NISE network
NANOSCALE INFORMAL SCIENCE EDUCATION

Nanomedicine: Nanomedicine Video, Gold Nanoshells, Nano Scaffolding, & Greene Chip

Formative

By Scott Ewing

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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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Table of Contents

Background

Objectives

- Evaluate Nanomedicine Package prototypes with OMSI visitors.
- Evaluate Nano Explorer kiosk prototype with OMSI visitors.
- Use the results of testing to refine prototype content, graphics, and user interfaces.

Methods

Data were collected over seven days in April and May 2008. We used a combination of naturalistic observations of visitors and 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, and experimenting with the activity multiple times. There were a total of 5 prototypes that were evaluated over the course of testing, although two of them were removed early due to mechanical reasons and one was available only for the last three days. We also recorded which components the visitors used and in what order.

Description of Prototypes

Four prototypes were tested from the Nanomedicine Exhibit. The first prototype (*Introduction to Nanomedicine*) consisted of an introductory video to Nanomedicine. Visitors push the start button and they were able to watch an explanatory video about nanotechnology. Part way through the testing, the video changed from a general introductory video about nanotechnology to a nanomedicine specific video created by the Museum of Science, Boston.

The second prototype (*Gold Nanoshells*) modeled gold nanoshells being dispersed through the body, collecting in cancerous cells, and destroying the cancerous cells. Visitors hit the start button then release or "inject" the gold nanoshells into the bloodstream. The bloodstream automatically circulates the nanoshells through the system with some of them landing in the cancerous region while the rest continue to circulate in the bloodstream. Once enough of the nanoshells have been deposited into the tumor, the visitor is prompted to turn on the "infrared laser." A light automatically illuminates the entire tumor region and an LED display indicates a rising temperature in the tumor while the surrounding tissue remains unaffected. After a short time, the tumor area rotates to reveal a dead tumor then rotates once more to reset the nanoshells and be ready for the

next visitor. This prototype had some mechanical problems and was removed the third day.

The third prototype (*Nano Scaffolding*) was about repairing damaged nerves using a nano-scaffold. Visitors had two options. Option A was to do nothing where the damaged nerve tissue is blocked by scar tissue and the nerve signal / message represented by LED lights blinking shows no connection between the two parts of the damaged nerve. Option B was to inject a nano-treatment that created a scaffold to help the nerve grow back together and re-establish the nerve connection that was lost. This prototype was removed on the 6th day due to mechanical problems.

In the fourth prototype (*Greene Chip*) the visitor had the chance to diagnose a disease in a patient with the use of a new technology called the Greene Chip. Visitors chose between three different patients; then they had to add the patient's sample to the Greene Chip. Once this was done, a computer screen showed how the Greene chip worked, by marking DNA in the sample then passing the sample over the chip. The chip has pathogen receptors which cause the marked pathogens in the sample to remain on the chip while the rest of the DNA washes off. Then visitors had to slide the chip under a scanner, and push a button to scan the chip. The computer scanned the chip and finally showed a list of all the diseases that were tested, and any pathogens detected in the sample. Then the visitor had the option to start again choosing a different patient.

A fifth prototype (*Nano Explorer*) was a computer interactive. Although not part of the Nanomedicine Package, OMSI included the interactive in the study to help collect data on the component. Visitors learned about what is Nanotechnology, what is cancer, and the alternatives in medicine using Nanotechnology like gold nanoshells to treat cancerous tumors, as well as new technology using iron nanoparticles to diagnose tumors in an early stage before they grow and spread. There were also several games where the visitor could either diagnose a mouse using the iron nanoparticles to detect a tumor, or destroy a tumor by injecting gold nanoshells into the mouse. This prototype wasn't available to use until the 5th day.

Results

A total of 156 people in 67 groups were observed and interviewed over the course of testing. Full results and ratings rubrics can be found in Appendix A. The five exhibit prototypes were tested over several days, except for the Gold Nanoshells prototype that had to be removed on the third day. Based on our observations and interviews with visitors several recommendations for improvements were made for each of the prototypes. Results described below will be presented for each of the prototypes.

