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Summative Evaluation of NISE Network's Public Forum: *Nanotechnology in Health Care*

for
Nanoscale Informal Science Education Network
by
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EXECUTIVE SUMMARY
SUMMATIVE EVALUATION OF NISE NETWORK'S *NANOTECHNOLOGY IN HEALTH CARE* FORUM

Over the previous three years, the Nanoscale Informal Science Education Network has experimented with forum models designed to provide attendees with an opportunity to learn about and discuss the implications of nanotechnology on their lives, society and the environment. For this summative evaluation, the forum, *Nanotechnology in Health Care*, was implemented at three NISE Net museums and evaluated with a pre-post one-group design.

- The forum experience enhanced attendees' understanding of nanotechnology, resulting in a significant and desirable increase in the knowledge that nanotechnology operates on a submicroscopic or smaller scale and a significant decrease in defining nanotechnology as microscopic or larger. The proportion of attendees who noted that nanotechnology properties are dependent upon size or scale also increased significantly from before the forum to after. Adults felt significantly more informed about nanotechnology after attending the forum. The forum model was most effective in positively influencing understanding of nanotechnology in audiences for whom science is not typically a strong interest.

- Attending the forum enhanced understanding of nanotechnology's potential impact. About two-thirds of attendees felt that both benefits and risks of nanotechnology were among the most important ideas to communicate to their family and friends about the impact of nanotechnology on their lives. Prior to the forum, half of the participants felt it was important to communicate about benefits, whereas only about one-tenth thought it important to talk about risks. After the forum, participants deemed it just as important to share the risks associated with applications of nanoscience as the benefits.

- The forum significantly increased awareness of both risks and benefits of nanotechnology in personal care products and medicine. The forum experience also significantly raised assessments of both the risk and benefit levels of nanotechnology for U.S. society as a whole. Respondents rated nanotechnology as significantly more beneficial than risky both before and after the forum.

- Attendees agreed that the forum discussions effectively considered both risks and benefits of nanotechnology. They felt the forum increased their familiarity with diverse viewpoints. They enjoyed being exposed to viewpoints different from their own, adding their own views to the dialogue.

- The forum significantly increased attendees' confidence in expressing their viewpoints about nanotechnology and in supporting their viewpoints about risks and benefits. The forum also increased attendees' assessment of the importance of citizen discussion of nanotechnology.

- Two weeks after the forum, attendees described one of the most valuable aspects as learning factual information about nanotechnology and its potential, thereby reflecting their "very valuable" ratings of the forums' opening two expert presentations. Attendees also wrote that hearing other's diverse viewpoints about nanotechnology's ethical and societal implications was one of the most valuable aspects of the forum. They rated as "very" valuable the forum's various discussion and dialogue components. Yet one-quarter of respondents wrote of disappointments with the small group component and rated the overall small group dynamics as "not particularly" or "slightly" valuable to them. These respondents attended forums that did not use table facilitators. The Q&A period, the two scenarios, and the overarching small group discussion question were rated as "moderately" valuable components in the forum model.

- About three-quarters of those reporting on their behavior two weeks after the forum were motivated by their experience to pay more attention to reports of nanotechnology in the media and to discuss with others the benefits of nanotechnology. Two-thirds of those responding to the follow-up survey noted that after the forum they explained nanotechnology to others and discussed risks. About half of this group searched out more information about nanotechnology generally, and three-tenths of the group searched out information about the specific forum topics of personal care products and medicine. A small portion of respondents had looked at nano-related product labeling or purchased nano-related products since the forum.

The *Nanotechnology in Health Care* forum model is successful in positively influencing attendees' definition of nanotechnology; their awareness, assessment, and understanding of both the benefits and risks of nanotechnology; their awareness of viewpoints different from their own; and their confidence in participating in public discourse about nanotechnology. Additionally, the forum model shows an important multiplier effect during weeks after the forum by inspiring significant proportions of attendees to discuss with others what nanotechnology is and the associated benefits and risks.

INTRODUCTION

NISE Network

Funded by the National Science Foundation, the Nanoscale Informal Science Education Network (NISE Net) is a national infrastructure of science museums and university-based nanoscience research centers. NISE Net includes three core partners (Museum of Science, Exploratorium, Science Museum of Minnesota) and numerous sub-awardees.[1] Over a period of five years (2005-2010), NISE Net partners will collaborate to foster public awareness, engagement, and understanding of nanoscale science, engineering, and technology through a wide variety of public deliverables including forums, programs, activities, exhibits, and a website.

Public Forums

The decision to engage the public via museum-based forums arose out of a growing international practice to involve citizens in discussion, dialogue, and deliberation about societal implications of science, engineering, and technology.[2] Over the initial three years of the NISE Net project, five museums across the nation have collaborated to research, design, implement and evaluate various models for public forums.[3] In the NISE Net model, public forums offer "citizens the opportunity to engage in thoughtful conversations about important public issues and their potential societal, environmental and ethical implications. They provide a vehicle for people of diverse views and backgrounds to deliberate on difficult issues and to seek a better understanding of the problem."[4]

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[1] Subawardees include, in alphabetical order: Association of Science-Technology Centers, Cornell University, Ft. Worth Museum of Science and History, Houston Children's Museum, Inverness Research Associates, Maryland Science Center, Materials Research Society, Multimedia Research, New York Hall of Science, North Carolina Museum of Life and Science, Oregon Museum of Science and Industry, Purdue University, Sciencenter in Ithaca, University of Wisconsin – Madison. Cornell and Purdue Universities were no longer subawardees in year three when this evaluation was completed.

