Nanoscale Informal Science Education Network
Exhibit Prototype Testing: 2006
A Formative Evaluation Report

Prepared for

OMSI
OREGON MUSEUM OF SCIENCE AND INDUSTRY

by
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NISE Network
Evaluation Report: OMSI Prototypes
July 14, 2006

Objectives

- Evaluate four exhibition prototypes with OMSI visitors prior to the meeting with NISE Net collaborators in Minnesota July 19–21, 2006.
- Use the results of testing to refine prototype content, graphics, and user interfaces.

Methods

Data were collected over several weeks in May and June 2006. We used a combination of naturalistic observations of visitors and prompted engagements 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 prototypes for the length of time visitors remained engaged. We recorded visitor dwell time, how many visitors used the prototypes 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 prototypes if there were any. There were a total of four prototypes that were presented in pairs (described below). We also recorded which components the visitors used. See Appendix A for the evaluation instruments.

Description of Prototypes

Four prototypes were tested. Prototypes 1 and 2 were tested simultaneously as a pair, and prototypes 3 and 4 were tested simultaneously as a pair. The content of prototypes 1 and 2 were related—both addressed the new technology of gold nanoshells used to treat cancerous tumors. The content of prototypes 3 and 4 were not directly related.

The first prototype (*Tumor*) modeled gold nanoshells being dispersed through the body, collecting in cancerous cells, and destroying the cancerous cells. In order to test this educational content before investing resources in developing electronics and physical mechanisms, this prototype was designed to have sequential actions activated by a staff member. Visitors launched “gold nanoshells” into a game area with the goal of getting the “nanoshells” to land in the target area labeled “tumor.” Once enough nanoshells collected in the “tumor” target, the staff member (1) turned on a light representing an infrared laser, (2) adjusted a temperature gauge to indicate the rising temperature in the tumor, (3) rotated a graphic depicting the destruction of the tumor cells, and (4) reset the

activity. The staff member did not explain the exhibit to visitors but simply operated the mechanisms.

The second prototype (*Infrared Light*) consisted of a row of four blinking LED lights (blue, green, red, and near infrared, which is invisible to the naked eye) the visitor covered with their finger. Experimenting with the lights, visitors discovered that near infrared light penetrates the skin more easily than other wavelengths of light. The near infrared light could be seen via a camera and monitor in the prototype. A graphic panel explained that near infrared light can penetrate tissue up to four inches and that gold nanoshells can be designed to absorb near infrared light and to heat up.

In the third prototype (*Surface Area/Volume*), visitors stacked either one 4" cube or eight 1" cubes into a 4" hollow box to "prove" that the one 4" cube and eight 1" cubes had the same volume. Visitors inserted 24 pegs into holes on one 4" cube—one peg for each square inch of surface area. Visitors inserted 48 pegs into holes on the eight 1" cubes—one peg for each square inch of surface area. This showed that the smaller blocks (that have the same volume as the bigger block) have twice the surface area. The instructions prompted the visitors to calculate the surface area and volume with the correct answer revealed through a flip panel. A graphic panel described a real-world example where surface area is critical to enable iron nanoparticles to be used to clean contaminated soil.

The fourth prototype (*Video Game*) was a computer interactive. Visitors learned about the optical properties of gold nanoparticles used in the field to quickly test whether water is contaminated with lead. (In the absence of lead, the gold nanoparticles remain clumped together, and the solution appears blue to the naked eye. However, in the presence of lead, the gold nanoparticles separate, and the solution appears red to the naked eye.) In order to save the townspeople, visitors worked to discover which of the four water sources of the town were contaminated with lead. The game is essentially a logic puzzle.

Results

A total of 108 people in 48 groups were observed and interviewed over the course of testing. Full results can be found in Appendix B and figures in Appendix C. Each pair of exhibit prototypes was tested over several days. Based on our observations and interviews with visitors several recommendations for improvements were made for each of the prototypes. Some of the recommended changes where implemented for the *Tumor*, *Infrared Light*, and *Video Game* prototypes and the prototypes were further tested with visitors. No changes were made to the *Surface Area/Volume* prototype. Additional changes to the *Tumor* and *Video Game* prototypes were made after visitor testing was completed and will be presented in Minnesota.

