Nanotechnology Onstage at the Museum of Science

Presentation Review

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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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Executive Summary

Each week, in collaboration with local nanoscale research centers, the Museum of Science, Boston offers its visiting public several opportunities to learn about nanotechnology through stage presentations. These presentations, given in the Gordon Current Science & Technology Center, are geared toward Museum visitors 12 years of age and older, and are typically no longer than 20 minutes in length. These presentations are supported by the Center for High-rate Nanomanufacturing (CHN), a National Science Foundation Nanoscale Science and Engineering Center headquartered at Northeastern University and the University of Massachusetts – Lowell.

This evaluation will consist of two phases: Phase One (described in this report) is intended to provide a baseline mapping of the content and techniques deployed in the presentations and to suggest potential lines of inquiry for the next phase of the evaluation study. In order to do this, seven presentations were videotaped and the educators' beliefs were captured and examined to allow for comparison of the programs. Phase Two will be informed by this evaluation and will include formative evaluation of two presentations created through funding from CHN.

Findings revealed that nearly all seven presentations communicated the importance of nanotechnology to audience members, describing it as a new science that allows us to manipulate atoms and molecules. These presentations also generally described nanotechnology as a field that has the potential to produce applications that have great impact on our lives. Other similarities, which arose across the seven presentations, included the communication of information on a core scientific or mathematical concept, basic mechanisms for audience members to follow up on their learning, and questions about the topic's ethical and safety implications. However, there was variation in the level of scientific depth and detail each presentation provided, whether consumer products were discussed, and how many research applications were highlighted.

In terms of communication techniques, most presentations included the use of analogies or metaphors, rhetorical questions, and graphics. However, there was variation in the number of techniques employed. Some presentations featured illustrative and audience engagement techniques such as a demonstration, audience poll, and props while other presentations featured no illustrative and audience engagement techniques.

In their interviews, educators oftentimes discussed the challenge of balancing the breadth and depth of their presentation. They wanted to provide a framework for the audience to understand the sheer size of nanotechnology's potential while simultaneously giving audience members an understanding of how something worked in scientific terms.

Introduction

Background Information on the Program

Each week, the Museum of Science, Boston offers to its visiting public the opportunity to learn about nanotechnology through a series of stage presentations. These presentations are held several times a week in the Gordon Current Science & Technology Center, where presentations are geared toward Museum visitors 12 years and older and are typically no longer than 20 minutes in length.

Nanotechnology presentations are developed and delivered by two Museum of Science education associates, with support from the Center for High-rate Nanomanufacturing (CHN), headquartered at Northeastern University and the University of Massachusetts – Lowell, and from the "Science of Nanoscale Systems and their Device Applications" Nanoscale Science and Engineering Center headquartered at Harvard University. These nanotechnology presentations are overseen by Carol Lynn Alpert, Director of Strategic Projects at the Museum of Science. The nanotechnology-related presentations that are analyzed in this report include the following:

- Carbon Nanotubes
- Cyborgs
- Nanomanufacturing: Nanofactories of the Future
- Nanomedicine
- Silly Putty Body Armor
- Small Science
- What is Nanotechnology?

With facilitation from the Research and Evaluation Department, the education associates and Carol Lynn Alpert developed target educational outcomes for the presentations. The defined outcomes were the following:

1) To increase the audience's understanding of what nanotechnology is;
2) To increase their knowledge of one or two additional points associated with the presentation's topic; and
3) To provide an engaging program that would increase the audience's interest in nanotechnology.

What Other Literature Tells Us about Stage Presentations and Communicating Nanotechnology to the Public

Prior evaluation studies that examine the presentation of current science and technology information in museums and public perceptions of nanotechnology provide context and background for this presentation review and the Phase 2 evaluation studies. At the Museum of Science, the live stage presentation is viewed as a way to present information that is responsive to new developments and to the audience's demographics (Alexander, personal communication, 2007). The March/April 2007 edition of *ASTC Dimensions*, titled "Performing Science: The Once and Future Science Show," commemorated demonstrations as a mainstay of science centers across America. *Dimensions* author Dante Centuori (2007) commented that dynamic educators are fundamental to presentations' success, with their passion for storytelling and personality being key aspects. Another contributor to the journal, Wendy Sadler (2007), described a small research study she performed on the short and long term impact of demonstrations which found that more than two years later, her study participants could remember the science presentations. Her study's participants tended to remember aspects of the presentations that were, what she termed, "curious" (counterintuitive) and "human" (in that they somehow involved using the audience). Participants less frequently reported remembering aspects of the presentations that were what Sadler termed "analogies" (visual interpretations of science), "mechanics" (learning how things worked) or "phenomena" (the experiential aspects such as demonstrations).

Some research has been performed to understand the public's current attitudes and awareness of nanotechnology, a burgeoning field that is receiving a great deal of attention in educational outreach efforts. In her literature review of 19 secondary research reports, Barbara Flagg (2005) found that less than half of the adult population had heard of the term "nanotechnology" and only a fifth could define it. Flagg also found that most of the public thinks the benefits of nanotechnology outweigh the risks and holds a positive attitude toward nanotechnology. Similarly, when Castellini, Walejko, Holladay, Theim, Zenner, and Crone (2007) surveyed 495 individuals ranging in age from 7 to 91, they found that less than half (41%) of respondents had heard of the term nanotechnology and most respondents had a neutral attitude toward it. Additionally, many respondents did not demonstrate a strong understanding of size, especially at small-scale dimensions. Only about half (45%) of the respondents recognized that atoms were smaller than the other objects they were presented (e.g., grains of sand, cells, electrons). Oftentimes, respondents did not rate atoms as being smaller than other microscopic choices.

Based on their findings, the aforementioned authors had several suggestions for how to effectively communicate nanotechnology to the public. Flagg (2005) suggested that the public could be attracted to nanotechnology by highlighting applications, placing emphasis on personal relevance, building on nanotechnology's benefits while still recognizing its risks, sharing consumer information, being aware of the values the audience brings with them, ignoring science fiction scenarios, building on nationalism, and focusing on the future. From their findings and prior literature, Castellini, Walejko, Holladay, Theim, Zenner, and Crone (2007) suggest that effectively presenting nanotechnology to the public involves understanding the misconceptions that audiences have; using visual representations of the metric system; posing questions; and choosing to convey only two or three main concepts. They also cited prior research to assert that strong presentations possess three central attributes: "(1) a definition that lists each of a concept's critical features, (2) an array of varied examples and non-examples, [and] (3) opportunities for learners to practice and/or discuss distinguishing examples from non-examples" (Tennyson & Cocchiarella, 1986, p.188).

Purpose of This Review

This report is the first phase of a two phase evaluation of the Museum of Science nanotechnology stage presentations. The first phase of the evaluation process, as detailed in this report, involved a review of the presentations delivered between the beginning and the middle of 2007. These programs were examined by both program and evaluation staff to generate an understanding of the shared features and characteristics that define this suite of nanotechnology programs. This first phase makes transparent the content and techniques used in the presentations and the thinking that guided the educators' decisions when developing and delivering the presentations. This document is intended to be a record to help the nanotechnology program educators develop the program's theory of action about how to best present nanoscale science and engineering to the Museum public.

The questions guiding this first phase of research were the following:

1. What content is expressed in the seven presentations? How does this content differ across presentations?
2. What communication techniques are used in the seven presentations? What are the similarities and differences among the presentations' communication techniques?