[2] For background on the development and formative evaluation of the NISE Net forum models, see:
Bell, L. (2008). Engaging the Public in Technology Policy: A New Role for Science Museums. *Science Communication*, *29* (3), 386-398.
Bell, L. & Livingston, T. (2008, January-February). Thoughtful decisions: The evolution of the NISE Net Forums. *Informal Learning Review,* 4-6.
Reich, C., Bell, L., Kollmann, E. K., & Chin, E. (2007). Fostering civic dialogue: A new role for science museums? *Museums & Social Issues*. *2*(2), 207-220.
Reich, C., Chin, E., & Kunz, E. (2006, July-August). Museums as forum: Engaging science center visitors in dialogue with scientists and one another. *Informal Learning Review*, 1-8.

[3] The NISE Forum Team that developed the forum model assessed in this summative evaluation includes Larry Bell and Barbara Costa (Museum of Science), Dave Chittenden, Jennifer Scott and Sabrina Sutliff-Gross (Science Museum of Minnesota), Veronica Garcia-Luis and Erin Wilson (Exploratorium), Brad Herring and Troy Livingston (North Carolina Museum of Life + Science), and Amanda Thomas and Marilyn Johnson (Oregon Museum of Science and Industry). Formative evaluators for the Forum Team include Christine Reich, Elizabeth Kollmann, Kirsten Ellenbogen, Amy Grack Nelson, and Scott Ewing.

[4] NISE Network. (2007). Nano public forums manual. www.nisenet.org. p. 5.

The overall goals of NISE Net's public forums are to engage adults and older youth in dialogue and deliberation about societal implications of nanoscale science, engineering and technology and to build capacity in the science museum community to engage the public in this kind of programming. More specific intended goals for the public participants include:

- Enhancing participants' understanding of nanoscale science, technology and engineering and its potential impact on the participants' lives, society, and the environment;
- Engaging participants in discussions and dialogues where they consider the positive and negative impacts of existing or potential nano-related technologies;
- Strengthening the public's acceptance of, and familiarity with, diverse points of view related to nanoscale science, technology and engineering;
- Increasing the participants' confidence in participating in public discourse about nanotechnologies and/or the value they find in engaging in such activities; and
- Attracting and engaging adult audiences in in-depth learning experiences.

All of NISE Net's public forums focus on the above goals via in-depth learning experiences ranging from two to three hours. Each forum model addresses the goals in slightly different ways but they all have common components: (1) presentations of background information about nanotechnology and societal implications (through live speakers, video, or theater) to help frame the subsequent public discussion; (2) posing of stimulus questions or scenarios to elicit diverse views on the impact of nanoscale science and technology on society and the environment; and (3) sharing of participants' views via small and large group discussions.

The Forum Team has developed forums in three content areas: *Nanotechnology: Risks, Benefits, and Who Decides?*; *Energy Challenges, Nanotech Solutions?*; *Nanotechnology in Health Care: Possibilities, Risks and Benefits*. Up to the point of this summative evaluation, formative evaluation focused on 23 forums in these content areas held by the five NISE Net museums on the Forum Team. The formative evaluation process continues to help guide further modifications. This summative evaluation assessed the impact of the forum about health care at three museums that were implemented in the late Spring of 2008.

Public Forum: *Nanotechnology in Health Care*

The public forum, *Nanotechnology in Health Care*, deals with the societal, ethical and environmental implications of nanoscience, nanotechnology, and nanoengineering in topical personal care products and in medical diagnosis and treatment. In the first hour of this forum model, two speakers provide background information. The first speaker introduces the basics of nanoscale science, and the second speaker presents on societal, ethical and environmental implications. Following an open question and answer period, participants meet in small groups during a second hour to discuss two scenarios and an overarching question:[5]

[5] The scenarios and overarching question documents used in the summative evaluation are available in Appendices A-C. The final versions of these forum documents are available on www.nisenet.org

- Scenario A: Nanotechnology in Topical Personal Care Products: This discussion period deals with long-term impacts of nano-sized particles on the body and environment; regulation and public disclosure; and consequences of not pursuing nanotechnology in sunscreens.
- Scenario B: Nanotechnology in Diagnosis and Treatment in the Body: This discussion period focuses on long-term impacts of nanoparticles on the body; equitable availability of technologies; and consequences of not pursuing or delaying these technologies.
- Overarching Question: After considering the specific scenarios, the small groups craft their positions on a more general question: "Under what conditions should nanotechnology applications in personal care and medicine be made available to the public?"

In closing, the small groups report on their discussions to the larger group.

METHOD

Study Design

The summative evaluation is a one-group pretest-posttest design, looking at the impact of the *Nanotechnology in Health Care* Forum model implemented at three NISE Net museums (Exploratorium, Oregon Museum of Science and Industry, and Science Museum of Minnesota). The one-group design was implemented because obtaining an equivalent control group was not logistically feasible. At each of three forum events, a pre-survey, immediate post-survey, and two-week follow-up online survey gathered information on seven research questions, which correlate with the forum goals for public audiences:

1. Did the forum experience enhance participants' understanding of nanotechnology?

2. Did the forum experience enhance participants' understanding of nanotechnology's potential impact on the participants' lives?

3. Did the forum influence participants' awareness of and assessment of nanotechnology's risks and benefits?

4. Did participants feel that the forum discussion and dialogue format effectively covered both risks and benefits of nanotechnology and exposed them to viewpoints different from their own?

