NISE network
NANOSCALE
INFORMAL
SCIENCE
EDUCATION

Nanomedicine: Gold Nanoshells, Infrared Lights, & Imaging

Formative

By Scott Ewing

March 11, 2007

Acknowledgements

The author would like to thank Kari Jensen, Jenny Gardner, Kelly Scherr, Todd Kehoe, Maria Montiel, Cate Rhodes, and Ana Peters for their support and contributions to this evaluation.

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

Scott Ewing
Oregon Museum of Science & Industry
1945 SE Water Ave
Portland, OR. 97214
sewing@omsi.edu
503-797-4590

Table of Contents

Introduction

Objectives

- Evaluate exhibition prototypes with OMSI visitors prior to the meeting with NISE Net collaborators in Minnesota March 11–13, 2007.
- Use the results of testing to refine prototype content, graphics, and user interfaces.

Methods

Data were collected on February 23, 2007. 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, and experimenting with the activity multiple times. There were a total of three prototypes that tested concurrently. We also recorded which components the visitors used.

Description of Prototypes

Three prototypes were tested from the Nanomedicine Exhibit Package. The content of prototypes 1 (*Tumor*) and 2 (*Infrared Light*) were related—both addressed the new technology of gold nanoshells used to treat cancerous tumors. The content of the third prototype (*Imaging*) addressed a different technology of iron nanoparticles used to detect the spread of cancer

The first prototype (*Tumor*) modeled gold nanoshells being dispersed through the body, collecting in cancerous cells, and destroying the cancerous cells. Previously, this prototype was visitor tested with a staff facilitator and later with a mechanical interactive in July 2006. Since then, the prototype has been modified to more accurately represent the process involved as well as to simplify the interface. 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.

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) which 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 could 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 (*Imaging*), visitors compared two pairs of MRIs of lymph nodes from prostate cancer patients. To determine whether prostate cancer had spread to the lymphatic system, researchers took MRI images before and after injecting iron nanoparticles into patients who had previously been diagnosed with prostate cancer. The images were mounted in a light box designed to create an optical illusion called the Pepper's Ghost. By pressing a toggle, each set of images alternated between the regular MRI and the enhanced MRI taken after the injection of nanoparticles. The two images in the left window showed how a healthy lymph node darkened in the enhanced MRI compared to the regular MRI. The two images in the right window showed how a cancerous lymph node remained bright in the enhanced MRI compared to the regular MRI. Accompanying copy explained how doctors could use this technology to more accurately determine whether prostate cancer had spread to the lymphatic system, which in turn determines the best course of treatment.

Results

A total of 22 people in 19 groups were observed and interviewed over the course of testing. Full results can be found in Appendix A. The three exhibit prototypes were tested over one day. Based on our observations and interviews with visitors several recommendations for improvements were made for each of the prototypes. A few minor recommended changes were made after visitor testing was completed and will be seen in Minnesota.

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

Tumor and Infrared Light

The *Tumor* and *Infrared Light* prototypes were tested simultaneously and were physically connected. After observing and interviewing 11 groups several problems were identified with the two prototypes.

- There was confusion with how to properly start the activity.
    - The start button is not placed near where the visitor interacts with the exhibit. It's recommended that either the syringe mechanism start the interactive or the start button be clearly and obviously located near where the interaction is to take place.

  - The steps could be labeled in order of what the visitor does (e.g., #1 hit the start button, #2 pull the syringe, #3 push “laser”) rather than have the numbers list what happens.

  - The red indicator lights looked like buttons. Some visitors were seen pushing the lights in an attempt to start the exhibit. In the final version backlighting is planned.

  - The activity never times out and resets. If the activity is abandoned and the next visitor presses the start button, the exhibit does reset, but the visitor wouldn’t necessarily know whether the action was to be observed or not. Either the exhibit could time-out after a fixed amount of time of inactivity, or alternate labeling could be used (such as “start over” or “reset”).

- Some visitors were vigorously pumping the syringe. Although it functions properly when used this way, it is likely to break.

  - It is recommended that range of motion is reduced or some other physical design change be implemented (such as a finger groove rather than a knob on an arm) so that the visitors are less likely to break the interactive.

- Visitors were not using the *Infrared Light* prototype (10 of 11 used *Tumor* while 5 of 11 used both).

  - The way the prototype was recessed from the plane of the nanoshells activity may have contributed to its reduced use. It could either be brought forward or have graphics drawing attention to it. Possibly the infrared exhibit could have the “laser” mounted on it and shining on the tumor to make a physical connection.

- The red light shines through the fingertip.

  - Ideally, the interactive would only reveal the passage of light through skin with the infrared light. Currently the red LED also brightens the tip of the finger. Visitors notice that both the red and infrared can be seen, though most realize the infrared seems to pass through the best. Possibly the red LED could be less bright or not included at all to keep the message clear and simple.

Summary of Tumor and Infrared Light Prototypes

About half the visitors (5 of 11) used only the *Tumor* prototype while about half used both the *Tumor* and *Infrared Light* prototype (5 of 11). One group used only the *Infrared Light* prototype. Those who used both prototypes demonstrated a higher level of understanding of the process and how the two components were related. Overall, the prototypes effectively communicated the information to the visitors when they completed both activities.

However, as mentioned, only about half the visitors actually used both. The *Infrared Light* prototype needs to attract more use for the exhibits to be most effective. Physical and graphical changes could be made to increase usage.