It is hoped that this report will spur dialogue among the nanotechnology presentation staff should they decide to revise the presentations before the formative evaluation phase. Phase two's formative evaluation will offer the program team with visitor-derived information they can use to improve and modify their programs.

II. Methods

A presentation review approach was taken in this evaluation. This meant that the presentations were videotaped and the educators' beliefs and behaviors were recorded to allow for comparison of the presentations. These evaluation methods allow evaluators to recognize the experience and knowledge the program staff have accumulated and aim to incorporate that expertise into the study findings. Thus, producing this report required that the evaluation and education teams work collaboratively to generate the findings. Two methods were employed: a review of videotaped presentations and educator interviews.

Review of videotaped presentations

Videotaping presentations allowed the content to be reviewed multiple times, including in group settings, and afforded the ability to map out content and presentation techniques. These videotaped presentations could also potentially serve as a comparison to highlight any changes made to future presentations.

A total of seven presentations were videotaped and analyzed. These seven presentations were delivered between late 2006 and August 2007 by three different educators. According to the educators, the videotaped presentations were not significantly different from previous presentations they had delivered.

After reviewing the videotaped presentations in May 2007, the evaluation staff developed a preliminary list of content and presentation communication techniques. Both evaluators and educators reviewed the presentations and discussed the list. Modifications were then made, and general agreement on the list was achieved. The videotaped presentations were subsequently reviewed three to five more times by an evaluator and a staff member, and the content and presentation techniques were mapped out by the evaluator.

The analysis of the videotaped presentations was subsequently based on these maps which detailed each presentation's content and techniques. The analysis also drew from the evaluator's experience of watching all the presentations multiple times as well as her experience as an audience researcher.

Educator interviews

Through experience presenting multiple times a week, educators have gained expertise on how to develop and deliver presentations. Through the interviews, we aimed to understand educators' perspectives about the defining elements and characteristics of their presentations. Evaluators asked educators to describe the main messages of their presentations, discuss the balance between aspects of the presentation like information vs. entertainment and verbal vs. visual presentation, and to identify the strongest and weakest parts of their presentations. Educators were also asked to speak generally about how they judge their presentations' success and what challenges they imagine audience members face in understanding nanotechnology.

Limitations

The design of this evaluation led to a number of limitations. First of all, this evaluation provides a one-time snapshot of the presentations and represents educator thoughts at a single point in time. Thus, it does not capture the dynamic nature of the presentations including changes in delivery (e.g., as impacted by the composition of the audience) and educators' thoughts about their presentations. Secondly, it is important to keep in mind that the evaluation is inherently influenced by the information each educator provided to the evaluator. Each educator responded to the interview questions differently and with different levels of depth. Third, it is also important to understand that the educators had different levels of experience delivering their presentations, and that each educator has a different personality, approach to presenting, and presentation content. Finally, it is important to recognize that this study was designed only to record the content and methods used in the presentations as well as some of the educators' thoughts about their presentations. The main goal of this report is to inform future phases of the evaluation and to create a generalize-able body of knowledge on the current content and techniques used in the nanotechnology presentations.

III. Results

The findings are divided into two sections that examine similarities and differences among presentation content (Question 1) and communication techniques (Question 2). Educators' perceptions are interspersed throughout both sections in sidebars.

Question 1. What content is expressed across presentations? How is it similar and different across presentations?

To see what content the seven presentations shared, educators were asked to describe the main messages of their individual presentations. Similarly, the evaluator examined the videos to determine what she felt the main messages were. The evaluator also recorded content points within each presentation. For the purposes of this report, main messages are defined as the broad, overarching ideas the educator tried to convey in the presentation. Content points are considered the individual points the educators make in their presentations related to the subject matter which ideally contribute to the presentations' main messages.

Similarities in main messages. Both analysis of the educators' interview responses and analysis of the videotaped presentations revealed that some central themes tie the seven presentations together. Evaluators found that nearly all the presentations communicated to audience members the importance of nanotechnology. The presentations also often described how nanotechnology is a new science that allows for the manipulation of matter on the scale of atoms and molecules and allows scientists to harness properties that emerge at that small scale. Nanotechnology was conveyed as having the potential to have great impact on our lives. Educators agreed that one of the main messages of their presentations was to provide an overview of nanotechnology and to be descriptive of some of the new materials resulting from nanoscale science, engineering and technology research.

Differences in main messages. Despite these similarities, educators differed in how specific their main messages were (see Table 1). Some main messages focused on providing an overview of nanotechnology while others focused on teaching people about specific nanotechnology applications or devices, developing positive attitudes toward science, or increasing the public's understanding about nanotechnology's potential risks and benefits.

TABLE 1. The Presentations' Main Messages Displayed by Thematic Category.[1]

Nanotechnology-related content (implications, processes, applications, structures)
• *Carbon Nanotubes*
  o Convey that carbon nanotubes exist
  o Express that carbon nanotubes are new
• *Nanofactories of the Future*
  o Describe how there are novel devices and materials being developed and researched in nanotechnology
  o Convey that building at this small scale requires new approaches different from other scales
  o Illustrate that the impacts of nanotechnology are big and may lead to changes in science
• *Nanomedicine*
  o Provide an overview of nanomedicine
  o Describe ways to detect cancer with nanoparticles
  o Convey how to treat cancer with nanoparticles
• *Silly Putty Body Armor*
  o Describe how new materials are being developed through nanoscale science research
  o Convey that nanotechnology is a big field of research with a variety of potential significant applications
• *Small Science*
  o Convey that there are reasons why small scale science leads to different capabilities than we've had before
  o Highlight the range of nanotechnology applications
	Definition of Nanotechnology
	• *Nanofactories of the Future*: Express that nanotechnology is science at the scale of atoms and molecules
	• *Nanomedicine*: Describe what nanotechnology means
	• *Small Science*: Express that nanotechnology is science at the scale of atoms and molecules
	• *Silly Putty Body Armor*: Convey that nanoscale science is at a scale smaller than you've imagined
	• *What is Nanotechnology?*
	  o Describe how nanotechnology is the manipulation of matter at the fundamental scales
	  o Detail how nanotechnology is a science in its infancy
	
	Safety concerns
	• *Nanofactories of the Future*: Alert the audience to concerns about the safety of nanotechnology
	• *Small Science*: Raise questions about the safety of nanotechnology
	
	Biology/Technology Related
	• *Cyborgs*
	  o Convey that the ability to integrate biology and technology may not be far away
	  o Alert the audience that the potential to integrate biology and technology is as frightening as is it is exciting
	
	Attitudinal
	• *Carbon Nanotubes*: Convey that carbon nanotubes are cool
	• *Cyborgs*: Express that science is cool

[1] Note: These are the main messages for the programs provided by the educators. Because the main messages from all the programs are listed in the table, they may be repetitious as some educators tended to use the same messages across presentations.

Similarities in content points. There were also some consistent content points covered across presentations (see Table 2). First, five of the seven presentations provided a straightforward discussion of nanotechnology, in which educators immediately delved into the topic, introducing why nanotechnology is important. All but one of these presentations provided a definition of nanotechnology. Second, all the presentations provided information on some core scientific or mathematical concept, such as properties of solids and liquids, the surface area to volume ratio, or the fundamental nature of atoms and molecules. Also, all of the presenters painted a generally positive picture of nanotechnology. Additionally, nearly all the presentations provided basic mechanisms for audience members to follow up on their learning, such as through websites. The educators also gave audience members the opportunity to ask questions afterwards. Finally, in all but one presentation, questions were raised about the ethical and safety implications of the topic. The only exception was the *Nanomedicine* presentation in which the educator told audience members that the nanomedicine therapy was not yet available to the public.