Intro to Nanomedicine Prototype

The *Introduction to Nanomedicine* prototype was formally tested over three days. From the total of 20 groups observed during these three days, we found that 65% (13) of them didn't use the exhibit. Of the remaining 35% (7) that used it, all of them expressed that they liked it the video because it was interesting, informative and clear. These visitors also expressed that the length was just right. To these visitors, nothing was unclear. Those who

saw the video were more likely to have heard of Nanotechnology than those who did not. Also those who did watch the video seemed to have a slightly better understanding nanotechnology as a whole than those who did not watch the video. Those who watched the video tended to be older than average for the rest of the exhibit prototypes.

Have you heard of Nanotechnology?	Intro video (n=19)	No intro video (n=40)
Yes	68% (13)	45% (18)
No	32% (6)	55% (22)

What does it mean?	Intro video (n=13)	No intro video (n=18)
Good understanding	0	0
Moderate understanding	39% (5)	39% (9)
Poor understanding	46% (6)	22% (4)
Don't know	15% (2)	39% (7)

General Introduction to Nanomedicine Video Observations

Some things were noticed related to the interaction of the visitor with this exhibit, such as when the hall was busy the volume in the video was too low, and people had trouble hearing it. Captioning would help with this issue. Also, the video presentation offers the opportunity for seating, particularly if the length of the video remains unchanged.

Nano Explorer Prototype

The *Nano Explorer* prototype was formally tested for three days. From the total of 19 groups observed during these three days, about half (10) of them didn't use the exhibit. From the 9 that used the exhibit, most of them had a good understanding regarding what was the exhibit about – detecting and curing cancer. Almost all of the interviewed visitors mentioned they learned something new, like new methods and techniques used in cancer detection and treatment. Finally, only two visitors expressed some things that they considered to be unclear in the exhibit, such as that there was no sound (due to technical problems) and that there was no keyboard and the e-mail option was not functioning.

General Nano Explorer Observations
The dwell time on this exhibit was long (3 min, 20 sec) so offering a place to sit could be a welcome addition. Since the prototype was in a simple kiosk, it will likely be more attractive and appealing when the exhibit has a proper title signage.

Gold Nanoshells Prototype

The *Gold Nanoshells* Prototype was only tested for half day. It was removed on the first day due to mechanical problems. Six groups were observed during this time. Only one of them didn't use the exhibit, and from the rest that used it (5), only 2 showed a strong understanding about the concept of the exhibit by mentioning it was about cancer treatment. Finally, two visitors expressed some things that they considered to be unclear in the exhibit, such as what was the wave length of the laser light used, why the use of gold, and that it wasn't very clear where the gold nanoshells went after treating the tumor.

General Gold Nanoshells Observations
A few visitors didn't notice the laser light and the thermometers. The general layout of the interface should be modified to make thermometers more obvious – ideally located near the tumors where the visitors are already looking. Also some of the lights look similar to buttons and some visitors would try and press them. Backlighting the steps in order would likely be a better solution in the final design.

Nano Scaffolding Prototype

The *Nano Scaffolding* prototype was removed on the 6th day due to mechanical problems. From the 46 groups that were observed over this time, 38 used the exhibit while 8 of them did not. Over half (22 of 38) of the visitors expressed a high level of understanding about the general concept of the exhibit, although it didn't seem to be very clear that the nanotechnology was only helping the body repair itself (rather than doing the repair itself). Only five people felt that something was unclear in the exhibit, by mentioning that it was hard for kids to understand, and that it wasn't very clear where in the body the nerves were located.

General Nano Scaffolding Observations
Some people didn't notice the nerve signal (LED lights blinking). Since the LEDs were recessed, shorter visitors weren't able to see them. By having the LEDs protrude, or by illuminating the surface itself should help to make the lights more noticeable.