5. Did the forum discussion and dialogue format increase attendees' confidence in participating in public discourse about nanotechnologies and increase their assessment of the importance of citizen discussion of nanotechnology?

6. Upon reflection of several weeks, what did participants consider most and least valuable in the forum experience?

7. Did participating in the forum encourage any activities in the subsequent weeks?

Procedure

Each museum recruited attendees for their respective forum event in a variety of ways, including: emails to members, volunteers, educators, Science Pub attendees, previous forum registrants and science and nano-related listserves; letters inviting staff at local hospitals and cancer clinics; postings on Craigslist and other web sites, museum and PBS station calendars, and Facebook; fliers and monitor announcements at the museum information desk and box office.

Prior to and immediately after the forum, attendees completed written questions on their awareness and knowledge of nanotechnology; risk and benefit assessments of nanotechnology; and feelings about forum discussion and dialogue.

In the post-forum questionnaire, attendees were asked to volunteer their email addresses to be invited two weeks after the forum to respond to an online survey. The delayed survey asked about perceived value of the forum experience and actions taken after the forum.

Sample

During the twelve months prior to this evaluation, the three museums held nine *Nanotechnology in Health Care* forums obtaining an average attendance of 26 people; thus, the expectation for attendance at the three evaluated forums was around 78 people. Whereas 78 people registered for the three forums, 45 people actually attended.

Not all participants' data qualify for the evaluation analysis: two participants were minors, and eleven adults did not fully complete both surveys due to late arrivals or early departures. Thus, 32 respondents provided matching pre-post surveys for the summative evaluation of the forum model.

The characteristics for the sample are given in Table 1 on the next page. The sample has slightly more men than women and an age distribution from 19 to 80 years, with a mean and median age of 42. Minorities comprise one-quarter (26%) of the sample. More than half (56%) of the sample has higher than a college degree, and half report a profession in either science or medicine.

Prior to participating in the forums, the sample of attendees felt better informed about nanotechnology than random samples from three national survey studies: 57% of forum attendees reported having heard "a lot" or "some" about "nanotechnology" compared with national sample results of 27%[6], 20%[7], and 19%[8]. The forum sample was interested enough to

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[6] Peter D. Hart Research Associates, Inc. (2007 Sept.). Awareness of and attitudes toward nanotechnology and federal regulatory agencies. Available at Project on Emerging Technologies at www.wilsoncenter.org. In August, 2007, Hart Research Associates conducted a representative national telephone survey of 1014 adults.

[7] National Science Board (2008 Jan.). Science and Technology: Public Attitudes and Understanding. Chapter 7 in Science and Engineering Indicators 2008. Available at National Science Foundation at www.nsf.gov/statistics/seind08/. In 2006, the University of Chicago National Opinion Research Center interviewed face-to-face a representative national sample of 1854 adults.

attend a forum on nanotechnology and thus could be expected to feel better informed than the average citizen.

In the forum sample, awareness of nanotechnology was not related to the classification variables of age, education or profession but was significantly associated with gender.[9] Those who had heard "a lot/some" were significantly more likely to be men (74%) than women (31%).

Table 1. Demographic and Background Characteristics of Forum Attendees Who Completed Pre & Post Surveys (N = 32)

Classification Variables		**% of N = 32**
Gender	Male	59%
	Female	41%
Age	Range: 19-80 years Mean = 41.9 years Median = 42 years	
Race/Ethnicity	White, not of Hispanic origin	74%
	Asian-American/Asian	23%
	Hispanic/Latino	3%
Highest level of education	High school graduate or less	3%
	Some college or technical	13%
	College graduate	28%
	Courses or degrees beyond college	56%
Profession in either science or medicine	Yes	50%
	No	50%
Awareness of Nanotechnology	Heard a lot	13%
	Heard some	44%
	Heard a little	41%
	Heard nothing at all	3%
	Not sure	0%

Of the 32 forum attendees described in Table 1, 23 (72%) provided their email address to be contacted for a two-week delayed follow-up survey. Of the follow-up sample, 17 (74%) completed the survey. Those completing this survey received a $10 gift card from amazon.com. The demographics and background characteristics of this sub-group were not statistically significantly different from the other forum attendees.

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[8] Kahan, D. M., Slovic, P., Braman, D., Gastil, J., & Cohen, G. (2007 March). Nanotechnology risk perceptions: The influence of affect and values. Available at Cultural Cognition Project at Yale Law School at http://research.yale.edu/culturalcognition/. In December, 2006, Knowledge Networks conducted a nationally representative online survey of 1500 adults.

[9] Fisher Exact Test is used with small samples to test whether two groups differ in the proportion with which they fall into two classifications. χ^2 (1, N=32) = 5.776, Fisher Exact test = 0.0292

Data Analysis

Pre-post comparisons were made with non-parametric statistics[10] (Fisher exact test, paired Wilcoxon signed-ranks test, Mann Whitney U test). Qualitative responses were analyzed deductively drawing on forum goals and inductively by looking at the responses themselves for keywords and key phrases. The two researchers independently coded open-ended responses with a third researcher reviewing the few disagreements. Relationships between dependent variables and classification variables were explored including gender (male, female); age (younger and older below and above the median age); education (college or less, beyond college); profession (science/medicine, other); and awareness of nanotechnology prior to attending the forum (a lot/some, a little/none). Ethnicity is not analyzed because the minority group is not large enough. In reporting results, statistical significance is reported in footnotes if *p* values are less than .05. All tables present rounded percentages so totals may rise above 100%.