Results described below will be presented for each of the pairs of prototypes.

Pair 1: *Tumor* and *Infrared Light* Prototypes
The *Tumor* and *Infrared Light* prototypes (figures 1 and 2) were tested simultaneously. After eight groups were interviewed, and others were observed, several problems were identified with the two prototypes and changes were made (figures 3, 4, 5, and 6). An additional 17 groups used the prototypes after the changes were made.

- There was confusion about the scale of the nanoshells.
    - The heading was changed from "Treating Cancer with Gold: The Potential of Nanotechnology" to "Super Small Gold Nanoshells: A Potential Treatment for Cancer" to emphasize the small scale.
    - We added information about how many gold nanoshells fit on the diameter of a human hair.
- Some visitors were not clear about what all of the parts of the *Tumor* prototype represented.
    - We labeled the living tumor, dead tumor, healthy tissue, and gold nanoshells in the explanatory copy.
- Some visitors were pumping the launcher, rather than flicking it, causing it to jam.
    - We added an arrow showing the direction to pull the lever.
    - We changed the instructional copy from "pump" to "shoot."
- Some visitors were wondering how the gold nanoshells got into the tumor.
    - We added copy explaining how the nanoshells get into the tumors through leaky blood vessels.
- Visitors were largely ignoring the *Infrared Light* prototype.
    - The graphic panels and prototypes were rearranged to draw more attention to the *Infrared Light* prototype.
- A few visitors were not covering the lights properly with their fingers in the *Infrared Light* prototype.
    - Graphics were modified to better show how the fingertip should cover the various lights.

Summary of *Tumor* and *Infrared Light* Prototypes
Visitors' understanding of the *Tumor* prototype increased after the changes were made. Four of eight visitors had a correct understanding of the exhibit prior to the changes. Afterwards, this number increased to 14 of 17 visitors. Visitors were more apt to use the *Infrared Light* prototype in the new configuration as well. One of eight used the prototype in phase one (figure 3), while all 17 groups used it in phase two (figure 4). Sixteen of the 18 groups who used the *Infrared Light* prototype were able to describe how only certain lights penetrated the skin. Of the 18 groups who used both exhibits, 13 were able to accurately describe the relationship between the two components. Overall, the prototypes effectively relayed the information to the visitors when they completed the activities.

However, there were constant mechanical problems with the *Tumor* prototype. The balls would easily jam, particularly if the visitor did not operate the ball-

shooting device properly the first time. A majority of the groups (14 of 25) said they experienced some difficulty with the launcher.

In order to address this problem, the ball launcher has been redesigned. Additionally, the activity has been automated so no activation by a staff member is required—the rotating tumor target area, the light, the thermometer, and reset are all automatic. The paths the balls take to the target area are now restricted into channels to reinforce the message that nanoshells reliably collect in tumors. The *Tumor* prototype has not been tested with visitors at OMSI in this third configuration.

Pair 2: *Surface Area/Volume* and *Video Game* Prototypes

The *Surface Area/Volume* and *Video Game* prototypes were tested simultaneously over the course of two days. Twenty-three groups composed of 66 people were observed and interviewed. Full results can be found in Appendix B. No significant changes were made during the course of testing these two prototypes.

Surface Area/Volume Prototype

The *Surface Area/Volume* prototype was intended to help visitors begin to build a physical knowledge of how particle size affects the ratio of surface area to volume by playing with blocks and pegs that highlight surface area (figure 7). The activity was engaging by itself, and the graphic panel tying the activity to nanoscience was rarely read. Only five of the 23 interviewed were seen reading the copy and only three were able to accurately describe how the iron nanoparticles can be used to help clean up toxic spills.