In its current configuration the *Infrared Light* prototype is physically connected to the *Tumor* prototype, however, it is recessed from the front plane of the exhibit. The graphic panels of the two components are flush with each other and maybe causing the *Infrared Light* exhibit to blend in and be overlooked. Ideally this piece could be brought forward and tested again or otherwise changed to draw more attention to it. However, it is less interactive than the *Tumor* prototype so may always receive less use.

Imaging Prototype

The *Imaging* prototype was tested simultaneously to the *Infrared Light* and *Tumor* prototypes. Eight groups composed of nine people in total were observed and interviewed. Results can be found in Appendix A. No modifications were made during the course of testing of this prototype.

The *Imaging* prototype was intended to help visitors see firsthand how nanotechnology could be used to improve medical imaging, specifically imaging prostate cancer that had spread to lymph nodes. Nearly everyone who tried the prototype was an adult, likely due to the content and lower level of interactivity. For the same reasons it was less popular than the *Tumor* prototype. Over half of the visitors demonstrated a clear understanding of what the prototype was trying to teach. However, the prototype was not without some issues.

For most of the visitors using the prototype, the windows were too low. Adults were stooping over or kneeling to peer into the windows. However, to remain wheelchair accessible, the prototype could not be much taller. This issue of accessibility will need to be addressed by the wider network team.

The toggle switch, while effective and intuitive once used, was not immediately clear at a glance. The switch is of an uncommon design so visitors were not familiar with its function. Also, the switch was black in a black frame that made it hard to see. The switch could be simply labeled “push” or another switch style could be used.

The images themselves were unnecessarily complex. In the left window, visitors compare a non-cancerous lymph node in a regular MRI and a nano-enhanced MRI. In the right window, visitors compare a cancerous lymph node in a regular MRI and a nano-enhanced MRI. Visitors are expected to compare two images in each window with the two images in the other window. Additionally there are imaging artifacts in the right window that may or may not be lymph nodes, which merely add to the confusion.

More simply, there should only be one window. Both regular MRIs (of the healthy and cancerous lymph nodes) would be visible at one time. When the toggle was switched, the two enhanced MRIs would be visible and visitors could clearly see the difference between them. Ideally an example MRI could be found that has both a healthy and a cancerous lymph node with in the same field of view. This would allow a comparison between a single regular MRI and a single enhanced MRI instead of a comparison between four images.

Finally, the copy could be adjusted so that the text is laid out in the logical order in which we expect people to read it.

Summary of Imaging Prototype

This prototype would benefit from additional testing with a simplified interface and graphical layout. If possible, due to the adult audience it attracts (7 of 8), the height could be increased to make it easier for visitors to look into the windows. This prototype has potential to clearly demonstrate benefits of nanotechnology in the field of medical imaging with a few relatively simple adjustments.

This report was based on work supported by the National Science Foundation under Grant No. ESI-0532536. Any opinions, findings, and conclusions or recommendations expressed in this report are those of the author(s) and do not necessarily reflect the views of the Foundation.

Appendix A: Data Summary

Tumor and Infrared Light Prototypes

Demographics

Response	(n=11)
Female	6
Male	5

Age

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

Dwell time

Response	(n=11)
Average time	2m 32s

Level of understanding of *Tumor* (Q1, Q4, & Q5)

Clear understanding is demonstrated by mentioning gold nanoshells, curing cancer, nanoshells collecting in the tumor, and how the light heats up the cancer to kill it. Partial understanding ignores a certain important feature (such as gold nanoshells).

Response	Completed *Tumor* activity only (n=5)	Completed *Tumor* activity and *Infrared Light* activity (n=5)
Clear understanding	1	5
Partial understanding	3	0
No understanding	1	0

Level of understanding of *Infrared Light* (Q1 & Q3)

Clear understanding is demonstrated by correctly determining which light is brightest, and what differences there are between the lights. Partial understanding ignores one aspect.

Response	Completed *Infrared Light* activity only (n=1)	Completed *Tumor* activity and *Infrared Light* activity (n=5)
Clear understanding	0	5
Partial understanding	1	0
No understanding	0	0

Understanding of how the *Tumor* and *Infrared Light* components are related (Q6)

Visitors' understanding is determined by their explaining how infrared light is used in this treatment of cancer since infrared light passes through the skin while visible light does not.

Response	Completed *Tumor* activity and *Infrared Light* activity (n=5)
Understanding	4
No understanding	1

Q7. How would you rate your knowledge of science from 1 to 10?

Response	(n=11)
Average rating	5.4

Imaging Prototype

Demographics

Response	(n=8)
Female	6
Male	2

Age

Response	(n=8)
8–11	0
12–14	1
15–18	0
19–25	0
26–35	2
36–49	4
50–65	1
66+	0

Dwell time

Response	(n=8)
Average time	56s

Level of understanding of *Imaging* (Q1, Q4, Q5, & Q6)

Clear understanding is demonstrated by mentioning nano particles used to image cancer where the coloration is affected depending on whether the lymph node is healthy or not. Partial understanding omitted a significant aspect, such as the use of nanoparticles.

Response	(n=8)
Clear understanding	4
Partial understanding	2
No understanding	2

Q7. How would you rate your knowledge of science from 1 to 10?

Response	(n=8)
Average rating	4.6