NISE network™
NANOSCALE INFORMAL SCIENCE EDUCATION

Introduction to Nanotechnology: Self Assembly, Colored Glass, & Metal Rubber

Formative

By Scott Ewing

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Acknowledgements

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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

Objectives

- Evaluate the tabletop exhibition prototype with OMSI visitors prior to the meeting with NISE Net collaborators in Minnesota March 25–28, 2006.
- Use the results of testing to refine prototype content, graphics, and user interfaces.

Methods

Data were collected over several days in early March (March 1, 2, 5, and 7). We used naturalistic observations of visitors followed by post-use interviews. Visitor dwell time was recorded as well as visitor behavior. The post-use interviews were conducted with one primary spokesperson for each visitor group.

Procedure

Evaluators observed visitors interacting with the prototype for the length of time visitors remained engaged. We recorded visitor dwell time, how many visitors used the prototype simultaneously, and behavioral observations including: visitors talking with each other about the prototype, reading the instructions and copy, experimenting with the activity multiple times, and how visitors manipulated the loose pieces of the prototype. The prototype consisted of three components (described below). We also recorded which components the visitors used.

Description of prototype

The prototype consisted of three components. The first component highlighted the concept that nanoparticles have unexpected properties. This point was illustrated with a piece of glass colored with gold nanoparticles that reflected red light. Visitors visually compared a small bottle of gold flakes with the red glass. (NOTE: We also tested a multi-color piece of glass colored with silver and a bottle of silver flakes.)

The second component addressed the concept (and importance) of self assembly. Visitors separated plastic pucks (embedded with magnets) that sat on a small "air hockey" table. When visitors pressed the "on" button the air blower turned on and the plastic pucks came together in a pattern, representing a self-assembled material.

The third part of the exhibition allowed visitors to examine the properties of self-assembled nanomaterial—Metal Rubber. Visitors briefly compared the ability of three materials (copper, rubber, and Metal Rubber) to stretch and to conduct electricity. (NOTE: The Metal Rubber was not durable enough to survive on the floor with visitors.)

Results

A total of 48 people in 19 groups were observed and interviewed over the course of testing. Full results can be found in Appendix A. After our first round of visitor testing with nine visitor groups, it became clear that some changes needed to be made to the

prototype. Few visitors read any copy or demonstrated an understanding of the concepts presented. To modify the prototype we:

1. Refined main messages communicated in headers
2. Strengthened hierarchy of the graphic layout
    a. Shortened body copy
    b. Eliminated two chunks of copy
    c. Made body copy chunks uniform in size and visual weight
    d. Visually simplified graphic background (changed from pattern to black)
3. Moved glass sample from graphic panel to an angle on the tabletop
4. Refined instructions for “Self Assembly” component
    a. Added the words “nanoparticles” and “self assembly”
    b. Added key labeling the pucks as “nanoparticles”

Results described below compare before (round one) and after we made our modifications (round two) rather than cumulative results. Ten groups used the prototype in the second round of visitor testing.

Component 1: Glass colored with nanoparticles

Orientation

Originally mounted vertically on the text panel (fig. 1) in round one, the glass did not get much attention from visitors. As a static display it garnered less attention than the air table, and only 2 out of 9 groups looked at the glass. For round two, we moved the glass down onto the tabletop, mounted at an angle. In the new position (fig. 2), more visitors looked at the glass and read the copy (4 of 10 groups).

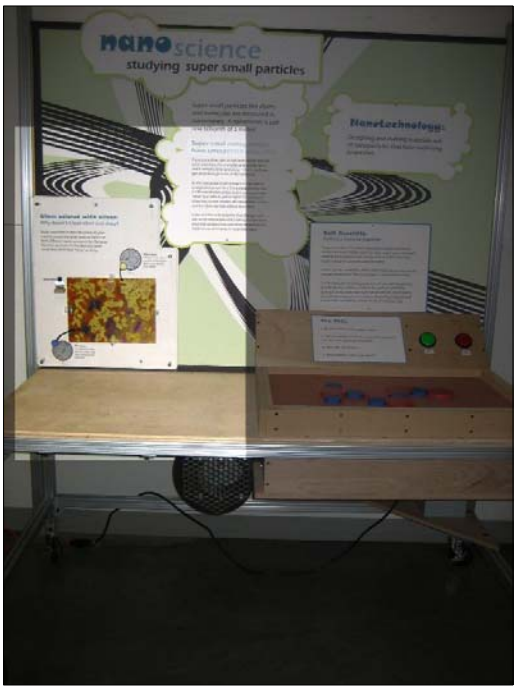

Figure 1

Round 1 with vertical placement of glass.