Visitors were, however, able to understand the concept of increased surface area with the smaller blocks. Sixteen of the 18 who answered the question said the volumes of the big block and total volume of the small blocks were equal. Thirteen of 18 were able to tell the combined surface areas of the small blocks were greater than the surface area of the large block.

Some problems were encountered during testing. The pegs fell out of the holes too easily. This was a source of frustration for the visitors. They would put pegs into the holes, rotate the cube to insert more pegs but the ones on the bottom would fall out. The blocks were rebuilt so the pegs fit more snuggly. Also, as mentioned, the informational copy was largely unread. Recommendations that were not implemented due to time constraints include (1) revising the graphic panel to be shorter and include a variety of exciting surface area phenomena at the nanoscale and (2) revising instructional copy to more strongly relate to nanoscience.

Video Game Prototype

The *Video Game* prototype (figure 8) was used by 19 of the 23 groups, though two groups had to leave during the interview. Of the remaining 17, all 17

described the exhibit as being about testing for lead in water. When asked how the test worked, eight visitors spoke of the gold nanoparticles while six visitors referred more generally to the color of the water after applying the test solution.

A few minor changes were made to the mouse pointer on screen to make it easier to see. The arrow was enlarged and its color was changed from white to black. The exhibit could benefit from a title or inviting graphic panel that can be seen from a distance. For visitor testing, the prototype consisted simply of a computer monitor and a mouse. We recommend using a trackball instead of a mouse for durability if this game is further developed.

Summary of *Surface Area/Volume* and *Video Game* Prototypes
Fewer problems were encountered with this pair of prototypes and only one round of testing was necessary. Overall, visitors were able to complete the activities with little difficulty and got the basic educational messages. However, both could benefit from additional work on the copy to help better relate the exhibits to the larger story of nanoscience.

Appendix A
Instruments

Group #_____ Time: _____min.____sec Date _____ Staff _____

Age/Gender: 2-4____ 5-7____ 8-11____ 12-14 ____ 15-18____ 19-25 ____ 26-35____ 36-49____ 50-65____ 66+____

Finger lights **Used first** **Didn't Use**

Talked about exhibit w/ other visitors: Y / N Read copy? Y / N

Put finger over several lights (including IR): Y / N Multi-user? Y / N

Tumor game: **Used first** **Didn't Use**

Talked about exhibit w/ other visitors: Y / N Read copy? Y / N

Launch pellets to fill up heart successfully? Y / N

Play several times Y / N Multi-user? Y / N

MECHANICAL COMMENTS/SAFETY CONCERNS:

_____

1. What would you tell someone this exhibits is about (probe)?

2. How could we make the launcher easier to use? Do you have any suggestions?

3. Was anything unclear in this activity? Y / N **What was that?**

4. Did you use the light activity? Y / N
What happened when you put your finger over the different lights? (What was the difference)?

5. Did you use the ball-launching activity? Y / N

What do the balls represent (what are they supposed to be)?

And where did they go when you launched them?

What happened when the light turned on?

6. (If applicable) How are the two parts related? Why are these two exhibits together?

7. On a scale of 1 to 10, rate your knowledge of science. 1 = "I know absolutely nothing" to 10 = "I am a research scientist."

1 2 3 4 5 6 7 8 9 10

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

9. AGE_____ GENDER _____

Group #_____ Time: _____min.____sec Date _____ Staff _____

Age/Gender: 2-4____ 5-7____ 8-11____ 12-14 ____ 15-18____ 19-25 ____ 26-35____ 36-49____ 50-65____ 66+____

Lead Testing **Used first** **Didn't Use**

Talked about exhibit w/ other visitors: Y / N Read introduction / Skipped through introduction

Apparent difficulty figuring out what to do? Y / N Click the wrong button after test? Y / N

Completed the activity (turned off contaminated water) Y / N Multiple rounds Y / N

Abandoned activity: _____

Surface Area: **Used first** **Didn't Use**

Talked about exhibit w/ other visitors: Y / N Read copy? Y / N

Use the pegs in the boxes: Y / N Assemble small blocks into large block? Y / N

Use the flip-pannels Y / N Multi-user? Y / N

MECHANICAL COMMENTS/SAFETY CONCERNS:

_____

1a. Did you use the computer activity? Y / N

1b. What would you tell someone this computer game was about? (Anything else?)

