



Changing Colors

Formative Evaluation

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THIS IS A FORMATIVE EVALUATION REPORT

Formative evaluation studies like this one often:

- **are conducted quickly**, which may mean
 - small sample sizes
 - expedited analyses
 - brief reports

- **look at an earlier version** of the exhibit/program, which may mean
 - a focus on problems and solutions, rather than successes
 - a change in form or title of the final exhibit/program

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Background

During October of 2008, Science Museum of Minnesota visitors provided feedback on the prototype exhibit *Changing Colors*. A total of 30 visitors used the exhibit. The exhibit's main message is that "scientists are using the nanophenomena we see in nature to create new products and applications with cool properties." Participants were observed using the exhibit and then interviewed about their experience. The "n" value for each question is reflective of the number of visitors who were observed or responded to that question. Additional visitor demographic information is available at the end of the report.

Results and Discussion

Exhibit's Objective

The main message of this exhibit is "scientists are using the nanophenomena we see in nature to create new products and applications with cool properties." In addition, the exhibit had three major learning goals:

- The butterfly scales and thin films contain no pigment.
- The butterfly scales and thin films are made up of layers of super thin, transparent materials. The spacing between the layers causes only certain light waves to bounce back to our eyes as colors.
- When you change the angle of the light, you change the color.

To understand whether these messages were being conveyed to the visitors, participating visitors were asked what they thought the exhibit was about, what they thought the connection was between the butterflies and the films, and if they saw a connection between the monitor and the rest of the exhibit.

Visitor perception of main message

Three tenths of the visitors appeared to take away the main message of the exhibit. One third of the respondents believed the exhibit to be about how light reflection creates color, while one out of five participants thought the exhibit was exclusively about the changing colors of butterflies. Less than one fifth of the participants (17%) provided a vague response or said that they did not know the exhibit's main message (see Table 1). A complete list of coded responses may be found in the Appendix. These responses show that most of the visitors took away the third learning goal of the exhibit or the larger main message.

Table 1: Visitor perception of main message (n=30)

	Percent of Respondents
Light reflection and color	33%
Nature inspires technology	30%
Butterflies change colors	20%
Don't know or vague response	17%

Visitors’ connections between butterflies and films

Visitors made strong connections between the butterflies and the films on the exhibit. More than half (57%) understood that the films demonstrated a synthetic representation of the naturally occurring phenomenon in butterflies. Three tenths of the visitors were unsure of the connection between the films and the butterflies (see Table 2). A complete list of coded responses may be found in the Appendix. Other responses included that the colors of the film and the butterflies were the same or that they were simply both reflective. Only one visitor identified the layering of multiple films to create the color changes, which is one of the learning objectives for this exhibit.

Table 2: Visitors’ connections between butterflies and films (n=30)

	Percent of Visitors
Natural vs. synthetic representation of same phenomenon	57%
Unsure of connection	30%
Other	13%

Less than half (43%) of the visitors looked at the monitor when working with the exhibit. Of those who looked at the monitor, all but one saw a connection between the exhibit table and the monitor. Half of these visitors thought the monitor provided examples of how the color change phenomenon is applied to synthetic products. The other half felt the monitor merely reiterated or elaborated on the information presented in the rest of the exhibit. A complete list of coded responses may be in the Appendix. These responses show that if visitors watch the screen, they understand that it is conveying the various ways that scientists have taken nanophenomena and turned them into “new products and applications with cool properties.”

Exhibit’s Relevance

Visitors were asked if the exhibit connected to anything in their lives. Those who responded affirmatively were asked to elaborate on the connection. Half of the visitors found the exhibit to be relevant to something in their lives. When asked to elaborate, nearly half of the respondents (47%) cited specific, everyday examples. One fifth of these visitors found relevance to their work or education. A few saw connections to other exhibits in the museum (see Table 3). A complete list of coded responses may be found in the Appendix.