Greene Chip Prototype

The *Greene Chip* prototype was tested for the full 7 days. From the 58 groups observed over this time, 54 used the exhibit and 4 did not. The majority (79.6%) of the visitors showed a high level of understanding about the general concept of the exhibit, although only 6 mentioned that the technology could be used for testing several diseases at one time. We noticed that most of the visitors that used the exhibit had problems at the beginning in figuring out what to do and overall they mentioned that the instructions were confusing and hard to follow. There was a general feeling that the information wasn't very clear.

General Greene Chip Observations

Overall the Greene Chip exhibit is difficult for both adults and children to operate; they have a hard time sliding the chip back and forth and following the instructions. The interface is unique and has multiple steps so it is important that the instructions are explicit and clear for the visitor. The on-screen text and instructions were too slow for some visitors leading to frustration or abandonment in some cases.

For some visitors, it was not obvious that the Greene Chip itself was on a slider and could be moved. Also, when the slider was moved under the scanner portion of the exhibit, it had a tendency to bounce off the stops. Unless the Greene Chip is in the proper location, the exhibit won't be able to scan the chip so it is important that it stays in place via magnets, physical notches, or some other mechanism.

Introduction to Nanotechnology and Nanomedicine

When the Introduction to Nanotechnology suite of exhibits were open on the 5th day, almost two thirds (12 out of 19 / 63.2%) of the groups that were observed used them before using the Nanomedicine prototypes. All of these visitors had a strong understanding of what the exhibits were about. Half (6) of the visitors who used the Introduction to Nanotechnology exhibits had said that they had not heard about Nanotechnology. Similarly, about half of those who had no exposure to the Introduction to Nanotechnology exhibits – both visitors before the exhibits were opened and those who had the opportunity to use the exhibits but didn't – had not heard of Nanotechnology. Due to the small number of visitors who used the Intro package and had heard of nanotechnology (6), it is difficult to draw any conclusions about increased knowledge without any dramatic trends.

Response	Used Intro package (n=12)	Did not use Intro package (n=47)
Have heard of Nanotechnology	50% (6)	53% (25)

Responses of those who have heard of Nanotechnology.

What does Nanotechnology mean?	Used Intro package (n=6)	Did not use Intro package (n=25)
Strong understanding	0	0
Moderate understanding	50% (3)	36% (9)
Poor understanding	0	40% (10)

Don't know	50% (3)	24% (6)

In general, the vast majority of the people interviewed over the entire seven days of testing who had used more than one prototype (84.4% – 38 / 45) had a strong understanding of the concept of the Nanomedicine package, with no obvious difference between the days where the nano suite exhibits were open, and the days that they were closed.

Overall considerations

Some of the visitors expressed that they want to know more about nanotechnology, like hazards, other applications, practical uses, etc; as well as more information about health care and medical advances using this technology. Finally, some of the visitors had some suggestions to improve the exhibits, such as graphical and instruction improvements, some specific comments about making more easy to follow the Greene Chip prototype, making the exhibits more kid friendly and interactive, and having more detailed and in depth information about different topics related with the Nanotechnology. Overall, adults seemed more interested in the exhibits than children did. This could be partially due to the complexity of nanotechnology or the topic of medicine and health care.

Universal Design Considerations

In an effort to make the exhibit packages accessible for all visitors, a Universal Design workshop and critique of the prototypes we held. Based on this effort several recommendations were created.

Overall considerations:

- Choice of font is difficult for a person with low vision ability. Choose large, simple fonts with high contrast and uniformity.
- Color choices (blue on blue) may not have enough contrast. The words on the copy panels are large enough to see, but poor contrast makes reading difficult.
- Button colors should be consistent and take queues from society (green means go, red means stop) as well as labeled.
- The buttons on the side panel video slide shows were hard to reach. Consider having the pictures on an automatic rotating slide show so it isn't necessary to press anything to forward the screen (though could still have the option to "skip" to the next image).
- Include audio labels on all components.
- Floor-plan layout can have an effect on accessibility. Consider including recommended floor plans or layout suggestions and tips with the packages.