All of the presentations also addressed the future of nanotechnology. Some of the presentations discussed this future using a science fiction angle (see Sidebar 1 for educators' perspective on why they took a science fiction approach). *Cyborgs*, for example, explicitly drew from science fiction films and demonstrated how current and future research (such as a bionic rat, based on research with nanowires) may make what was once science fiction a reality. *Small Science* also recognized that the space elevator, which sounded like science fiction to the educator herself, might be a possibility and that legitimate scientists are making calculations on it. "It's a big picture, dreamy picture" the scientists possess, the educator described in *Nanofactories of the Future*. *Nanomedicine* tried to dispel the myths of nanobot machines in the bloodstream and *Nanofactories of the Future* similarly described a technology that was far away from being a reality—a fictional Nanomanufacturer 9000 machine that could create tissues, orange juice, and other comforts for when one is sick.

Sidebar 1: Educators' Perspectives on the Inclusion of Current Research

Two educators described putting wildly imaginative ideas into their presentations to expand the audiences' understanding of what nanotechnology is and could be. They wanted to create a framework for audience members to see just how big nanotechnology could be as a field:

- *[I] always make a statement about [nanotechnology's] big scope even if [I'm] not elaborating, trying to feed the notion. [There's the] space elevator example because [it's] big, alerts people…*
- *Capture the fact it's theoretical… so create fanciful ones, harness imagination. Unabashedly push ideas where [they're] far out.*

Barbara Flagg's (2005) recommends not confusing the public by mixing fact with fiction. However, most of the examples described above are not science fiction but rather describe potential applications that are not likely to be developed until sometime in the future.

Variations in content depth and complexity. Across the seven presentations, the videotape analysis showed variation in the depth of scientific information presented. As educators expressed during interviews, some of the presentations, such as *Silly Putty Body Armor* and *Cyborgs*, were developed with a broad audience in mind. In *Cyborgs*, the depth of information related to nanotechnology was low and core scientific principles were seemingly absent. Instead, a significant amount of time was spent teaching what is involved in engineering an effective bionic arm (mechanical, power, and control considerations) and raising questions about ethical considerations. Nanotechnology was loosely threaded into the presentation toward the end:

Now this is a picture of Charles Lieber. He's a researcher across the street at Harvard's College of Engineering and Applied Sciences… Charlie is an expert at making little tiny switches, electrical switches that are called nanowire transistors. They're really tiny. He's been doing this a long time and has gotten really good at it. He got the idea of maybe he could wire nerves on top of this…

Nanotechnology was introduced in the context of nanowires, with the educator briefly describing how tiny a nanowire is and telling visitors that nanowires have been around for a while. Through this example, the educator subtly illustrates the relationship of nanowires to advanced applications. However, nanowire transistors and nanotechnology were not defined and the field of nanotechnology was left largely unaddressed. Thus, in *Cyborgs*, nanotechnology is a secondary content area.

Like *Cyborgs*, *Silly Putty Body Armor* took an indirect approach to introducing nanotechnology. However, it still had a good amount of basic science and nanotechnology information in it. Using an "ooey gooey" substance as the centerpiece of this presentation, *Silly Putty Body Armor* taught visitors that atom and molecule arrangement affects a substance's properties. Nanotechnology was introduced into the presentation through the example of military armor that is like silly putty, except that nanoparticles are what make it similar to the substance. Nanotechnology was subsequently defined. Despite these different approaches, neither *Silly Putty* nor *Cyborgs* were ineffectual in captivating audience interest. However, both featured less time and less depth on the topic of nanotechnology than the other presentations.

Other presentations provided an introductory, but focused overview of nanotechnology. These presentations included *What is Nanotechnology?* and *Small Science*. They conveyed basic messages about how small things are at the nanoscale, why small size matters, how nanotechnology is useful to the creation of new applications, and where this science is moving in the future. Both presentations generally described how new materials and structures like buckyballs and carbon nanotubes result from manipulation of matter at the level of atoms and molecules.

There were also more conceptually complex presentations that focused explicitly on nanostructures or nanotechnology-related processes. The *Carbon Nanotubes* presentation, for example, focused on the core scientific principles behind the structure and properties of carbon atoms and carbon nanotubes. The discovery of buckyballs and carbon nanotubes were discussed as were their structural arrangements and potential applications. *Nanomedicine* took the audience through the different steps involved in detecting leukemia and spent a great deal of time describing and demonstrating the detailed differences between a fluorescent versus magnetic nanoparticles. It also highlighted the role of DNA in detecting cancer. *Nanofactories of the Future* discussed carbon nanotubes and the concept of high-rate nanomanufacturing—manipulating matter on a small scale at a high throughput. The presentation also introduced concepts such as nanomachines and self-assembly. All together, the topics introduced in these presentations included more detail. *Carbon Nanotubes* and *Nanomedicine,* in particular, presented a higher level of depth than other presentations.

<u>Variations in use of applications.</u> Aside from the variation in presentation depth, there were other differences in the presentations' content points. A couple of the presentations aimed to garner audience interest in and understanding of nanotechnology by covering audience-friendly content like consumer products. Some of the consumer products discussed in *Small Science* included a roll of tape, khaki pants, a digital camera, and a tissue box. Additionally, *Carbon Nanotubes* displayed a tennis racket and *Silly Putty Body Armor* showed nano-enabled sports padding. Presentations that used consumer applications presumably provided ways for audience members to draw connections between items in their everyday lives and the ways nanotechnology-enabled applications could enhance their lives. This strategy was recommended by Barbara Flagg (2005).

<u>Variations in coverage of current research</u>. All presentations covered examples of current research in nanotechnology, which could be considered a method that may generate audience interest and understanding. By discussing research applications, educators illustrate how the properties and behaviors of nanotechnology relate to core scientific principles and can positively impact our lives. However, the presentations varied in the frequency and depth in which current research examples were presented. In *Nanomedicine,* for example, only one research application was presented: the University of Florida's research on detecting and treating leukemia through the use of nanoparticles. Many of the other presentations provided two or more examples including: a description of fabrics developed by the military to protect soldiers, the production of more advanced computer memory, and the production of nano-cars that serve as machines on a small scale. The incorporation of multiple research examples into the presentations could help to illustrate the scope of nanotechnology and highlight the fact that the research is being conducted in several fields (see Sidebar 2).

TABLE 2. Content Points Covered in the Videotaped Presentations.