1c. Were you able to turn off all the contaminated/bad water? Y / N

1d. How does water test work? Why does the water turn blue or red?

2a. Did you use the activity with the boxes? Y / N

2b. What would you tell someone this exhibit was about? (Anything else?)

2c. How do the volumes of the little blocks compare to the big block?

Same volume / Little blocks have more volume / Big block has more volume

2d. How do the surface areas of the little blocks compare to the big block?

Same area / Little blocks have more area / Big block has more area

2e. How can iron be used to help clean up ground contamination?

3. On a scale of 1 to 10, rate your knowledge of science. 1 = "I know absolutely nothing" to 10 = "I am a research scientist."

1 2 3 4 5 6 7 8 9 10

4. If these were your exhibits, what would you change to make them better?

5. AGE_____ GENDER _____

Appendix B
Data Summary

Tumor and Infrared

Q1. What would you tell someone this exhibit is about?

Response	Round 1 (n=8)	Round 2 (n=17)
Curing cancer/killing tumor	4 (50%)	10 (59%)
Using nanotechnology to cure cancer/kill tumors	1 (13%)	3 (18%)
Other	3 (38%)	3 (18%)

Q2. How can we make the launcher easier to use? (Not asked in round 1)

Response	Round 1 (n=8)	Round 2 (n=17)
Like a pinball machine or syringe	N/A	4 (24%)
Make it work properly	N/A	3 (18%)
No change	N/A	3 (18%)
Don't know	N/A	2 (12%)
Better explanation	N/A	2 (12%)
Use a button	N/A	1 (6%)
Change completely	N/A	1 (6%)

Q3. Was anything unclear in this activity? What was that?
Only those who said there was something unclear are counted.

Response	Round 1 (n=3)	Round 2 (n=6)
Problem with launcher	3 (100%)	4 (66%)
Figuring out where to start	0	1 (16%)
Didn't see the thermometer	0	1 (16%)

Q4a. Did you use the light activity?

Response	Round 1 (n=8)	Round 2 (n=17)
Yes	1 (13%)	17 (100%)
No	7 (87%)	0 (0%)

Q4b. What happened when you put your finger over the different lights?
Responses from people who answered "yes" in Q4a.

Response	Round 1 (n=1)	Round 2 (n=17)
Red and infrared/long wave lengths shined through	1 (100%)	12 (70%)
Some colors shined through	0	5 (30%)

Q5a. Did you use the ball launching activity?

Response	Round 1 (n=8)	Round 2 (n=17)
Yes	8 (100%)	15 (88%)
No	0	2 (22%)

Q5b. What do the balls represent?
Responses from people who answered "yes" in Q5a.

Response	Round 1 (n=8)	Round 2 (n=15)
Nanoshells	4 (50%)	10 (67%)
Medicine	2 (25%)	1 (7%)
Glass balls/pieces of gold	0	3 (20%)
Don't know	2 (25%)	0

Q5c. Where did they go when you launched them?
Responses from people who answered "yes" in Q5a.

Response	Round 1 (n=8)	Round 2 (n=15)
Into the tumor	5 (63%)	7 (47%)
Into the bloodstream	1 (13%)	3 (20%)
Into the tumor by chance/hopefully/eventually	3 (37%)	5 (33%)

Q5d. What happened when the light turned on?
Responses from people who answered "yes" in Q5a.

Response	Round 1 (n=8)	Round 2 (n=15)
Heated up the tumor/balls	4 (50%)	12 (80%)
Killed the tumor	1 (13%)	3 (20%)
Don't know	3 (37%)	0

Q6. How are the two parts related?
Question asked only if applicable.

