the IR camera?

2 If not, can the connection be made quickly and easily?

3 Once the image created by the IR camera is understood, can it be used to demonstrate the connection between light and heat?

3 Evaluation Process

Our evaluation process consisted of three steps: preliminary prototyping, survey design, and final evaluation.

3.1 Preliminary Prototyping

Our first step was to place objects of or containing varying temperatures before the IR camera and observe color contrast. We hoped to see convection currents or at least temperature gradations by combining hot and cold water. The angle (from above) and resolution (too low) of the camera and the time necessary for significant temperature change proved to be major obstacles to a demonstration of convection. Ice or cold water dropped into hot water simply disappeared below the surface and, therefore, the view of the camera. We tried water, ice, dry ice, and ethanol in several plastic and glass containers and could not see convection. Eventually, combining hot and cold water would produce a color change on the screen. Executed on a small scale (small drops of one into the other) the desired effect was produced far too slowly; on a large scale (pouring a large amount of one into the other) produced a color change that happened too quickly.

We also brought several lights and found one that worked well and finally decided on a two-part demonstration. The first was designed to test visitors understanding of the connection between heat and IR image color. This demonstration consisted simply of two transparent plastic buckets, one filled with hot water and the other with cold. The second part made use of a strong light bulb and blank surface (a table top or board on an easel). The bulb was turned on and moved across the surface. When on, the bulb heated the surface leaving a trail of heat visible on the IR screen.

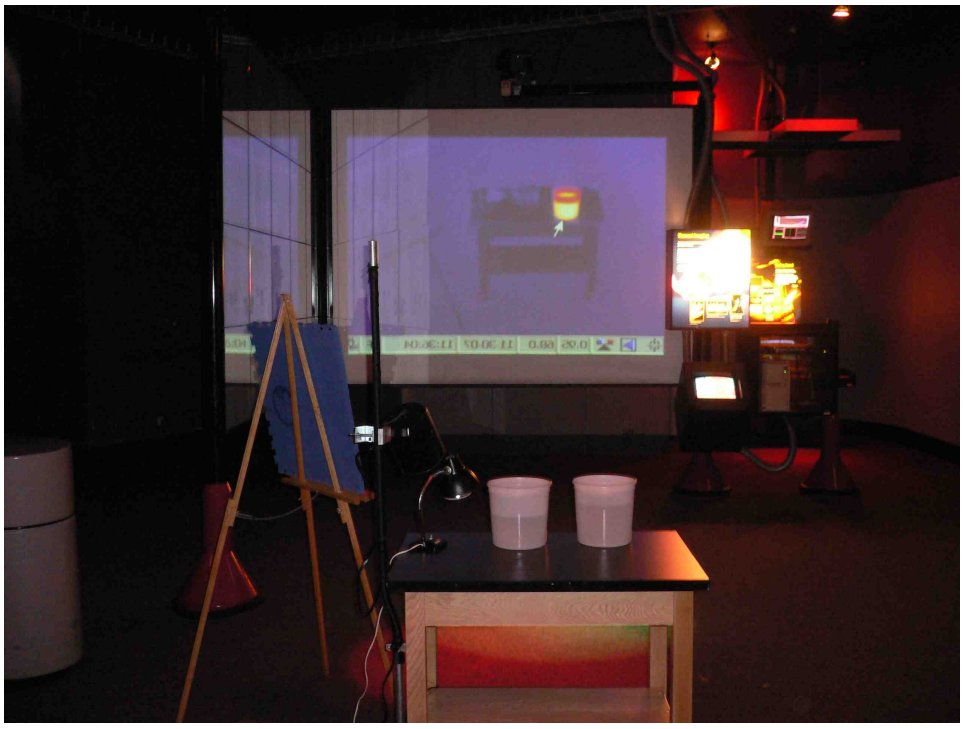

Figure 1: Setup of the materials used during the evaluation. Left to Right on the Bottom: Easel, Light, Cold Water Bucket, Hot Water Bucket. Center Top: Screen with IR image of the setup projected onto it. Note that the hot water is Yellow while the colder objects appear Blue.

3.2 Survey Design

Using this prototype demonstration as a basis, we created a preliminary oral survey. One demonstrator would ask the questions and prompt the visitor while the other observed and recorded the responses. We collected responses from 10 groups of visitors on Friday, November 16th, in front of the IR camera from 4:00 p.m. to 5:00 p.m.. We then made adjustments to the question phrasing in order to eliminate potential biasing and clarify the survey. The final version of this survey (used on Saturday, November 17th between 10am and 12pm) is included in Appendix A with instructions for the interviewer.

4 Results

We surveyed 39 groups of visitors (> 100 people). Our sample was 54% female and 46% male and dominated by children ages six to twelve (41%). We found that 51% of respondents entered understanding the connection between heat and color as shown by the IR camera. 49% either did not understand what the IR image was showing them or inverted the color scale in their responses. After feeling the water, however, 95% understood the image.