	Presentation 1: *What is Nanotechnology ?*	**Presentation 2: *Cyborgs***	**Presentation 3: *Carbon Nanotubes***	**Presentation 4: *Nanomedicine***	**Presentation 5: *Small Science***	**Presentation 6: *Nanofactories of the Future***	**Presentation 7: *Silly Putty Body Armor***
Did the presentation contain:							
Definition of nanotechnology	Yes	No	Yes	Yes: Zoom	Yes: Zoom	Yes: Zoom	Yes: Zoom
Nanostructures	Somewhat: Buckyball, carbon nanotube	No	Yes: Carbon nanotubes, buckyballs	No	Yes: Buckyball, carbon nanotubes	Yes: Carbon nanotubes	No
Core scientific concepts	Yes: Atoms/molecules	Yes: Central nervous system	Yes: Atoms/molecules	Yes: Cancer, DNA	Yes: Surface area/volume	Yes: Arranging molecules, atoms	Yes: Solids/liquids
Current research & applications	Yes: Water, health, environment	Yes: Health	Yes: Computers, water, energy, space, building	Yes: Cancer detection	Yes: Health, military	Yes: Fabric, computer, crime	Yes: Military
Everyday consumer products	No (future applications)	Somewhat: Cochlear implants, pacemaker	Yes: Sports / tennis racket	No	Yes: Computer, medical	Yes: Computer, socks	Yes: Sports
Scope of nano	Yes	No	Yes	No	Yes	Somewhat	Somewhat
Ethical / safety concerns	Yes	Yes	Yes	No	Yes	Yes	No
Historical background	Yes	Somewhat	Yes	No	No	No	Yes
Pop culture	No	Yes: Films	Somewhat	No	No	No	Yes
Sci-fi twist	No (but recognized)	Yes	No	No (but recognized)	No (but recognized)	Yes	No
Future of nano	Yes	Yes	Yes	Yes	Yes	Yes	No
Centrality of nano	Yes: Immediately introduced	No: Mentioned once in middle	Yes: Immediately almost introduced	Yes: Immediately introduced	Yes: Immediately introduced	Yes: Immediately introduced	Somewhat: Introduced in the second half
Follow up	Yes: Website	No	Yes: Sample	Yes: Website	Yes: Website	Yes: Website	Yes: Sample

Sidebar 2: Educators' Perspectives on the Inclusion of Current Research Examples

Educators considered the incorporation of current research to be a strength of their presentations, especially since it helped to make nanotechnology tangible. Educators told us that the research applications were something that the audience could easily conceptualize and connect with:

- *Applications of the research we do right away, tangible… [It's] tangible, understandable, [and has an] impact.*
- *Fact that it's phenomenological and you can see it…*

Research applications also fit with educators' belief in the importance of telling stories about scientific discoveries or innovations, which as an added bonus, would keep the audience interested:

- *Highlight a story…*
- *[I] like the research example picked in this presentation. Here picked more major captivating research examples…*
- *Highlights research of one person...*

Despite all of the benefits the research examples were believed to provide, educators questioned whether they left audience members with a misunderstanding of what nanotechnology is, limiting their understanding to specific applications and concepts. Would audience members be able to grasp the concepts of what nanotechnology is, how the current research applications work, *and* recognize that nanotechnology's reach is much broader than the examples they had just learned about? For a few presentations, educators pondered whether to use examples or not. Some educator comments included the following:

- *Research examples – [does it] give a broad enough look? Like talking about specific research, but don't know if representative enough of a body of work.*
- *Worry these are the only things are important about nanotechnology. Not completely comprehensive in one sense. Just examples and not sure if [they're a] good idea.*
- *Sometimes [it's] hard because [I'm] jumping – [I] want to give [an] overview of [the topic], but [I] talk about something so specific, people get confused… Based on some questions [I] get afterwards, they think that's the only way to do it…*

Question 2: What communication techniques are used across presentations? What are the similarities and differences between the presentations' communication techniques?

Presentations were examined for similarities and differences in their visual and verbal presentation of information and audience involvement (see Table 3). Once again, there were some generalities in techniques that extended across presentations.

All of the presentations were accompanied by digital PowerPoint-style slides. These slides were projected onto the Gordon Current Science & Technology stage screen, which consists of four large screens. Different images were pulled up onto different screens corresponding to content points. Oftentimes, the graphics had diagrams demonstrating how the applications or concepts worked. There were also microscopic level images, which gave a sense of the scale and suggested that the material was very small. Images of real world objects were also frequently used to ground the content in everyday life or popular culture. On occasion, cartoons were used, oftentimes to conjure an abstract thought or to reinforce the subject matter. One example of this was a cartoon of a person in a polka dotted robe with a cold used in *Nanofactories of the Future*. Basic animation was also used on occasion and typically consisted of linear motion of a diagram, such as an arrow moving or being added to a diagram to highlight the movement of a nanoparticle. Only *Small Science* made use of video footage. Educators also frequently used short amounts of text in the PowerPoint to accompany terminology, to reinforce concepts they were describing, or to help keep track of the part of the presentation they were at.

Most presentations used more speech than visuals to convey information. Because the concepts educators conveyed were often difficult to comprehend, educators employed analogies, metaphors and similes in their descriptions of phenomena. This technique allowed them to describe concepts in terms of objects and phenomena that audience members were already familiar with. Examples included:

- "It's like moving LEGOS with bulldozers" (*Intro to Nanotechnology*),
- "[It] works like how a water wheel might work or a spinning wheel" (*Intro to Nanotechnology*), and
- "[It] buckles and waves like the springs in your mattress" (*Nanofactories of the Future*).

Analogies were also heavily used to explain what the nanoscale looks like, particularly when educators zoomed down the scale. For example, in *Small Science*, the educator zoomed in 1,000 times to take the audience from the space to the Earth, zoomed in 1,000 more times to take the audience from Earth to the Boston area, then to a house, a fingernail, red blood cell, and finally to a strand of DNA. The zooming technique was used in about half of the presentations. In addition, almost all presentations used prefixes to place nanotechnology in context, such as centi-, milli-, micro-, and nano-. Rhetorical questions were also used in most presentations to frame the information presented. For example, the *What is Nanotechnology* presentation was organized around the three questions, "How is it new?" "What can it do?" and "Do you care?"

At times, the analogies and metaphors were accompanied by other representations of the concept. For example, when the nano-memory was described in its on and off state, the educator showed a diagram of the state, and used a carbon nanotube model and her arms to represent and verbally describe how the nanotube is "sitting like a bridge" over a "canyon" in one state and sticking to the bottom in the other state.

In contrast to the analogies, metaphors, rhetorical questions, and graphics, other techniques were used less frequently. Among infrequently used techniques were models, which represented the content being discussed in a 3D format. The model of the carbon nanotube – a sheet of hexagon-shaped wire rolled into a tube—appeared in two presentations, *Carbon Nanotubes* and *Nanofactories of the Future*. A soccer ball appeared in *Carbon Nanotubes* to highlight a buckyball's structure. Other props, such as consumer products, were used in *Small Science* and *Carbon Nanotubes*.

Models, such as the one described in the above paragraph, were often a part of demonstrations. In *Nanomedicine*, balls and sticky tape represented cells and DNA. Five of the seven presentations had demonstrations, which ranged from rolling up a piece of paper in both orientations (vertically or horizontally) in *Carbon Nanotubes* to using silly putty and corn starch in different manners (pulling it apart versus throwing it on the ground, stirring quickly versus stirring slowly). The demonstrations tended to highlight core principles of the presentation.

Audience involvement also varied greatly by presentation, and to some degree, by educator (see Sidebar 3 for educators' perspectives on the audience engagement techniques). Polls were used frequently in many of the presentations. In *Nanomedicine*, audience members were asked to raise their hands if they knew someone who had cancer, and in *Small Science* audience members gave a thumbs up or thumbs down to show whether they thought khaki pants were made with nanotechnology. Basic educator questions, a technique in which the educator asks the audience a simple, easily answerable question and they respond as a group, were also used. Another technique used by educators was something we termed the Question-Response-Translation (QRT) technique. Examples of this technique included guessing the surface area to volume ratio of a sugar cube in *Small Science*, naming the film character on the screen in *Cyborgs*; and reviewing whether the featured materials acted like solids or liquids in *Silly Putty Body Armor*. Only *Silly Putty Body Armor* involved calling on individual audience members to answer a question with a microphone. Two presentations asked an audience member to come up onto the stage and assist with a demonstration, a technique we termed the Magician's Assistant. This involved performing a basic task such as pouring a liquid into a flask in *Small Science* or picking up an object from a bin of balls in *Nanomedicine*. The use of these techniques varied between educators. One educator tended to ask the audience basic questions throughout her presentations, whereas another educator tended to ask basic questions of the audience only during a specific part of one presentation.