Response	Round 1 (n=1)	Round 2 (n=15)
Need a light that can pass through skin	1 (100%)	12 (80%)
Don't know	0	3 (20%)

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

Response	Round 1 (n=8)	Round 2 (n=17)
Average rating	6.6	5.0

Demographics

Response	Round 1 (n=8)	Round 2 (n=17)
Female	6 (75%)	7 (41%)
Male	2 (25%)	10 (39%)

Age

Response	Round 1 (n=8)	Round 2 (n=17)
8–11	5 (63%)	3 (18%)
12–14	0	0
15–18	0	0
19–25	0	0
26–35	0	1 (6%)
36–49	0	9 (53%)
50–65	2 (20%)	4 (24%)
66+	1 (12%)	0

Surface Area/Volume and Video Game

Q1a. Did you use the computer activity?

Response	(n=23)
Yes	19 (83%)
No	4 (17%)

Q1b. What would you tell someone this was about?

Two of the 19 did not answer this question.

Response	(n=17)
Testing the water	17 (100%)

Q1c. Were you able to turn off all the contaminated/bad water?

Two of the 19 did not answer this question.

Response	(n=17)
Yes	16 (94%)
No	1 (6%)

Q1d. How does the water test work?

Three of the 19 did not answer this question.

Response	(n=16)
Discussed nanoparticles	8 (50%)
Discussed color change of water	7 (44%)
Don't know	1 (6%)

Q2a. Did you use the activity with the boxes?

This refers to the Surface Area/Volume prototype. One of the 23 did not answer.

Response	(n=22)
Yes	20 (91%)
No	2 (9%)

Q2b. What would you tell someone this was about?

Response	(n=20)
Volume and surface area	13 (65%)
Volume	3 (15%)
Properties of molecules	1 (5%)
Decontaminating soil	1 (5%)
Don't know	2 (10%)

Q2c. How do the volumes of the little blocks compare to the big blocks?

Responses from two of the 20 were not available.

Response	(n=18)
Same volumes	16 (89%)
Don't know	2 (11%)

Q2d. How do the surface areas of the little blocks compare to the big block?
Responses from two of the 20 were not available.

Response	(n=18)
Little blocks have more	15 (83%)
Don't know	2 (11%)
Big block has more	1 (6%)

Q2e. How can iron be used to help clean up ground contamination?

Response	(n=18)
Don't know/didn't read	15 (83%)
Filters it	1 (5%)
Iron oxidizes the contamination	1 (5%)
Large surface area helps	1 (5%)

Question 3. How would you rate your knowledge of science from 1 to 10?
Data collected from 16 of the groups.

Response	(n=16)
Average rating	5.3

Demographics

Response	(n=23)
Female	17 (74%)
Male	6 (26%)

Age

Response	(n=23)
8–11	1 (4%)
12–14	4 (17%)
15–18	0
19–25	2 (9%)
26–35	3 (13%)
36–49	12 (52%)
50–65	0
66+	1 (4%)