- Low-glare Plexiglas should be used.
- Include angled text/instructions where appropriate for easy reading.
- Tabletop height seemed a bit low for our users with wheelchairs. Consider rising slightly.

Introduction to Nanomedicine video

- Button placement was in the crook of the stand. It is hard to reach from a wheelchair in this position. Consider moving to the outside edge or to a location where this issue will be avoided.
- The introductory video had no captioning. The sound level was low enough that it was difficult to hear when the hall was busy.

Detecting Diseases: Greene Chip

- The pipette button has too much tension. It proved difficult to press down for visitors with arthritis or other reduced dexterity.
- The on-screen type was too small for visitors with vision impairment.

Curing Cancer: Gold Nanoshells

- Syringe spring had a bit too much tension. This could be loosened.
- There were reach issues with the "laser" activation button. Consider moving it closer to the front of the exhibit.
- It may not be practical but having a "laser" light that was actually warm (like a heat lamp) might help visitors both appreciate the warming occurring in the tumor as well as add a tactile experience for visitors with little to no vision.

Repairing Nerves: Nano scaffolding

- Neural pathway lights were sunk into the surface and hard to see from low angles (smaller children or visitors in wheelchairs).
- A model of a "nanoscaffold" could be included for visitors to touch. Otherwise all the action happens behind Plexiglas.

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Appendix A: Data Summary

Introduction to Nanomedicine Video Prototype

Gender	(n = 9)
Female	5 (55%)
Male	4 (44%)

Age	(n = 9)
8–11	1 (11%)
12–14	0
15–18	2 (22%)
19–25	0
26–35	2 (22%)
36–49	3 (33%)
50–65	1 (11%)
66+	0

Dwell time	(n = 9)
Average time	1 m 58 s

How was the length of the video?	(n = 7)
Too short	1 (14%)
Just right	6 (86%)
Too long	0

Did you like the video?

Responses of people who answered “Yes”.

Response	(n = 6)
Interesting	2 (33%)
Informative and clear	2 (33%)
Efficient and clear information	1 (17%)
Have big display of Nanotechnology	1 (17%)

Nano Explorer Prototype

Gender	(n = 9)
Female	6 (66%)
Male	3 (33%)

Age	(n = 9)
8–11	0
12–14	3 (33%)
15–18	1 (11%)
19–25	0
26–35	0
36–49	3 (33%)
50–65	2 (22%)
66+	0

Dwell time	(n = 9)
Average time	3 m 19 s

What would you tell someone this exhibit was about?

Response	(n = 9)
Cure / detection of cancer	7 (77%)
New alternatives to cure cancer	3 (33%)
Building a mouse	1 (11%)
Use of new technology	1 (11%)

What was your favorite part about it?

Response	(n = 9)
Information about new alternatives to cure cancer	2 (22%)
Information about detection of cancer	2 (22%)
Games	3 (33%)
Information about nanotechnology	1 (11%)
Didn't watch enough to know	1 (11%)

Did you learn anything? What was that?

Responses of people who answered "Yes".

Response	(n = 8)
New things that help cure cancer	3 (38%)
New methods used for early detection of cancer	3 (38%)
Properties of nanotechnology	2 (25%)

Was anything unclear?

Only those who said there was something unclear are counted.

Response	(n = 2)
No keyboard, no e-mail	1 (50%)
No sound	1 (50%)

Gold Nanoshells Prototype

Gender	(n = 7)
Female	4 (57%)
Male	2 (29%)
Unknown	1 (14%)

Age	(n = 7)
8–11	3 (43%)
12–14	0
15–18	0
19–25	0
26–35	1 (14%)
36–49	1 (14%)
50–65	0
Unknown	2 (29%)

Dwell time	(n = 4)
Average time	4 m 8 s

What would you tell someone this exhibit was about?

The exhibit had mechanical problems on the first day, and had to be removed.