FORUM IMPLEMENTATION

Each museum site was faithful to the forum model outlined in the forum manual. Few differences were observed across the three sites. All three forums were held at the museum sites hosting the events during weekday evening hours. The forums involved a short introduction, two speaker presentations, Q&A, a small group discussion about two different nanotechnology scenarios, a report-out/larger group discussion and wrap-up.

Minor differences were observed in the duration and delivery of each activity, but the basic order of events and type of content covered were consistent across sites. The most obvious difference among sites was in the implementation of the small group discussion. Where one museum had staff members serve as table facilitators, two groups did not include this component. The level of participation among some attendees at the latter sites appeared to decrease as the discussions progressed, although the more vocal group members did make an effort to include these attendees in the discussion.

In March and May 2008, *Nanotechnology in Health Care* forums were held at the Exploratorium, Oregon Museum of Science and Industry, and Science Museum of Minnesota. All three forums occurred on a weeknight between the hours of 7pm – 9:15 pm, generally following the 2 – 2.5 hour time estimate proposed in the forum manual. Upon arriving at the museum, attendees were greeted by the event moderator and other staff members and directed to

[10] Non-parametric statistics are used when the assumptions of parametric tests may not be met and when data are in ordinal or nominal scales. In this report, footnotes present a definition of a statistic when first used in the report and also present the significant results.

the forum room. Two forums were held in an informal classroom type setting, and the third forum occupied a larger room more typically used for presentations. The physical set-up for the forums was similar across sites, consisting of several round tables clustered near the speakers' podium.

Participants typically entered the forum room 5-30 minutes before the forum started and chose a seat at one of the tables. While waiting for the forum to begin, they completed the evaluation pre-survey, helped themselves to light refreshments and/or mingled with one another, museum staff, or the speakers. Although seating was unassigned, staff asked attendees sitting alone to join other tables to help ensure each was as full as possible for the small group discussions.

How the three sites implemented the forum and how they compared to the forum model as described in NISE Net's forum manual[11] is described below. Each site followed a common agenda: the event began with a short introduction; followed by two speaker presentations; Q & A; a small group discussion about two different nanotechnology scenarios; a report-out/larger group discussion; and wrap-up.

Introduction. The introductions at each site generally followed the process described in the forum manual: Forum moderators welcomed participants, introduced the forum topic and format, briefly described the NISE Net project and the museum's role in NISE Net, and introduced the speakers. At two sites, a small number of latecomers entered the room during the introductions. This slightly lengthened the forum manual's estimated five-minute time allotment as moderators welcomed the new attendees and quickly gave them verbal information or print materials they had missed.

Speaker presentations. Following the forum model, there were two expert speakers at each site. The first speaker gave an introduction to nanoscale science, and the second speaker addressed societal, ethical or environmental implications of nanotechnology in health care. Five of the six invited speakers came from local universities, and the sixth was a museum coordinator of adult learning. All speakers used PowerPoint presentations to help illustrate specific topics they were covering. Each sites' combined presentations ran close to one hour, somewhat longer than the forum manual's estimate of 50 minutes.

Question & answer period. Audience members asked the speakers questions both during and after their presentations, running longer than the five minutes projected by the forum manual.

Small group discussions. Following Q &A, attendees participated in a round table discussion. All sites followed the forum model, which suggests small group discussions for approximately 45 minutes, comprising 15 minutes dedicated to Scenarios A and B each, followed by 15 minutes on the overarching question.[12] The event moderators generally kept the schedule on track by announcing when it was time to move from one task to the next. At the three tables that the evaluator observed across sites (one per site), participants did not abruptly switch their focus

[11] NISE Network. (2007). Nano public forums manual. www.nisenet.org.

[12] See Appendices for Scenario A (Nanotechnology in Topical Personal Care Products), Scenario B (Nanotechnology in Diagnosis and Treatment in the Body) and Overarching Question (Under what conditions should nanotechnology applications in personal care and medicine be made available to the public?).

from one task to another, but rather completed their discussion on the topic at hand before moving on to the next assigned task.

At all three observed tables, the group discussions began with one person reading the scenario questions, followed by others offering a comment or clarifying question. These early discussions demonstrated that attendees were engaged and understood the questions they were asked to address. In all three table discussions, attendees also made reference to the formal presentations and gave consideration to both risks and benefits of nanotechnology.

One of the three sites used discussion facilitators as suggested in the forum manual. At the observed table, the facilitator implemented actions suggested in the manual by guiding the group through the agenda, keeping track of time, using active listening, encouraging participation, and keeping the group focused and on task. This site also placed printed cards on each round table that listed discussion "ground rules" and the Overarching Question. The attendees observed at all three sites initially contributed to the discussions; however, at two sites without a formal facilitator, some participated less as the discussion period progressed. At the non-facilitated sites, more vocal attendees did work to include others by asking them questions or asking them to share their perspectives. At the facilitated site, the observed facilitator was able to take actions proactively to prevent imbalances in the discussion.

The speakers also played a role in the small group discussions. Speakers at two sites immediately joined one table discussion, and then later circulated among the tables and fielded attendees' questions. At the third site, the two speakers talked between themselves during the discussion of Scenario A and then circulated among tables to answer questions during the discussion of Scenario B. Participants at the observed tables typically responded to the speakers by asking them questions about their presentation or the topic being discussed.