Table 3: Exhibit relevance to visitors’ lives (n=15)

	Percent of Visitors
Specific, everyday examples	47%
Work or school	20%
Other exhibits within the museum	13%
Other	20%

Observed Behaviors

Participants were observed while using the Butterfly exhibit. All but one participant tilted at least one butterfly and most (63%) tilted all three. Nearly three quarters of the visitors (73%) used the headphones but no one pressed the button to hear the audio in Spanish (see Table 4). All of the participants tilted the mounted films. Approximately half of the participants looked at the large label while slightly fewer looked at the monitor (53% and 43%, respectively). Of those who looked at the monitor, most (85%) also pressed a button on the monitor. Data collectors reported that one tenth of the visitors were visibly confused and did not seem to know what to do.

Table 4: Participant behavior (n=30)

	Percent of Visitors
Tilted films	100%
Put on headphones	73%
Pushed button for English audio	70%
Looked at large label	53%
Looked at monitor	43%
• Pressed the button	(85%)
Pushed button for Spanish audio	0%

Ease of Understanding

What to do at the exhibit

Less than half of the visitors (43%) felt that it was easy or very easy to figure out what to do at the exhibit (see Table 5).

Table 5: Ease of understanding what to do with the exhibit (n=30)

	Percent of Respondents
Very easy	20%
Easy	23%
Somewhat easy	37%
Not easy	20%

Those individuals who felt something was confusing or frustrating were asked to elaborate. Two fifths (40%) of these respondents said that the text was confusing and overwhelming. Suggestions from visitors included adding an introduction and numbering the directions. Six participants pointed out that the directions given in the headphones were inaccurate or unclear. One fifth of these visitors reported that only the blue butterfly seemed to reflect light, perhaps due to the direction the light was focused. A complete list of coded responses is included in the Appendix.

Level of vocabulary used

Two thirds of the visitors thought that the vocabulary was “just right” (see Table 6). Nearly one quarter (23%) found the vocabulary to be “too difficult.” One participant declined to answer because he “didn’t really read it.”

Table 6: Level of vocabulary used (n=29)

	Percent of Respondents
The vocabulary was too easy	7%
The vocabulary was just right	67%
The vocabulary was too difficult	23%

Those visitors who found the vocabulary to be too difficult were asked to elaborate on what word or words they thought were difficult. Many of the respondents were unable to give specific answers, but some shared that they thought there was too much information or too many words used in the exhibit:

- I don’t remember. (2)
- Pigments. There were just too many words.
- Wordy. Talked fast. Rattled off a bunch of words.
- Other light exhibits around would make it easier. Difficult as stand-alone.
- I don't know.
- Seems a little too complex.

Interest and Enjoyment**Visitor Interest**

Nearly three quarters of the visitors (74%) were interested in the exhibit, though the majority (57%) indicated that they would not do it again (see Table 3). More than one quarter (27%) of the visitors found the exhibit not very interesting.

Table 7: Interest level (n=30)

	Percent of Visitors
I was so interested, I'd do it again	17%
I was interested, but I wouldn't do it again	57%
I wasn't really interested	20%
I didn't find it interesting at all	7%

Those individuals who found the exhibit interesting were asked what they thought was most interesting part. Approximately one fifth of the visitors named either the butterflies, the light reflection and color changes, or the films to be the most interesting aspect. A few visitors (14%) thought that the information about how nature influences technology was interesting. A complete list of coded responses is included in the Appendix.

Visitor Enjoyment

Two thirds of participants felt the activity was enjoyable but only less than one tenth (7%) would recommend others try the exhibit (see Table 8). One third of the visitors did not enjoy the exhibit.

Table 8: Enjoyment level (n=30)

	Percent of Visitors
It was so enjoyable, I'd encourage others to try it	7%
It was enjoyable	60%
I didn't really enjoy it	20%
I didn't find it enjoyable at all	13%

Additional Information

Participants were asked if they wanted to see more information than what was currently presented in the exhibit. Approximately one quarter of the visitors (27%) responded that they would like more information. These visitors suggested having information regarding how the films are used, the use of different colors and shapes, and more examples:

- Maybe airplanes.
- It's... I kind of understand how wavelengths work – could do a better job of explaining more.
- Nice to see where [they] used films specifically – give more examples.
- What do we use it for? How to get from here to here – process of it.
- Shapes in films. How that's tied to butterfly shapes.
- Different at night versus during the day?
- Different shades of colors, how they can get so colorful.