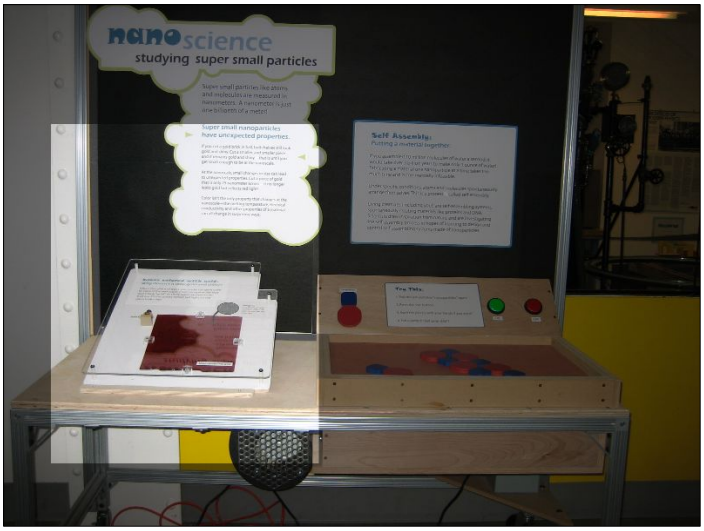

Figure 2

Round 2 with angled placement of glass.

Glass colored with gold vs. silver

We had two versions of glass colored with metal nanoparticles—one colored with gold nanoparticles and one colored with silver nanoparticles. The glass colored with gold was a uniform color of red. The glass colored with silver had several colors (ranging from yellow to blue to pink) resulting from different-sized nanoparticles of silver.

Three groups studied the glass colored with silver and three groups studied the glass colored with gold. None of the visitors who studied the glass colored with silver understood that its color was from silver particles. In contrast, all 3 of the groups who studied the glass colored with gold were able to explain that the glass was red due to the gold particles.

Component 2: Self assembly model

During the first round of testing, many visitors did not demonstrate an understanding that the pucks on the air table represented self-assembling nanoparticles. Four of the 9 groups incorrectly described the activity as being about magnets, stars and planets, or electrons and protons. Four of the groups said it was about molecules or atoms. One group said it was both about molecules and magnets. When asked what the pucks did when the prototype was turned on, 7 of 9 groups gave vague answers about the pieces coming together. Two groups mentioned self assembly.

In the second round of testing (after changing the instructional copy, layout, and adding a key for the pucks), visitors' understanding improved. Five of 10 groups said the pucks were molecules or atoms, and 4 groups said the pucks were nanoparticles. One group said the pucks were electrons, protons, and molecules. When asked what the pucks did, 4 of 10 groups gave vague answers about the pieces coming together. However, 6 of 10 groups explained that the pieces assembled or self assembled, indicating that they had read the copy.

Figure 3

Round 1 self-assembly component highlighted.

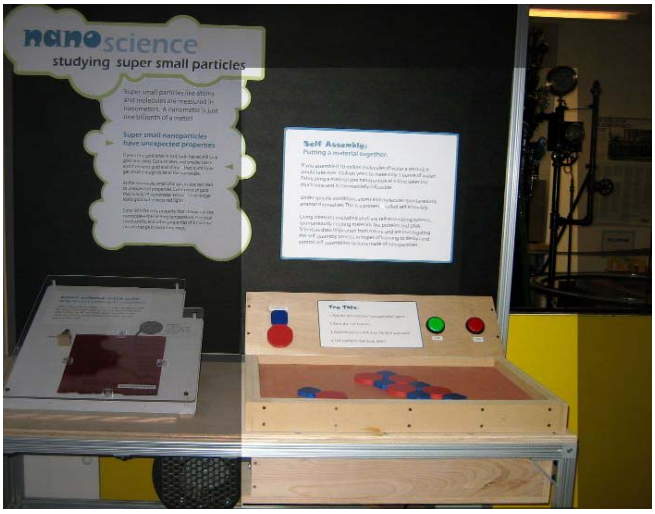

Figure 4

Round 2 self-assembly component highlighted (including enlarged copy, new instructions, and nano-particle key).