Group share and wrap up. The event concluded with the forum moderator asking each small group to share key points made during the discussion. At all sites, one attendee shared the group's findings by reading or summarizing written notes taken during the small group discussion period. At some tables, other attendees chimed in to elaborate or clarify points made.

Following the small group summaries, the moderator led a large group wrap-up discussion to reflect on issues raised during the forum. The speakers assisted in this final discussion by helping to answer questions. Each site approximated the forum manual's seven-minute time estimate. The primary factor ending the final discussion was the time of night and need to complete the post-forum evaluation surveys, which were administered immediately following the wrap-up.

RESULTS: UNDERSTANDING OF NANOTECHNOLOGY

The forum experience significantly increased participants' understanding that nanotechnology operates on a submicroscopic or smaller scale and that nanotechnology properties are dependent upon size or scale. Those whose professions were not in science or medicine moved toward understanding that nanotechnology is on a submicroscopic scale or smaller; and the forum experience was particularly effective at improving women's understanding that nanotechnology involves manipulation at a small scale.

Additionally, after participating in the forum, respondents agreed significantly more with the statement: *I feel informed about nanotechnology.* Prior to the forum, agreement with this statement was significantly higher in those who were more aware of nanotechnology; however, this gap disappeared in post-forum ratings.

The summative evaluation addressed whether or not the forum experience enhanced participants' understanding of nanotechnology. The survey asked respondents to define nanotechnology and to rate how informed they feel about the subject.

Definitions of Nanotechnology

Both before and after the forum event, attendees were asked: *Please define nanotechnology as best you can.* The coding scheme of the open-ended responses was devised based on a deductive analysis drawing on the talking points for forum speakers provided in the forum manual and an inductive analysis looking at the responses themselves for keywords and key phrases. The two research authors independently coded random-ordered pre and post responses over three rounds of coding, and a third researcher reviewed the few remaining disagreements.

Four categories fully describe the data set:

I. Size/Scale
II. Size/Scale-Dependent Properties
III. Manipulation or Engineering at a Small Scale
IV. Benefits or Potential Benefits

Each category was coded dichotomously according to whether or not an open-ended response included the category. A full response could be coded into more than one category, but the same text word or phrase could not be included in more than one category. For example, the following response is coded into categories I, II, and IV: *The use of materials at the nanometric scale* (I)*, taking advantage of the unique properties inherent in particles of that size* (II)*, to create new products, generate energy, diagnose and treat disease, etc.* (IV).

Each of the four categories is described below with illustrative responses:

I. Size/Scale: This category captures what the respondent knows about the size and scale of nanotechnology and includes two sub-categories.

a. Microscopic Scale or Larger: This sub-category includes references to size or scale at the microscopic scale and larger. Keywords include *small, very small, itty bitty, little, microscopic, micro level, micro scale, particles* and synonyms.

Respondent examples include:

The use of minute (very small) particles.
Technology that utilizes extremely small units of matter.
Use of small-size mechanical devices.
Nanotechnology is the development of technology involving really, really small components.
The use of extremely small materials to accomplish a variety of useful functions.

b. Submicroscopic or Smaller: This sub-category refers to size or scale at the submicroscopic, molecular, atomic or nanometer scales. Keywords include *submicroscopic, molecule, atomic level, nano scale, nano level, nanoparticles, nanometer scale, 10^{-9}, one billionth of a meter* and synonyms. Respondent examples include:

<10 to the –9m
Technology that utilizes materials on the nanometer scale.
Utilizing materials at the atomic level.
The technology of the sub micro level (but more strictly nano I guess).
Submicroscopic
Very small molecules, less than 50nm in diameter.

The forum manual suggested the following speaker talking points supporting this subcategory: "Nanotechnology has to do with very small things, smaller than you can see with an ordinary microscope. A nanometer is very small, a billionth of a meter or 10-9 (insert size comparison here: for example 80,000 nanometers = width of human hair)."

II. Size/Scale-Dependent Properties: This category includes references to size or scale-dependent properties or unique properties of nanoscale materials. A response in this category should indicate an awareness that properties or behaviors are different at the nanoscale and/or different scales. Keywords include *property, ability, reactivity, different, altered nature* and synonyms. Respondent examples include:

A technology whose nano-scale application gives it a "special oomph" or property to make it useful/different than non-nano scale.
At the atomic level – taking advantage of properties of atoms in the atomic state as opposed to conglomerates of atoms or polymers.
Nanotechnology is the application of materials at the nanometer scale that have properties not present at the micro- or macro-scale.
Nm-size particles that have different properties than larger size particles.

The forum manual suggested the following speaker talking point supporting this category: "Materials can have different characteristics at the nano scale (for example, different colors of gold particles)."

III. Manipulation or Engineering at Small Scale: This category includes responses that indicate that respondents are aware that nanotechnology involves the manipulation or engineering of small things. Typically a response will use verbiage that indicates an understanding that scientists are going beyond what is created in nature and making new macro-level things with nano-level things. Keywords include *manipulate, engineer, design, build, make, create* and synonyms. Respondent examples include:

Engineering the use of very tiny objects.

The manipulation (and other action verbs!) of matter at the atomic, or nano-scale, level.

Study of creation and manipulation of materials on a very small scale.

Building and dealing with very small objects.

This category was not addressed in the forum manual's talking points for speakers.