Response	(n = 5)
New cancer treatment	2 (40%)
Bacteria getting burned by laser	1 (20%)
Other	2 (40%)

What do you think the gold balls are/represent?

Response	(n = 5)
Treatment of disease	1 (20%)
Leaking blood vessels	1 (20%)
Don't know	1 (20%)
Germs	1 (20%)
Nano sized gold balls	1 (20%)

Where did they go once you injected them?

Response	(n = 5)
Blood stream to the tumor	2 (40%)
Blood stream/vessel	2 (40%)
Into the tumor	1 (20%)

What happened when you turned on the "laser"?

Response	(n = 5)
Temperature of tumor rises and kills tumor	2 (40%)
Laser hits balls	1 (20%)
Light turns on	1 (20%)
Burns cancer	1 (20%)

Was anything unclear?

Only those who said there was something unclear are counted.

Response	(n = 2)
Not clear that the gold balls are the medicine	1 (50%)
Where else do the gold balls go, why using gold, what wavelength of light is used	1 (50%)

Nano Scaffolding Prototype

Gender	(n = 41)
Female	22 (54%)
Male	18 (44%)
Unknown	1 (2%)

Age	(n = 41)
8–11	7 (17%)
12–14	6 (15%)
15–18	7 (17%)

19–25	2 (5%)
26–35	6 (15%)
36–49	10 (24%)
50–65	2 (5%)
66+	1 (2%)

Dwell time	**(n = 41)**
Average time	1 m 11 s

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

The exhibit had mechanical problems on the 6th day, and had to be removed.

Response	**(n = 38)**
Didn't use	8 (21%)
Fixing / repairing nerves	22 (58%)
Repairing bones / tissues / organs / hemorrhages	14 (37%)
Nano scaffold / nanotechnology repair	10 (26%)
Tissue heals itself	2 (5%)
Other	2 (5%)

Q2. What do the lights show / represent?

Responses from people who answered in Q1.

One of the 38 did not answer this question.

Response	**(n = 37)**
Nerves, nerve impulses, etc	24 (63%)

Don't know	12 (32%)
Other (blood cells, antibodies, etc)	1 (3%)

Q3. What happens if you use option A?

Responses from people who answered in Q1.

One of the 38 did not answer this question.

Response	(n = 37)
Scar tissue, no connections, no repair, etc.	33 (87%)
Don't know	1 (3%)
Other	3 (8%)

Q4. What happens if you use option B?

Responses from people who answered in Q1.

One of the 38 did not answer this question.

Response	(n = 37)
Nerves heal / repair (with nanotechnology)	11 (29%)
Nerves heal / repair (no mention nanotechnology)	23 (61%)
Other	3 (8%)
Nanotechnology helps body repair itself	0 (0%)

Q5. How do you think a doctor might use this technology in the future?

Responses from people who answered in Q1.

One of the 38 did not answer this question.

Response	(n = 37)
Healing injuries / other parts of the body	15 (40%)

Healing specific nerve damage	12 (33%)
Other	6 (16%)
Don't know	4 (11%)

Q6. Was anything unclear?

Only those who said there was something unclear are counted.

Response	(n = 5)
Hard for kids to understand	2 (40%)
Kept scaffolding in longer	1 (20%)
Where nerves are	1 (20%)
At first it didn't make sense	1 (20%)

Greene Chip Prototype

Gender	(n = 59)
Female	32 (54%)
Male	25 (42%)
Unknown	2 (3%)

Age	(n = 59)
8–11	11 (19%)
12–14	8 (14%)
15–18	10 (17%)
19–25	2 (3%)

26–35	9 (15%)
36–49	13 (22%)
50–65	4 (7%)
66+	2 (3%)

Dwell time	**(n = 59)**
Average time	2 m 12 s

Q7. What would you tell someone this exhibit was about?

Response	**(n = 54)**
Didn't use	4
Detecting diseases	43 (80%)
Don't know	3 (6%)
Other	8 (15%)

Q8. What is a "Greene Chip"?

Responses from people who answered in Q7.