Component 3: Metal Rubber

The Metal Rubber component was intended to show the unexpected characteristics of a self-assembled nanomaterial (fig. 5 and 6). Unfortunately the Metal Rubber sample broke with the first visitor group, and we were unable to collect data for this component.

Figure 5

Metal Rubber component highlighted in picture.

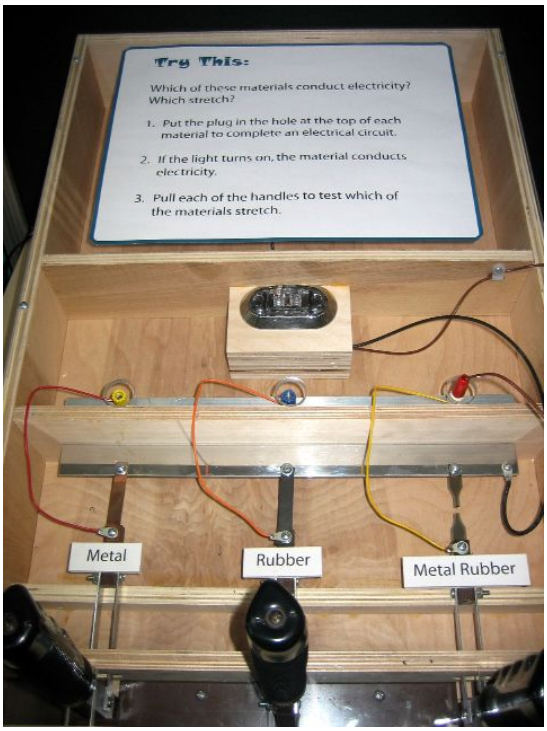

Figure 6

Close up of Metal Rubber component.

Summary

By simplifying the graphic layout and copy, the tabletop exhibition prototype was improved and visitors were able to better understand the concepts presented. The glass colored with gold was simpler and easier to understand for the visitors than the glass colored with silver. While the glass colored with silver was more colorful and demonstrated a wider variety of nanoparticle properties, it was too complicated for visitors to understand. Removing the glass from the graphic panel and setting it on an angle on the tabletop drew more attention from visitors.

For the model of self assembly (consisting of an air table and pucks), changing the instructional copy to contain the word “nanoparticle” and adding a key labeling the pucks as “nanoparticles” eliminated misconceptions about what the pucks represented. Adding the words “self assembled” to the instructional copy, reducing the number of copy chunks, and enlarging the header and body copy increased the percentage of visitors describing the pucks as “self assembling” indicating that visitors had read the copy.

Unfortunately the Metal Rubber sample broke with the first visitor group, and we were unable to collect data for this component.

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Appendix A: Data summary

Question 1: What would you tell someone this exhibit was about?

Visitors may give more than one answer.

Response	Round 1 (n=9)	Round 2 (n=10)
Molecules/molecular models	4 (44%)	2 (20%)
Pieces coming together	3 (43%)	0
Magnets/magnetism	2 (22%)	0
Nanotechnology	1 (11%)	2 (20%)
Nanoparticles	1 (11%)	4 (40%)
Self-assembly	0	2 (20%)
Colors changing with particle size	0	1 (10%)
Future manufacturing process (re: self-assembly)	0	1 (10%)
Complexity of nature (re: self-assembly)	0	1 (10%)

Question 2a: Was there any time when it wasn't clear what was happening?

Response	Round 1 (n=9)	Round 2 (n=10)
Yes	2 (22%)	1 (10%)
No	7 (78%)	9 (80%)

Question 2b: When was that?

"Before reading the instructions."

"Not sure how it related to nanotechnology."

"Expected the same pattern. And I didn't know why it turned off."

Question 3: Why is the glass that color?