Interpretation and Recommendations

As more than half of the participants had difficulty using the exhibit, efforts to make “Butterfly” more user-friendly are required. The audible directions need to be rerecorded to reflect the current structure of the exhibit. Visitors struggled with the written instructions as well. Implementing more structure to the instructions may help alleviate this problem (i.e. numbering, headings and subtexts, etc.). Participants also had difficulty seeing the iridescence in all three butterflies. The light appeared to be mounted in such a way that the beam struck only one of the butterflies. If possible, allow visitors to adjust the direction of the light.

Visitor Demographics

Visitor information was self-reported. Nearly three quarters of the visitors (73%) were female. Half of the visitors came to the museum in a group composed of adults and

children. The other half attended with other adults only. The majority of the visitors were adults, with three tenths being children.

Table 9: Visitor age range (n=30)

Percent of Respondents	
8-12	27%
13-17	3%
18-21	7%
22-29	17%
30-39	17%
40-49	23%
50-59	0%
60+	7%

Appendix

Visitors' perceptions of main messages (n=30)

33% (10) Light reflection and color

- How light is reflected off of things.
- Colors or something. [Prompted by father] How light changes colors.
- How light reflects off butterflies' wings and tells you how light is made.
- Iridescence. How changing structure affects what you see.
- How light waves reflect off of different objects.
- Trying to explain different colors and how they're refracted.
- How light affects color.
- How butterflies in different light you get a different image in your eye.
- The use of light in products to create color.
- How light is reflected and shows color.

30% (9) Nature inspires technology

- How an idea from nature is being taken from humans to be used in technology.
- Technological applications rendered from natural resources.
- How the coloring of butterflies/how it's created is being used by technology today.
- Applying ability of natural color shift to man-made things.
- How natural things... How science is embedded in nature.
- How nature can inspire things that are useful to people.
- I suppose things that occur naturally take that technology to apply to things like make-up.
- How someone discovered that butterfly wings have layers and some things [that have been] done like cell phones and lipsticks use the same concepts that were developed.
- Nanotechnology in everyday life.

20% (6) Butterflies change colors

- How butterflies aren't the exact color you assume they will be.
- How butterflies change colors.
- Butterflies have really interesting colors.
- How colors change. How different pigments of butterflies can change.
- What type of butterflies and butterfly colors there are.
- The different colors the butterflies give off.

17% (5) Don't know or vague response

- Show us how to know different things about animals.
- Appreciation for science.
- Shining lights on butterflies.
- No idea what it is about.
- I don't know.

Connection between butterflies and films (n=30)

57% (17) Natural vs. synthetic representation of same phenomenon

- Seems like they have the same sort of material.
- Science and nature; both have changing colors.
- They've got that shiny, color change thing.
- Took different things that were apparent in butterflies and tried to reproduce them in films.
- Showing similarity of coloring. Layering of thin layers.
- Technology learned from nature.
- Same as before [applying ability of natural color shift to man-made things]. Examples of how this works.
- Their wings do the same things.
- An "inspired by" kind of thing.
- If you tilt them different ways, you see them different ways.
- The way the light affects the changing color.
- Butterflies are a natural film, others are made in a lab.
- Pretty close, some of the same concepts. Difficult to see the way it works.
- See the connection – taking what is in nature and creating products to create color.
- Light changes color and does the same thing on the butterflies.
- How light is reflected and shows color. Butterflies absorbing or reflecting light and that's what the film is doing.
- Easier to see change on films.

30% (9) Unsure of connection

- I don't know. (3)
- I don't think I realized there's three here and three here. The colors are the same. I wasn't sure if they were directly related. I had to figure out the black stuff down here. I was trying to understand. It's not very clear, not understood easily.
- Didn't really make sense. You can see through the films but not through butterflies.
- It was hard to sort through the information to see the connection.
- Not real sure. Neat though.
- I don't see one.
- Wasn't sure.