In short, there were varying levels of audience involvement and illustrative techniques implemented across presentations, and it is unclear how these techniques relate to effective presentation communication. In *Nanomedicine*, several techniques were used including a demonstration with an audience member and several models (e.g., paperclips, balls, sticky tape) and graphics on the overhead screen. It is possible that audience members may have had a difficult time keeping track of the presentation in the midst of all of these techniques. In order to understand the impact of multiple techniques on the audience, further studies need to be conducted.

Although Tennyson and Cocchiarella (1986) suggested using various examples and non-examples in the presentation, this technique was not frequently implemented in the seven observed presentations. A non-example sets up a negative contrast or dispels a potential misconception or misunderstanding of the audience. A brief negative contrast was done in *Nanofactories of the Future* and *Silly Putty Body Armor*, when nanotechnology is described as "not 10 times, not 100 times, not 1000 times, but 10,000 times" smaller than an object. Other comparisons were set up between real world factories and factories for nanomachines in *Nanofactories of the Future*, and between treating cancer with non-targeted chemotherapy and treating it with the targeted drug delivery systems in *Nanomedicine*.

Other factors varied across presentations, which might be expected given that each educator has different approaches and personalities. Two of the educators occasionally inserted personal opinion or experiences into their presentations. This technique could make the educator seem more accessible and personable to the audience, or it could also pose a risk of offending audience members. Similarly, some educators infused greater amounts of humor into their presentations than other educators. Some visitors may like the addition of humor while others may be offended by this content. In the *Carbon Nanotubes* presentation, for example, the educator said: "A few years later, the scientists were awarded the Nobel prize for their discovery. Yay! Notice there were five scientists, three scientists get the Nobel Prize. If any of you are gunning for the Nobel Prize, I recommend being old and having gray hair."

Across presentations, two of the educators tended to provide an overview of the presentation. This meant that presentations were neatly divided into an introduction and approximately three sections (see Appendix C). The overview seemed to be especially clear when divided into basic quips, such as with *Carbon Nanotube's* three sections, "How we found them," "Why they're cool," and "Why you should care." The presentations may benefit from being organized by three basic phrases if educators want to convey and reinforce the main messages.

Finally, throughout their presentations, educators tended to repeat and review content as a way to reinforce learning. What was introduced in the beginning, such as the fact that everything in the world is made of atoms and molecules, was brought up again toward the end of the presentation. For example, throughout *Carbon Nanotubes*, the educator brought up the fact that the structure of a molecule impacts the materials' properties. Toward the end of the presentation, the educator said again, "Remember I said in the beginning, the geometry of the molecule determines the properties of the material." At some point in nearly all of the presentations, the educators included reviews of material presented earlier.

TABLE 3. Presentation Techniques Used in the Videotaped Presentations.

	Presentation 1: *What is Nanotechnology?*	Presentation 2: *Cyborgs*	Presentation 3: *Carbon Nanotubes*	Presentation 4: *Nanomedicine*	Presentation 5: *Small Science*	Presentation 6: *Nanofactories of the Future*	Presentation 7: *Silly Putty Body Armor*
Did the presentation use:							
Verbal	Yes: Advanced organizers, reviews, vocabulary, analogies, visual references, personal, negative contrasts, imagine, rhetorical questions	Yes: Advanced organizers, vocabulary, review, visual reference, personal	Yes: Advanced organizers, review, vocabulary, personal, rhetorical questions, analogies	Yes: Advanced organizers, review, vocabulary, personal, imagining, analogy, negative contrast, visual references	Yes: Analogy, vocabulary, personal, review, rhetorical question, vocabulary, visual reference, non-example	Yes: Visual reference, rhetorical question, review, negative contrast, analogy, imagine	Yes: Terms, negative contrast, metaphor, rhetorical, visual reference, personal, vocabulary, review
Illustrative	No	No	Yes: Demo, models	Yes: Demo, models	Yes: Demo, consumer props, model	Yes: Demos, model	Yes: Demos, consumer props
Audience engagement	Yes: QRT	Yes: QRT, poll	No	Yes: Poll, magician's assistant, QRT	Yes: Poll, QRT	Yes: Poll, QRT	Yes: Question one audience member, poll
Movement	Yes: Gesturing	Yes: Gesturing	Yes: Gesturing	Yes: Gesturing	Yes: Gesturing	Yes: Gesturing	Yes: Gesturing, into audience
Multimedia	Yes: Graphics (real world, diagrams, microscopic, cartoon)	Yes: Graphics (real world, diagrams, microscopic, cartoon)	Yes: Graphics (real world, diagrams, microscopic)	Yes: Graphics (real world, diagrams, microscopic images); basic animation	Yes: Video, graphics (cartoon real world, microscopic, diagrams)	Yes: Graphics (unknown)	Unknown

Sidebar 3: Educators' Perspectives on Audience Engagement and Presentation Techniques

The audience was a central factor in influencing educators' thinking and decision making about how to design a strong presentation. The educators judged their presentations' merit by the audience's reaction. Audience retention, behaviors (applause, posture, voicing of appreciation afterwards), and the number and types of questions posed after the presentation were all ways educators judged the success of their presentations. Educators perceived their presentations as being strong if they increased audience engagement and audience understanding of nanoscale science and engineering after changing their presentations. All three educators wanted to see audience members stay and appear engaged:

- *…See a click in people's eyes…*
- *…Get a big crowd and they always stay…*

All educators recognized the many barriers that impede the public's understanding of nanotechnology. When asked what challenges they imagined their audience members facing, all three of the educators raised the issue that nanotechnology is very theoretical and difficult to relate to people's everyday lives. It's "not something they can see, touch, taste" nor very "experiential."

Educators believed they would increase audience engagement through techniques like demonstrations, visuals, audience hooks, and stories. Oftentimes, they considered these techniques strengths of their presentation:

- *There's something fun right away.*
- *Physical visual aids – it's something I carry through multiple steps through the presentation, it helps people. When people have questions later, they're pointing at it – helps to see 3-D structure.*

However, one educator noted that nanotechnology-related demonstrations are impacted by availability and what one can actually show.

Two of the educators described having to contend with the audience's scientific illiteracy when speaking about nanotechnology. Because nanotechnology draws heavily from other sciences, one educator described having to carefully choose which words to include in the presentation: "Balancing where to throw in some words that you assume the audience knows, or to say it in a different way." In their presentations, educators also tried to educate the audience on fundamental scientific concepts:

- *Try to correct deficiencies they have – prefixes, metric system; crash course*
- *Try to give quick definitions; try to explain things wherever possible, even if it's an aside…*

In addition to providing quick definitions, at times scientific literacy was addressed by explaining core scientific principles to audience members. This was evidenced in *What is*

Nanotechnology? when the educator said, "You've probably heard that everything in the world is made of atoms. If you haven't heard that before, I'm telling you now: everything in the world is made of atoms."