Response	**(n = 54)**
Chip / device for disease detection, etc.	35 (65%)
Don't know	14 (26%)
Other	5 (9%)
Something environmentally related	0 (0.0%)

Q9. What happened when you scanned the slide?

Responses from people who answered in Q7. Although this question was erased after the first day.

Response	(n = 7)
Show diseases / scan for diseases	5 (9%)
Don't know	1 (2%)
Kills germs / cures diseases	1 (2%)

Q10. How is this technology different than regular tests a doctor would do?

Responses from people who answered in Q7.

Response	(n = 54)
Test more than one at a time	6 (11%)
Faster, saves time, accurate, etc.	17 (33%)
Don't know	15 (28%)
Other (same, new, etc.)	16 (30%)

Q11. Was anything unclear?

Only those who said there was something unclear are counted.

Response	(n = 16)
Instructions	10 (63%)
Interface	2 (13%)
Copy / information	7 (44%)

All Prototypes and Common Questions

Gender	(n = 70)
Female	36 (51%)

Male	26 (37%)
Unknown	8 (11%)

Age	**(n = 62)**
8–11	11 (18%)
12–14	10 (16%)
15–18	9 (15%)
19–25	2 (3%)
26–35	9 (15%)
36–49	15 (24%)
50–65	4 (7%)
66+	2 (3%)

Dwell time	**(n = 70)**
Average time	3 m 40 s

What this group of exhibits is about?

Question asked only if applicable.

Response	**(n = 45)**
Strong understanding	38 (84%)
Moderate understanding	4 (9%)
Poor understanding	3 (7%)

Strong understanding is demonstrated by mentioning Nanotechnology, Nanomedicine, detecting and treating diseases, future of healthcare, etc. Moderate understanding is

demonstrated by mentioning things like help people with cancer, health and how people get better, body functions and how technology helps people. And poor understanding ignores a significant aspect of the exhibits (such as the Nanotechnology).

Did you use the other exhibits (Introduction to Nanotechnology)?

The Introduction to Nanotechnology exhibits were closed for the first 4 days.

Response	(n = 19)
Yes	12 (63%)
No	7 (37%)

Have you heard of "Nanotechnology"?

Response	(n = 57)
Yes	31 (54%)
No	26 (46%)
Responses from people who answered "Yes"	(n = 31)
Strong understanding	0 (0.0%)
Moderate understanding	12 (39%)
Poor understanding	10 (32%)
Don't know	9 (29%)

Strong understanding is demonstrated by mentioning the scale of nanotechnology (a billionth of a meter) along with its use. Moderate understanding is demonstrated by mentioning the use of small particles to cure diseases, small/tiny technology, use of tiny structures for different applications, etc. And poor understanding ignores a certain important feature (such as the use of nano scale materials).

Was there anything you'd like to know more about?

Responses from people who answered "Yes".

Response	(n = 21)
General nanotechnology info (practical uses, hazards, current applications, etc.)	10 (48%)
Health information (nerves, body repair, regenerating tissues, preventive medicine, whooping cough)	5 (24%)
More kid oriented	1 (5%)
Written info to take home and recommended websites	1 (5%)
Greene chip info & how pathogen DNA sticks	2 (10%)
Nanobots	1 (5%)
Concrete cases of cured people (cancer and other diseases)	3 (14%)
More in depth information in every section	2 (10%)
More pictures	2 (10%)

What would you change to make the exhibit better?

Response	(n = 57)
Greene chip comments	10 (18%)
Graphical / instruction improvements	9 (16%)
Kid friendly / interactive	6 (12%)
Demo of electron micrographs w/poster sized images	1 (2%)
More geared towards adults	1 (2%)
Detailed medical info (describe nerves better, other methods for procedures, brain treatments, examples of nerve damage)	2 (4%)
More dramatic	1 (2%)
Information improvements (websites, more info, examples, etc.)	6 (11%)

Educators to assist people	1 (2%)
No suggestions	29 (51%)