IV. Benefits or Potential Benefits: This category includes responses that a) state benefits exist or potentially exist; b) imply how an application is beneficial; or c) give an application of nanotechnology that on face value is beneficial. Keywords include *benefit, good, innovation, effective, efficient, practical purposes, solution, cheaper, faster, better* and synonyms. Respondent examples include:

Science that addresses problems from an itty bitty perspective to solve problems or investigate possible alternatives for solutions.

Tiny computers and other technical aids that perform tasks otherwise impossible or more difficult w/traditional technology.

Nanotechnology is the development of medicine and other products involving extremely small particles of material (one micrometer or smaller).

The study and development of processes and applications (under a very large umbrella – med.-cosmetics) at the "nano" level of materials and chemicals.

The forum manual suggested the following speaker talking point supporting this category: "Nanotechnology will enable new advances in fields such as medicine, computing and consumer products, and will likely have an effect on much of everyday life."

Table 3 presents each category and the percent of pre- and post-forum responses that were coded into those categories. All but three respondents (9%) had some definitional concept of nanotechnology coming into the forum, and two of those three could provide a definition after experiencing the forum (see bottom row in Table 3).

Table 3. Pre & Post Category Percentages in Nanotechnology Definition Responses (N =32)

Category	% in Pre Response	% in Post Response
Ia. Size/Scale: Microscopic or Larger	56%	28%
Ib. Size/Scale: Submicroscopic or Smaller	34%	69%
II. Size/Scale-Dependent Properties	9%	34%
III. Manipulation or Engineering at a Small Scale	22%	34%
IV. Benefits or Potential Benefits	22%	25%
No Answer, Don't Know	9%	3%

Prior to the forum, more than half of the sample defined nanotechnology as microscopic or larger (Ia) and one-third as submicroscopic or smaller (Ib). The forum experience led to a significant decrease in "microscopic or larger" definitions[13] and a significant increase in "submicroscopic or smaller" definitions.[14]

Prior to the forum, about one-tenth of the sample described size/scale-dependent properties (II) in their nanotechnology definition. After attending the forum, one-third of respondents described size/scale-dependent properties, a statistically significant increase.[15] There was no beyond-chance influence of the forum experience on the remaining two categories (III, IV) with respect to respondents' definition of nanotechnology.

Response categories both before and after the forum experience were independent of age, education and awareness of nanotechnology coming into the forum. However, there were significant relationships between the pre-forum responses and the variables of profession and gender:

- Defining nanotechnology as "microscopic or larger" was significantly more likely before the forum for those not in scientific or medical professions (81%) than for those working in science and medicine (31%).[16] This difference disappeared in the post-forum responses (31% of non-science/medicine professions; 25% of science/medicine professions).
- Prior to the forum, defining nanotechnology as "submicroscopic or smaller" was significantly more likely for those with a profession in science or medicine (56%) compared to those in other professions (13%).[17] This difference disappeared in post-forum responses (69% for both groups).
- Men gave significantly more pre-forum responses coded as "III. Manipulation or engineering at a small scale" than women (37% of men; 0% of women).[18] This difference disappeared in post-forum responses (32% of men; 39% of women).

[13] The McNemar change test is applicable in pre-post same-sample designs in which measurement is nominal (in this case, a response falls into a category or not). The test assesses the statistical significance of the changes between the pre and post response categories by looking at discordant pairs; that is, those people whose nanotechnology definition response includes a category prior to the forum but not after and those whose response includes a category after the forum but not prior. McNemar test with continuity correction: χ^2 (1, N=32) = 4.923, p = 0.0265

[14] McNemar test with continuity correction: χ^2 (1, N=32) = 7.692, p = 0.0055

[15] McNemar test with continuity correction: χ^2 (1, N=32) = 4.900, p = 0.0269

[16] χ^2 (1, N=32) = 8.127, Fisher Exact test = 0.0113

[17] χ^2 (1, N=32) = 6.788, Fisher Exact test = 0.0233

[18] χ^2 (1, N=32) = 6.131, Fisher Exact test = 0.0252

Feeling of Being Informed

In addition to the open-ended responses discussed above, forum attendees rated their agreement with the statement: "I feel informed about nanotechnology." As indicated in Table 4, attendees were close to "neutral" before the forum in their responses to this statement; whereas, after the forum, the ratings increased significantly toward the "agree" level.[19] In the pre-forum survey, agreement with this statement was significantly higher for those who were more aware of nanotechnology prior to the forum (median = 5) compared with those who were only a little aware of the topic (median = 2),[20] but this difference disappeared in the post-forum rating (medians = 6 for both).

Table 4. Mean and Median Ratings of Agree/Disagree Statement (N = 32)

Agree/Disagree Statement	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
	1	2	3	4	5	6	7
I feel informed about nanotechnology.	Pre Mean Rating = 3.8 Post Mean Rating= 5.3 Pre Median = 3.5 Post Median = 6.0						

[19] The matched-pairs Wilcoxon signed ranks test is the non-parametric alternative to the paired *t*-test. It is applied in pre-post same-sample designs in which measurement is ordinal (in this case, a response is one number on the scale of 1 to 7). The test looks at the direction and relative magnitude of the pre-post differences in ratings for individual respondents. Wilcoxon matched-pairs signed ranks: N = 30, z = 3.9769. $p \leq .0001$.

[20] When measurement is ordinal, the Mann Whitney U test assesses whether two independent samples represent populations that differ in central tendency or median. This is a non-parametric alternative to the two-sample *t*-test. Mann Whitney U test: z = 2, $p = 0.0228$.