When developing their presentations, educators also described placing themselves in the audience's shoes to think about what they, themselves, would be interested in and how they would understand a concept. They applied their own theories of learning:

- *[I] mostly answer the question, 'If [I] didn't know the stuff, what would I need to hear to understand it?'*
- *…[I] have the philosophy of explain one thing really well [and] then do an overview of a lot of things from previous teaching, experience. [I] try to find one thing that is a nice catch and story that can be representative of a topic.*

Other factors also emerged in educators' decisions about how to present the content. They included logistical aspects like the stage space and technical capabilities, the length of time they had, and their budget. One educator expressed relying on personal judgment to decide how to present something and make decisions about the content to be presented. Another educator discussed the inherent limitations of the content matter. The educator also brought up feeling personally ambivalent about the importance of nanotechnology since its future impact is unclear.

IV. Discussion

It was reasonable to expect that some of the presentations' main messages, content points, and presenter techniques would vary with each presentation based on the educator's style and the topic. Inherently, the educators have different personalities – some incorporate greater humor into their presentations, some focus more on history, and some speak at faster rates. However, given that this is a suite of presentations developed and delivered by a single nanotechnology education program at the Museum of Science, one would expect to find similarities in the content presented and techniques implemented. This evaluation was designed to give the Museum of Science a chance to map this content as well as the techniques used. It aimed to generate an understanding of the similarities and differences that existed between the presentations and inform the next steps of the evaluation. This section discusses what implications the findings have for the next steps of the evaluation.

Content Questions the Findings Pose for Formative Evaluation

The findings of this evaluation raise several questions about how the content of the presentations affects who views them, what is learned, and what questions they generate for audience members.

- Diversity in presentation techniques and main messages can be viewed as an asset that results in a suite of programs that appeal to a range of individuals with different interests and backgrounds. Will individuals with higher interest in and/or scientific understanding about nanotechnology be more attracted to and/or be more likely to stay for presentations that present information at higher scientific levels?

- Given the differences in the content complexity of the seven presentations it was possible that those who attended presentations with higher levels of science information may report learning a greater amount of information. Is a higher level of content understanding or more scientific learning reported from viewers of these presentations? Or alternatively, are the main messages that audience members report at the same level of detail across presentations? Additionally, there is a greater opportunity for confusion when information is presented at a high level. Is more confusion or misunderstanding reported from audience members at presentations with more complex content?

- Health is a topic known to appeal to Gordon Current Science & Technology Center visitors (Storksdieck, Stein, & Dancu, 2006) and to female Museum of Science visitors (Chin & Reich, 2005). Would *Nanomedicine* appeal to a greater number of audience members than some other nanotechnology-related presentations? More specifically, would *Nanomedicine* appeal to more female audience members or prompt more females to attend? Or, would a greater number of individuals who are in careers related to the health sciences field be in attendance?

- Two of the presentations, *Cyborgs* and *Silly Putty Body Armor*, did not immediately address nanotechnology. Does having different opening structures and drastically different titles from other nanotechnology-related presentations lead to a broader swath of individuals watching the presentations?

- There was also variation in the number of research examples provided, which may change visitors' perceptions of the scope of nanotechnology research. If fewer applications are discussed it is possible that the audience will erroneously feel that nanotechnology research is limited.
    - Do presentations that highlight only one or a few research applications (e.g., *Nanomedicine* and *Cyborgs*) garner: a) less interest in the topic, b) less understanding of the content, and/or c) less understanding of nanotechnology's scope as a far-reaching field?
    - Do audience members walk away from the presentation having generated a limited understanding of what nanotechnology is?
    - When future applications are discussed, particularly with a science fiction angle, do audience members think nanotechnology is more advanced than it really is?

- Barbara Flagg (2005) recommended including applications and consumer information in nanotechnology communication. All of the presentations discussed nanotechnology applications, but only some of the presentations discussed consumer products. Is the inclusion of nanotechnology applications and consumer products in presentations compelling to audience members? Does it contribute to their understanding of nanotechnology's scope?

- All of the presentations provided a definition of nanotechnology. After watching these presentations, to what degree are audience members able to define nanotechnology? Do audience members understand that nanotechnology is manipulating matter at the level of atoms and molecules?

- Two of the educational goals the educators posed were to inspire audience members to be interested in continuing to learn about nanotechnology, and to inspire audience members to develop questions about nanotechnology. All the presentations provided audience members with the ability to follow up on their learning, but it would be interesting to learn how many individuals actually do so by either asking the educators questions after the presentation, taking the cards with the website address, or viewing the sample. Furthermore, nearly all of the presentations discuss the uncertainty of nanotechnology's future and its safety implications at the end of the presentations, it might be interesting to see if this content creates questions that the audience continues to think about or is interested in.

Communication Technique Questions the Findings Pose for Formative Evaluation

While most presentations incorporated techniques like analogies, rhetorical questions, and graphics, there was variability in the number of techniques employed in each of the presentations. Educators perceived a presentation's weakness to be a lack of demonstrations or illustrative techniques, but it is possible that including too many techniques may impede understanding and serve as a distraction.

These thoughts raise some questions about the impact of the communication techniques. How many illustrative and audience engagement techniques do audience members expect from the presentations? Which types of presenter techniques are enjoyed or remembered most? Are these techniques cited when audience members describe their understanding of the topic? Would the inclusion of techniques less often used in the presentations, such as the use of non-examples, enhance audience understanding of concepts?

Considerations for the Nanotechnology Program Team

Finally, this evaluation raises some questions that the nanotechnology educators/team may want to consider about the nanotechnology presentation program. First, the variation in educators' main messages suggests differences in their interpretation of what a main message is. Achieving a standardized set of main messages within the program would standardize recognition of the challenges that the audience has in understanding nanotechnology and help to ensure that programs were presenting consistent ideas about nanotechnology. The findings suggest that it might be helpful if the program comes up with a set of outcomes for all the nanotechnology presentations. These outcomes might include attitudinal, educational, behavioral, and presentation-specific content goals. In addition, the team should think more deeply about the presentation techniques that it uses. For example, does the team think it's important to highlight multiple research examples or is it better to talk about one research example in-depth? In what situations do they think research examples are necessary, and how do they think these examples should be implemented? Similar questions could be asked about other presentation techniques.

V. Conclusion

This evaluation looked carefully at similarities and differences between nanotechnology presentations at the Museum of Science. In moving forward, this phase of the evaluation will help to hone the questions asked during the formative evaluation. Below, in bold, were the questions originally outlined for the formative evaluation. Each sub-bullet elaborates on that question based on this report's findings.

- **Who attends and how does this compare to the targeted audiences**?
    - o How do the demographics of attendees to nanotechnology-related presentations compare to other Gordon CS&T presentations and to general museum demographics?
    - o Do different presentations tend to draw and hold different audience members?
    - o Are audience members attracted by the title or the content implied by the title?

- **What is the extent of audience members' engagement with the program and how does that compare to the expected level of engagement?**
    - o Is there a part of the presentations (such as a particular content or presenter techniques from Tables 2 and 3) when visitors tend to disengage or engage visibly with presentations?

- **What do audience members find to be the most engaging aspects of the program?**
    - o Do the most engaging aspects of the program tend to be presentation communication techniques or specific content?
    - o Do audience members understand the core concepts that the demonstrations highlighted?

- **What do visitors report learning and how does this compare to the educators' stated goals and messages?**
    - o Do audience members report understanding the presentations' individual main messages and the main messages that define this suite of nanotechnology presentations?
    - o Do visitors understand the scope of nanotechnology or do they tend to think nanotechnology is related only to the applications each presentation describes?
    - o Are some types of content points (as displayed in Table 2) more easily recalled than others?
    - o Can visitors identify presentation techniques (as displayed in Table 3) that specifically support their reported learning outcomes?