13% (4) Other

- Some are same [colors].
- They have different reflections.
- They're brighter because light reflected off of certain parts of butterflies.
- I thought they were pretty. Colors obviously.

Connection between monitor and exhibit (n=12)

50% (6) Applications of phenomenon in synthetic products

- I think the monitor shows different applications, [pointing to table] shows phenomenon.
- Some was repeating, some extension. Real life examples, like cosmetics.
- Gave a few examples.
- Helpful. Solidifies what they teach in the headset. Backs up how it could be applied.
- More about how things are used based on this principle.
- The different layers and the spaces that separate light passed through is what's reflected. Showed actual products, lipsticks.

50% (6) Reiteration or elaboration on what was presented

- It tells you what the headphones are saying.
- Different shapes on wings were in display.
- Seems kind of secondary. Has additional information.
- Both describe the same thing.
- With different light then you get a different image.
- On the same topic. Correlated well.

Confusing/frustrating parts of exhibit (n=15*)

*Several participants provided more than one response.

40% (6) Text/Written Instructions

- A lot of words. Too many.
- It wasn't clear how to follow through with the relationship between the butterflies and the films.
- Too much text. Maybe [include] directions for where to start. I didn't know where to start first.
- The directions are better in other Science Museum exhibits where they are numbered.
- Hard to see the purpose. It needs a better introduction. Not knowing what [you're] looking at is frustrating and distracting.
- I wasn't sure what it's about. After I read all of it, then I saw the connection. [It] needs an introduction.

40% (6) Audible Instructions

- When she said the big words.
- There was a part I wasn't sure about what she was talking about – putting slides in holders.
- I didn't know which thing they were talking about on the headphones.
- "Put the slide on the line" [referring to mounted slides].
- When they say to put the slide in, it's already there. That's the only direction they gave.
- The headphones play right into the butterflies but not the slides.

20% (3) Poor Butterfly Reflection

- The butterflies. I could only see something change on the blue one, not on the others. I didn't know what to see on the others.
- Some of the butterflies don't seem to do it. Concept [is] good, examples don't show it very well.
- I didn't feel I got the effect of it. One of the butterflies worked but two didn't.

7% (1) Other

- I didn't know if the light was supposed to move. It was simple. I thought we should be able to do more.

Exhibit relevance to visitors' lives (n=15)

47% (7) Specific, everyday examples

- Paints on cars that shift in the night.
- Hologram stickers.
- Sunglasses. LCD displays.
- Car windows.
- Magnifying glasses? I don't really know.
- Reminds me of polarized light and sunglasses.
- That if you put a different lens on a camera, you'd see a different picture. The colors would be different, darker or lighter.

20% (3) Work or school

- I remember having wave physics in high school. I remember how waves work and now I can apply that to this.
- Connects to my work. I work for 3M. We do a lot with polarizing light.
- I worked at 3M on films.

13% (2) Other exhibits within the museum

- The light stuff downstairs. Reflections downstairs.
- With other exhibits where it is used.

20% (3) Other

- Butterflies can fly.
- Color – that's everyday.
- How color changes. I like changes of color.

Most interesting part of exhibit to visitors (n=22)

23% (5) Films

- Color thing.
- The color stuff.
- Changing colors on mirrors.

- How when you rotate them around they change colors.
- That the plates moved to catch different light. Hands on.

23% (5) Light reflection/color change

- Learning that there isn't any pigment in the wings, just how light reflects.
- Change colors.
- To know wings reflect differently so your eyes can see them.
- The light waves.
- I like color and shiny.

18% (4) Butterflies

- The butterflies. (2)
- The butterflies when they shined.
- Tilting the butterflies. The butterflies themselves – they're the prettiest.

14% (3) Nature's influence on technology

- Reading about different applications of the phenomenon. Different ways people took phenomenon from nature and applied it to technology.
- I feel like we've seen color and light throughout the museum. It's interesting that they brought nature into it.
- How something from nature influences scientists.

23% (5) Other

- How... That it has tons of layers on its wings.
- To hear that nanotechnology is being used in other applications.
- Layers of film and how that works.
- Not sure what I was doing.
- All interwoven – butterflies and the written material on the monitor.