RESULTS: UNDERSTANDING OF POTENTIAL IMPACT OF NANOTECHNOLOGY

After the forum, about two-thirds of attendees felt that both benefits and risks of nanotechnology were among the most important ideas to communicate to their family and friends about the potential impact of nanotechnology on their lives. The forum experience significantly increased participants' likelihood to communicate about risks but did not significantly change their likelihood to communicate about benefits, which half of the participants would already do prior to the forum.

To address whether or not the forum experience enhanced participants' understanding of the potential impact of nanotechnology, attendees were asked: *What is the most important idea to communicate to your family and friends about the potential impact of nanotechnology on their lives?* The coding scheme of the open-ended responses was drawn from the talking points for forum speakers provided in the forum manual as well as a review of themes in the responses themselves. The two research authors independently coded random-ordered pre and post responses over two rounds of coding.

Four categories fully describe the data set of what forum attendees would communicate to family and friends:

I. There are benefits
II. There are risks
III. It is important to become aware of nanotechnology
IV. Nanotechnology is a developing field

Each category was coded dichotomously according to whether or not an open-ended response included the category. A full response could be coded into more than one category, but the same text word or phrase could not be included in more than one category. For example, the following response is coded into categories I, II, and III: *that it potentially has significant benefits in the application of clinical healthcare* (I)*,but that it (like any medicine) carries considerable LT risks which we don't yet understand* (II) *so should attempt to inform themselves of any products that they use it in* (III).

Each of the four categories is described below with illustrative responses:

I. <u>There are benefits:</u> This category includes references to the benefits of nanotechnology. Keywords include *benefit, improvement, helpful, effective, potential, impact, solution, good, valuable* and synonyms. Although a respondent could note more than one benefit, their response would be counted only once in this category. Respondent examples include:

Nanotechnology is being explored in many different areas from manufacturing to health care and likely to produce many new products and applications in the future.

This is a field with enormous medical and scientific potential to resolve and develop medical challenges as well as solve some environmental issues.

That in healthcare these new technologies will enable us to have a greater understanding and design more effective interactions in healthcare setting – from patient compliance to diagnostics.

It could be used to solve pressing world problems (disease, sustainability, biofuels, food).

The forum manual suggested the following speaker talking point supporting this category: "Nanotechnology will enable new advances in fields such as medicine, computing and consumer products, and will likely have an effect on much of everyday life."

II. <u>There are risks:</u> Responses in this category include references to risks of nanotechnology. The category also includes responses that suggest that we need to control, track, label or test some aspect of nanotechnology. Keywords or phrases include *risk, side effect, unknown, safety, caution* and synonyms. Although a respondent could note more than one risk, their response would be counted only once in this category. Respondent examples include:

Unknown full/side effects.

Nanotech not reported in cosmetics.

Think twice – there is a lack of research on long term effects.

The forum manual suggested the following speaker talking point supporting this category: "Along with the new benefits of nanotechnology will come unknown risks to our health, our environment and our society."

III. <u>It is important to become aware of nanotechnology.</u> In this category, respondents tell family and friends that they should become informed about, learn about, prepare for, or watch for nanotechnology. Keywords include words like *learn, inform, prepare* and synonyms. Respondent examples include

It's happening, watch out.

It's coming their way and this will require some learning on their part.

I think it's important to encourage people to educate themselves so that they can make informed decisions about nanotechnology.

The forum manual did not address this category.

IV. <u>Nanotechnology is a developing field.</u> Responses in this category suggest that the field of nanotechnology is still in its early days. Keywords include *developing, formative, early* and synonyms. Respondent examples include

It's still a formative field.

Lots of design room down there.

It's the next industrial revolution.

The forum manual suggested the following speaker talking point supporting this category: "Nanotechnology is an emerging area of scientific research that encompasses many areas of study, including chemistry, biology, engineering, physics, and medicine."

Table 5 presents each category and the percent of pre and post-forum responses that were coded into those categories. One-quarter of the attendees did not answer this question in the pre-survey but did provide a response in the post-survey (see bottom row in Table 5).

Table 5. Pre & Post Category Percentages in Important Idea to Communicate Responses (N =32)

Category	% in Pre Response	% in Post Response
I. There are benefits	50%	63%
II. There are risks	13%	69%
III. It is important to become aware of nanotechnology	9%	19%
IV. Nanotechnology is a developing field	22%	6%
No answer, Don't know	25%	0%

Prior to the forum, only 13% of the respondents described risks (II) as an important idea that they would communicate to family or friends. After the forum, attendees were significantly more likely to communicate that "there are risks" with nanotechnology.[21] Attending the forum did not significantly influence respondents' inclination to communicate to family or friends that there are benefits to nanotechnology, that one should become aware of nanotechnology or that nanotechnology is a developing field. Proportions of response categories before and after the forum were independent of classification variables.

[21] McNemar test with continuity correction: χ^2 (1, N=32) = 16.056, p = 0.0001.

RESULTS: AWARENESS AND ASSESSMENT OF RISKS AND BENEFITS

Participating in the forum significantly increased attendees' reported awareness of both the risks and benefits of nanotechnology in personal care products and medicine. The forum experience also significantly raised participants' assessments of both the risk level and benefit level of nanotechnology for U.S. society as a whole.

The summative evaluation addressed forum attendees' awareness of nanotechnology's risks and benefits and their assessment of the risk and benefit of nanotechnology for society as a whole.