Appendix C
Photographs

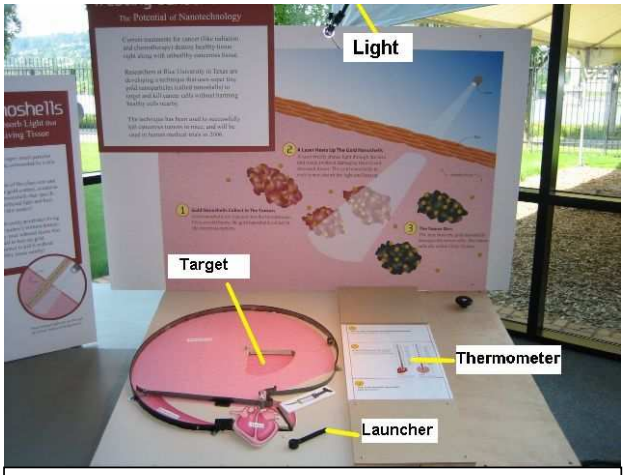

Figure 1: Tumor prototype phase 1

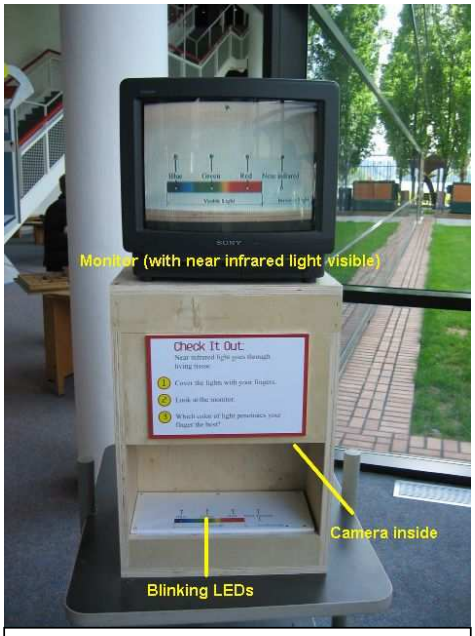

Figure 2: Infrared prototype phase 1

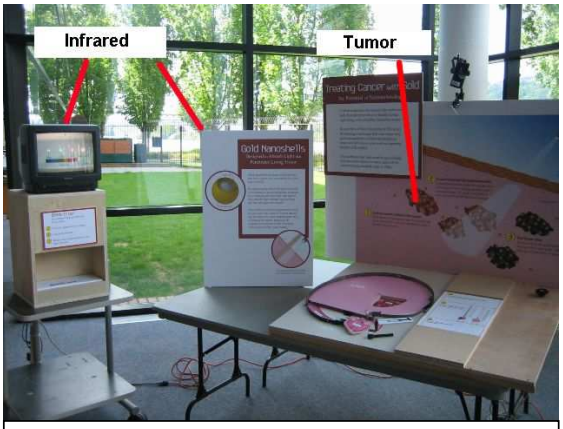

Figure 3: Tumor and Infrared prototypes phase 1

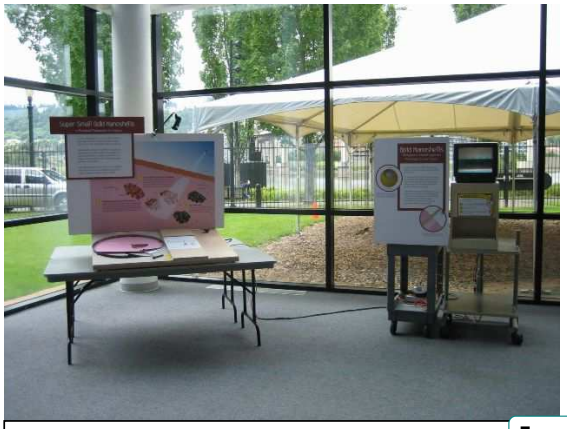

Figure 4: Tumor and Infrared prototypes phase 2

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Figure 5: Tumor prototype phase 2

Figure 6: Infrared prototype phase 2

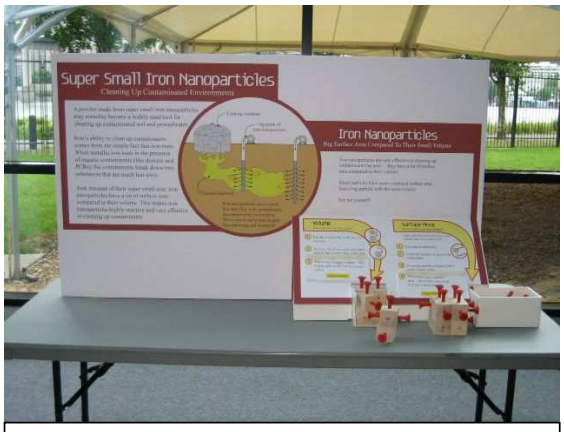

Figure 7: Surface Area/Volume prototype

Figure 8: Video Game prototype