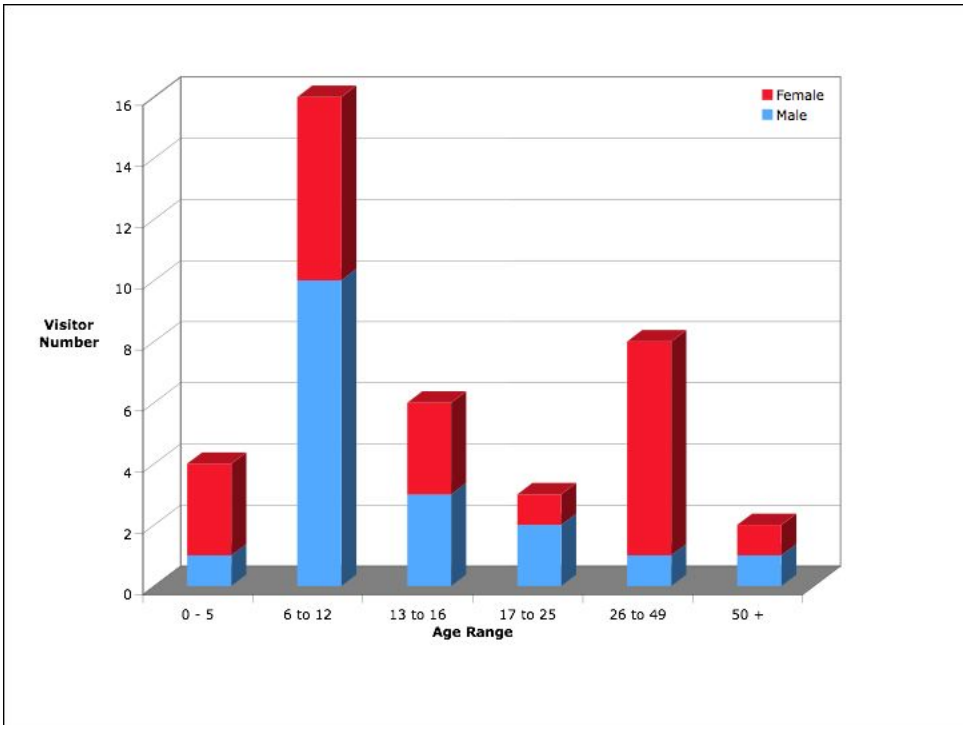

Figure 2: Survey respondents by age and sex.

After establishing the connection between heat and color, all visitors were shown a light and asked to predict the image that would appear. 87% correctly responded that the bulb would appear as a yellow spot on the screen representing the area warmed by the light. 13% could not predict

the effect of the light and needed to first either see the light on the screen or feel the surface and the light to correctly answer. Note that some of these 13% became confused because the light was occasionally hot enough to reset the scale of the camera and when the camera scale reset the color scale flipped to make hot things a darker color. We believe this number would have been lower if the cameras scale had been fixed rather than variable.

Finally, visitors were asked to evaluate the prototype and suggest ways to improve a future exhibit. They were first allowed to play with the prototype. Popular activities included: dipping hands in water and watching their color change, using cold water to create a mustache or highlights in hair, and using the light to paint on the easel, table top, or their clothing. 23% preferred the water based activities and 16% chose the light as their favorite (61% liked both equally). There was a universally positive response to the demonstrations interactive component, especially as it allowed visitors to feel what they were seeing. It was both useful (helping people to make the connection between light and heat quickly) and engaging (creating and enjoyable, positive experience). Specific visitor suggestions are noted in Appendix B.

5 Conclusions

The most significant and relevant conclusions drawn from the demonstration and corresponding survey are as follows:

1. 49% of visitors will understand what they see on the IR Camera without a demonstration or labels.
2. 95% of visitors left understanding the connection between Heat and IR Color
3. 87% of visitors left understanding the connection between Light, Heat and IR Color (Problem: IR Camera scale changes)
4. Universal (100%) positive response for “Hands-On” interaction.

While we understand that MSI may not be able to incorporate playing with open water into the exhibit we recommend that they do include a components that use touch as well as the IR camera to show the connection between light and heat.

A Heliostat Evaluation

Circle One: M F

Age: ————————-

Standing in front of the setup shown in Figure 1

QUESTION 1 Look at these two buckets of water on the screen. Can you tell me what the difference is between them?

If the answer to QUESTION 1 is 'different colors' then ask Question 1a else move on to Question 2.

QUESTION 1a What do you think the colors mean?

After they have answered, ask them to find out by feeling the water.

QUESTION 2 Now, what do you think the colors mean? *(Ask them to elaborate if necessary:)* Which color is the hottest? Which is the coldest?

Now move onto the lamp plus the surface. Hold up the light, turned off.

QUESTION 3 If I turn on the lamp, what will the picture show?

After they have answered, turn on the light. If they have gotten QUESTION 3 wrong, repeat the question or elaborate with QUESTION 1a

QUESTION 4 Where is the heat coming from?

Allow them to play with the water, the light, and their image on the camera.

If they are hesitant, suggest sticking their hand in the water and looking at the color change or painting on the easel or their clothes with the light.

QUESTION 5 What about this demonstration really interested you? *If no answer, ask them:* What was your favorite part or what would you like to see in an exhibit??

QUESTION 6 Is there anything else you would like to see in an exhibit like this?

B Respondent Suggestions and Comments

- Liked using cold water to make hands "disappear" on IR camera.
- Wanted to use ice and see hot and cold water mixed.
- Liked give each other /themselves highlights, mustaches etc.
- Liked use a light source to paint on clothes or easel.
- Wanted more concentrated light source to use as a "brush"
- Suggested using a Hair Dryer along with the light source to paint on clothes
- Suggested using the IR camera to compare regular and energy efficient light bulbs.

C Pictures

Figure 3: Visitors enjoy playing with their images using the IR camera.

Figure 4: Images shown by IR camera during demonstration. Top: Turning on the light heats the table. Bottom: Stripe of heat 'painted onto the easel by the light.'