Only 2 of 9 groups looked at the glass pre-modification. 4 of 10 groups looked at the glass post-modification.

Response	Silver (n=3)	Gold (n=3)
Don't know	3 (100%)	0
Gold particles	N/A	3 (100%)

Question 4: What are the red and blue pucks supposed to be?

Visitors can give more than one answer.

Response	Round 1 (n=9)	Round 2 (n=10)
Molecules/atoms	6 (67%)	6 (60%)
Positives and negatives/magnets/magnetic	3 (33%)	0
Stars and planets	1 (11%)	0
Electrons/protons	1 (11%)	1 (10%)
Nanoparticles	0	4 (40%)

Question 4b: What do the pucks do when you turn it on?

Response	Round 1 (n=9)	Round 2 (n=10)
Come together	5 (56%)	3 (30%)
Come together and form a shape/pattern	2 (22%)	1 (10%)
Assemble or self-assemble	2 (22%)	6 (60%)

Question 5a: Have you heard of nanotechnology?

Response	Round 1 (n=9)	Round 2 (n=10)
Yes	7 (78%)	8 (80%)
No	2 (22%)	2 (20%)

Question 5b: What does nanotechnology mean?

Categorized responses from those who said yes to Q5a.

Response	Round 1 (n=7)	Round 2 (n=8)
Don't know	1 (14%)	2 (25%)
Science fiction answer	1 (14%)	0
Demonstrated low understanding	3 (43%)	1 (13%)
Demonstrated moderate understanding	2 (29%)	0
Demonstrated high understanding	0	5 (62%)

Science fiction answer examples:

Tiny robots

Tiny machines

Low understanding examples:

Small stuff

Little particles

Moderate understanding example:

Dealing with the very small parts of molecular science

Using small particles to help mankind

High understanding examples:

Reconfiguring molecular structures to get the desired properties

Human application of the molecular self-assembly process

Note: Some of the visitors with high understanding responses seemed to derive their responses from the exhibit itself indicating they had read and understood the copy.

Question 7: How would you rate your knowledge of science from 1 to 10?

Response	Round 1 (n=9)	Round 2 (n=10)
Average rating	4.4	5.3

The rounds 1 and 2 results are similar, but the higher self-rating in round 2 may be the reason why the responses to several questions in round 2 were more favorable after modifications. The sample size and differences are small enough to make it difficult to draw any conclusions.

Question 8: If this were your exhibit, what would you change to make it better?

Visitors may give more than one answer.

Response	Round 1 (n=9)	Round 2 (n=10)
No suggestion	4 (44%)	4 (40%)
"Have more shapes [of magnetic pieces]."	3 (33%)	0
"Didn't see how the two parts related."	1 (11%)	0
"Indicate if there is a correct pattern."	1 (11%)	0
"Increase the air flow."	1 (11%)	0
"Improve the graphics."	1 (11%)	0
"Have them form different patterns."	1 (11%)	0
"Give real-life examples of nanotechnology."	0	2 (20%)
"Have a picture of real molecules in a similar pattern."	0	1 (10%)
"Have the air stay on longer."	0	1 (10%)

"The glass sample did not draw my attention."	0	1 (10%)
"Explain the scale better."	0	1 (10%)
"Explain the silver glass better."	0	1 (10%)

Demographics:

Genders of group	Round 1 (n=21)	Round 2 (n=27)
Female	14 (67%)	14 (52%)
Male	7 (33%)	13 (48%)

Ages of group	Round 1 (n=21)	Round 2 (n=27)
2–4	3 (14%)	6 (22%)
5–7	1 (5%)	6 (22%)
8–11	3 (14%)	2 (7%)
12–14	3 (14%)	0
15–18	0	0
19–25	1 (5%)	1 (4%)
26–35	4 (19%)	4 (15%)
36–49	2 (10%)	6 (22%)
50–65	4 (19%)	2 (7%)
66+	0	0

Time spent	Round 1 (n=9)	Round 2 (n=10)
Less than 1 minute	0	0
1–2 minutes	5 (56%)	3 (30%)
2–5 minutes	3 (33%)	6 (60%)
5–10 minutes	1 (11%)	1 (10%)
10+ minutes	0	0
Average time spent in minutes	2.8	3.2