- **What suggestions do audience members have for how the program could be improved?**
    - o Do visitors tend to suggest changes to presentation communication techniques or specific content?

- **What questions, if any, do audience members still have about nanotechnology following their participation in the program?**
    - If participants have questions, what is the nature of their questions (e.g., concrete or conceptual)?
    - What content do audiences ask questions about (e.g., ethics, future of nanotechnology, and understanding of specific concept)?
    - Do questions tend to be similar across presentations?

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Appendix A: Interview Questions

A. Questions on Individual Presentations

Presentation title:
Presenter:
Date:

1. What do you think are the main messages of this particular presentation?

2. How do you think you these main messages are conveyed?

3. Describe the balance between the visual presentation of information and the verbal presentation of information.

4. Describe the balance between the information versus entertainment factors.

5. Describe the logic of the presentation in terms of the content & structure.

6. Identify points of audience involvement.

7. What do you think are the strongest parts of this presentation? Why?

8. What do you think are the less strong parts of this presentation? Why?

B. Cross-Presentation Comparison

Answer these questions generally about the presentations.
What informs your decision to present the content in a specific way?

Across presentations, how do you judge your criteria for success?

What are the main messages of your presentations?

Answer these questions about nanotechnology in general.
What challenges, if any, do you think the audience typically has with the main messages you convey on nanotechnology?

How do you address these challenges?

Appendix B: Video Characteristics

CHN PRESENTATION CHARACTERISTICS

a. Verbal
- Advanced information organizers
  - Asking rhetorical questions
  - Foreshadowing what new ideas will be discussed
- Reviewing sections of what was just discussed (summary)
- Providing a term or new vocabulary for a concept
- Asking the audience to imagine extreme ideas (science fiction)
- Metaphor, analogy, simile (relationship between familiar with unfamiliar)
- Comparisons
- Zooming down the scale
- Negative contrasts to concept, non-examples
- Bringing in aspects of popular culture
- References to visual presentation images
- Personal aspects (belief or experience)

b. Illustrative (non-verbal)
- Demonstrations
- Models
- Consumer product props

c. Audience engagement
- Magician's Assistant (assist with simple task)
- Group polling
- Question to audience member, response and translation (QRT) of learning
- Stepping into the audience space
- Passing a prop around the audience

d. Follow up:
- Q&A at end
- Nano website cards
- Sample for viewing at end

e. Presenter behavior
- Gesturing (hand motions for descriptive, emphasis)
- Moving into the audience

f. Presentation elements to 1) tell a story in and of itself, 2) support a presenter's point, 3) aesthetic
- Animation
- Video
  - Man on the street video
  - Other video
- Symbols/graphics
  - Cartoons, images for aesthetic images
  - Real world / microscopic images to give sense of structure at nanoscale
  - Figures of underlying concepts

g. Structure
- Linking beginning and end activities/statements
- General science concepts leading into nanotechnology
- Nanotechnology introduced immediately

Content Points

- Definition of nano (relationship to atoms & molecules; size)
- Nanostructures (buckyballs, nanotubes, etc.)
- Core scientific concepts
  - Surface area to volume
- Why is nano important (may lead to changes as a science, has many potential applications)
- Describing current research and application (novel devices & materials are being developed)
  - How it's done (new approaches are required)
  - Content areas:
    - Medicine/Health
    - Water
    - Environment
    - Energy
    - Computers
    - Transportation
    - Military
    - Sports
- Nano is a big field (with many potential applications)
- Safety and environmental concerns
- Historical background in science
- Prompt to think of the future

Appendix C: Timeline Approximation of Each Presentation's Content Points and Presentation Techniques

CARBON NANOTUBES

PRESENTATION'S MAIN MESSAGES

- Convey that carbon nanotubes exist
- Express that carbon nanotubes are new
- Convey that carbon nanotubes are cool

Start — End (18 min)

INTRODUCTION

Content:
- **Opening:** Human history changed by materials
- **Overview:** How we found them, why they're cool, why you should care
- **Core scientific principles** atoms/molecules & arrangement, properties
- **Definition of nano**

Techniques: Gestures, graphics (real world, diagrams, microscope), metaphors / analogies, vocabulary

(~4.5 min)

POINT 1: How we found them

Content:
- **Historical background scientific discovery**
- **Nanostructure:** buckyball, carbon nanotube

Techniques: Popular culture, vocabulary, graphics (real world images, diagrams), model, analogy / metaphor, text

(~2.5 min)

POINT 2: Why they're cool

Content:
- **Carbon atom properties**
- **Carbon nanotube properties (electrical, mechanical)**
- **Semiconductors**
- **Applications** (energy, computers)
- **Properties** (stronger, lighter, flexible)

Techniques: Demonstration, review, model, graphics (diagrams, microscopic), gestures, analogy / metaphor

(~3.5 min)

POINT 3: Why you should care

Content:
- **Current & future applications:** computers, water, energy, space
- **Challenges:** price, manipulation, health
- **Health/safety**
- **Today:** devices, consumer applications (computer, sports)
- **Review:** 3 main points

Follow up: questions & sample

Techniques: Review, model, gesture, personal, rhetorical question, graphics (real world, diagrams, microscopic)

(~7.5 min)

CYBORGS

PRESENTATION'S MAIN MESSAGES

- Express that science is cool
- Convey that the ability to integrate biology and technology may not be far away
- Alert the audience that the potential to integrate biology and technology is frightening as is it is exciting

Start — End (15 min)

INTRODUCTION

Overview: What cyborgs means, famous examples, current research maybe making "science fiction into reality"

POINT 1: What does Cyborgs mean?

Content:
- **Definition of cyborgs**
- **Popular culture**
  - Darth Vader, Dr. Oct, Picard, 6 Million Dollar Man

Techniques: QRT, graphics (real world, cartoons, diagrams), personal, gestures, poll, text, vocabulary

(~4 min)

POINT 2: What it takes to engineer an arm

Content:
- **Engineers work in teams**
- **Overview:** what arm does, engineering: mechanical, power, control
- **Mechanical: Hands' degree of freedom**
  - Application: Space robohand
- **Power: battery**
- **Control:**
  - Core scientific concepts (central nervous system)

Techniques: Gestures, graphics (real world, diagram, cartoon), text outline, vocabulary, personal, review

(~4 min)

POINT 3: Current research

Content:
- **Real life application:** health (hearing, pacemaker), real life examples, nanowire transistors
- **Possible future:** health

Techniques: Personal, graphics (real world, cartoons, microscopic), popular culture, gestures, visual reference, review

(~4.5 min)

CONCLUSION

Content:
- **Ethical implications:** privacy
- **Prompt to think of the future**
- **Ethical concerns**

Techniques: Graphics (cartoons, real world), personal

(~2 min)

NANOMEDICINE

PRESENTATION'S MAIN MESSAGES

- Provide an overview of nanomedicine
- Describe what nanotechnology means
- Describe ways to detect cancer with nanoparticles
- Convey how to treat cancer with nanoparticles

(Note: The diagram below does not fully list the graphics in the presentation due to the style of videography)

Start

End
(~17 min)

INTRODUCTION

Content:
- **Definition**
- **Overview:** what nano is, how relates to research, cancer
- **Definition of nano** (zoom)
- **Nanoparticles**
- **Overview:** what scientists do with nanoparticles with cancer research, detect, treat

Techniques: Analogy, gesturing, graphics (microscopic images), rhetorical question, poll, personal, vocabulary, comparison, visual reference, basic animation

(~4.5 min)

POINT 1: Detecting Cancer

Content:
- **Scientific concept** (leukemia)
- **Research application:** magnetic, fluorescent nanoparticles; materials (silicon dioxide, iron)
- **Core scientific concept: DNA**
- **Overview**

Techniques: Graphics (microscopic images, diagrams, real life images), imagine, demos, vocabulary, negative contrasts, QRT, gesturing, rhetorical question, Magician's Assistant, basic animation, text outline, review, metaphors, visual reference

(~8.5 min)

POINT 2: Treating cancer

Content:
- **Future nano**
- **Non harmful shell:** Gene therapy, chemotherapy targeted delivery

Techniques: Gestures, graphics (diagrams), imagine, science fiction, negative contrast, basic animation, vocabulary

(~3 min)

POINT 3: Where we are currently

Content:
- **Not ready yet**

Follow up: Website

Techniques: Gestures, graphics (diagrams, microscopic), imagine

(~1 min)

NANOFACTORIES OF THE FUTURE

PRESENTATION'S MAIN MESSAGES

- Express that nanotechnology is science at the scale of atoms and molecules
- Describe how there are novel devices and materials being developed and researched in nanotechnology
- Convey that building at this small scale requires new approaches different from other scales
- Illustrate that the impacts of nanotechnology are big and may lead to changes in science
- Alert the audience to concerns about the safety of nanotechnology

(Note: The diagram below does not fully list the graphics in the presentation due to the style of videography)

Start

End
(16.5 min)

INTRODUCTION

Content:
- **Imagine**
- **Building top down & bottom up:** arranging atoms/molecules
- **Definition of nano-manufacturing and nano** (zoom)

Techniques: Imagine, graphics (cartoon, microscopic images), poll, gesturing, analogy, negative contrasts, visual reference to graphic, rhetorical questions

(~4 min)

POINT 1: Nanotubes & application

Content:
- **Nanostructures:** carbon nanotubes properties
- **Research / application:** crime sensors, foam, computer memory

Techniques: Rhetorical question, model, analogies, gesturing, graphics (diagrams), review, comparisons

(~3.5 min)

POINT 2: Nanomachine

Content:
- **Nanomachine manipulation/control:** nanocar
- **Self-assembly / high rate**
  - o **Research/application:** self assembly of gold wires
- **Review**

Techniques: Gesturing, imagine, visual reference, demonstrations, diagram, QRT, negative contrasts

(~5.5 min)

POINT 3: Why is nanotechnology important?

Content:
- **Future:** environment, space elevator, medicine nanobot vs. quantum dots
- **Consumer products:** socks
- **Safety**

Follow up: Website

Techniques: Rhetorical question, gesturing, review, QRT

SILLY PUTTY BODY ARMOR

PRESENTATION'S MAIN MESSAGES

- Describe how new materials are being developed through nanoscale science research
- Convey that nanotechnology is a big field of research with a variety of potential significant applications
- Convey that nanoscale science is at a scale smaller than you've imagined
  (Note: The diagram below does not list the graphics in the presentation due to the style of videography)

Start — End (16.5 min)

INTRODUCTION

Content:
- **Overview:** military and sports applications
- **History of silly putty**
- **Core scientific principles** (atoms/molecules & arrangement, properties)
- **Demos:** silly putty, corn starch

Techniques: Poll, analogy / metaphor, QRT with one audience member, gesturing

(~5.5 min)

POINT 1: Review of principles behind solids & liquid

Content:
- **Core scientific principles** (solids & liquids)
- **Review**
- **Sheer thickening liquids**

Techniques: Poll, vocabulary, demo, gesture, review

(~2.5 min)

POINT 2: How is this useful for body armor?

Content:
- **Research / application:** military/fabrics
- **Nanoparticles**
- **Nano definition** (zoom)
- **How it works in silicon**
- **How it works with silly putty**
  - o review with scientific vocabulary

Techniques: QRT with one audience member, analogy, gesturing, rhetorical questions, metaphor, demo

(~5 min)

POINT 3: Scope of Nanotechnology

Content:
- **Consumer products** (sports foam)
- **Magnet thickening**
- **Nanotechnology field scope**

Follow up: questions & sample

Techniques: Consumer props, personal, visual reference, negative

(~3 min)

SMALL SCIENCE

PRESENTATION'S MAIN MESSAGES

- Express that nanotechnology is science at the scale of atoms and molecules
- Convey that there are reasons why small scale science leads to different capabilities than we've had before
- Highlight the range of nanotechnology applications
- Raise questions about the safety of nanotechnology

Start — End (21 min)

INTRODUCTION

Content:
- **Opening:** it's happening
- **Consumer products use nano**
- **Many people don't know what nano is**
- **Review**
- **Definition of nano** (zoom)

Techniques: Poll (consumer product props), video (man on the street), graphics (cartoon, real world, microscopic image), analogy, gesture, vocabulary, rhetorical question, review

(~6.5 min)

POINT 1: Why does doing science at this small scale matter?

Content:
- **Core scientific concept:** surface area/volume ratio
- **Research / Application:** health, military fabrics

Techniques: Rhetorical question, QRT, prop, gestures, Magician's Assistant & demo, gestures, text, graphics (cartoon)

(~4.5 min)

POINT 2: How is this useful to nanotechnology?

Content:
- **Bottom up manufacturing**
- **Application:** nanocar, computer memory, medical tubes
- **Nano-structure**: buckyball, carbon nanotubes

Techniques: Review, graphics (microscopic, diagrams, animation, real life), model, vocabulary, gesturing, analogies, scope, review, text, visual reference, rhetorical question

(~6 min)

POINT 3: Future

Content:
- **Future applications:** space elevator
- **Consumer products today using nano**
- **Review poll:** everything made of atoms & molecules
- **Safety**

Follow up: website

Techniques: Model, graphics (microscopic, cartoons), personal, consumer product props, non-examples

(~3.5 min)

WHAT IS NANOTECHNOLOGY?

PRESENTATION'S MAIN MESSAGES

- Describe how nanotechnology is the manipulation of matter at the fundamental scales
- Detail how nanotechnology is a science in its infancy

Start — End (~13 min)

INTRODUCTION

Content:
- **Opening:** It's in the news
- **Overview of presentation:** How is it new, what can it do, do you care?
- **Definition** (prefix)
- **Core scientific concepts:** "Everything in the world is made of atoms"

Techniques: QRT, analogy, graphics (diagram), gesturing

(~2.5 min)

POINT 1: How is it new?

Content:
- **New materials from nanotechnology**
  - o **Arrangement**
  - o **Nanostructure (Buckyball, carbon nanotube)**
- **New Techniques**
  - o **Current research/application:** scanning probe microscope, quantum corral
- **New ideas how to make & manipulate things on this scale**
  - o **Current research/application:** nanocar, cell ATP
  - o **Fine control to manipulate matter**

Techniques: Graphics (diagrams, images from real world), analogies, gesturing, visual reference, vocabulary, review, text outline

(~3.5 min)

POINT 2: What can it do?

Content:
- **Impact**
  - o **Possible research & application (water, energy, health, environment)**

Techniques: Graphics (diagrams, images from real world, microscopic), analogies, gesturing, visual references, review, negative example, vocabulary, personal

(~3 min)

POINT 3: Do you care?

Content:
- **Possible negative consequences**
  - o **Health, history examples**
- **Good or bad?**
- **Envision future technologies & consequences**

Follow up: website

Techniques: Graphics (images from real world, cartoon), analogies, rhetorical question, review, imagine, personal, review, QRT

(~4 min)