Awareness of Risks and Benefits

Before and after the forum, attendees rated their level of agreement with four statements, listed in Table 6, which related to awareness of risks and benefits of nanotechnology. As indicated in Table 6, respondents were close to "somewhat disagree" or "neutral" before the forum in their ratings of the statements; whereas, after the forum, the ratings increased significantly to "somewhat agree."[22] Attendees felt they became significantly more aware of both risks and benefits of nanotechnology in both personal care products and medicine.

Table 6. Mean and Median Ratings of Agree/Disagree Statements (N = 32)

Agree/Disagree Statements	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
	1	2	3	4	5	6	7
I am aware of risks or potential risks of nanotechnology in personal care products like lotions and cosmetics.	Pre Mean Rating = 3.2 Post Mean Rating= 5.0 Pre Median Rating = 3 Post Median Rating = 5						
I am aware of benefits or potential benefits of nanotechnology in personal care products.	Pre Mean Rating = 3.3 Post Mean Rating= 4.7 Pre Median Rating = 3 Post Median Rating = 5						
I am aware of risks or potential risks of nanotechnology in medicine.	Pre Mean Rating = 3.6 Post Mean Rating= 4.8 Pre Median Rating = 4 Post Median Rating = 5						
I am aware of benefits or potential benefits of nanotechnology in medicine.	Pre Mean Rating = 4.3 Post Mean Rating= 5.5 Pre Median Rating = 5 Post Median Rating = 5.5						

[22] Wilcoxon matched-pairs signed ranks tests: risks/personal care: N = 29, z = 3.9668. $p \leq .0001$; benefits/personal care: N = 30, z = 3.5712. $p = .0002$; risks/medicine: N = 30, z = 3.7233. $p \leq .0001$; benefits/medicine: N = 30, z = 3.1198. $p = .0009$.

In the pre-forum survey, rated awareness of medical benefits was significantly higher for those in science or medical professions (median = 5) compared with those in other professions (median = 4).[23] This difference disappeared in the post-forum rating.

Assessment of Risks and Benefits

Additionally, before and after the forum, attendees responded to two survey questions assessing risk/benefit attitude. One question asked respondents: "In general, how risky do you consider nanotechnology to be for the United States society as a whole?" Another question substituted "beneficial" for "risky." The order of the risk and benefit questions alternated on the surveys to avoid an order effect. Respondents chose one number on a scale from 1 (low risk/low benefit) to 7 (high risk/high benefit).

Table 7 shows the pre and post risk/benefit means and medians. Attendees rated nanotechnology as significantly more beneficial than risky both before[24] and after the forum.[25] Ratings moved significantly higher from before the forum to after for both risk[26] and benefit[27] attitudes.

Table 7. Mean and Median Ratings of Risk/Benefit Question (N = 32)

Risk/Benefit Attitudes	Low risk/ benefit 1	2	3	4	5	6	High risk/ benefit 7
In general, how **risky** do you consider nanotechnology to be for the United States society as a whole?	Pre Mean Rating = 3.1 Post Mean Rating= 4.1 Pre Median Rating = 3 Post Median Rating = 4						
In general, how **beneficial** do you consider nanotechnology to be for the United States society as a whole?	Pre Mean Rating = 5.7 Post Mean Rating= 6.0 Pre Median Rating = 6 Post Median Rating = 6						

The results of these two survey questions can be compared to results of the same questions in a national survey study,[28] in which the average American is relatively neutral about risk and benefit (median ratings = 4 for both risk and benefit questions). Compared to the average American, forum attendees rated nanotechnology as less risky (pre median rating = 3) and more beneficial (pre median rating = 6).

[23] Mann Whitney U test: z = 2.5951, $p = 0.0047$.

[24] Wilcoxon matched-pairs signed ranks test: N = 29, z = 3.94 57, $p \leq .0001$.

[25] Wilcoxon matched-pairs signed ranks test: N = 28, z = 3.9735, $p \leq .0001$.

[26] Wilcoxon matched-pairs signed ranks test: N = 27, z = 2.8891, $p = .0019$.

[27] Wilcoxon matched-pairs signed ranks test: N = 27, z = 2.1032, $p = .0177$.

[28] Currall, S. C., King, E. B., Lane, N., Madera, J. & Turner, S. (2006). What drives public acceptance of nanotechnology? *Nature Nanotechnology*, *1*, 153-155. In August, 2005, Zogby International conducted a representative telephone survey of 503 adults.

RESULTS: FORUM DISCUSSION AND DIALOGUE FORMAT

Participants enjoyed being exposed to viewpoints different from their own and added their own viewpoints to the group discussion. They agreed that the discussions effectively covered both risks and benefits of nanotechnology.

Responses to pre and post forum surveys show that participation in the forum significantly increased attendees' confidence in expressing their viewpoints about nanotechnology and in supporting their viewpoints about risks and benefits of nanotechnology. The forum experience also significantly influenced their familiarity with diverse viewpoints related to nanotechnology and increased attendees' assessment of the importance of citizen discussion of nanotechnology.

Those attendees with suggestions for improvement recommended more time for presentations and discussion as well as gathering a larger group of more diverse participants.

The summative evaluation asked attendees about their perceptions of the effectiveness of the discussion and dialogue format in exposing them to viewpoints different from their own and in exposing them to both benefits and risks of nanotechnology. Attendees also assessed how the format influenced their confidence in participating in public discourse and their rating of the importance of that participation.

Perceived Effectiveness of Forum Format

After the forum, participants were asked to agree or disagree with five statements, listed in Table 8, describing the effectiveness of the forum format. Respondents "agreed" that they were exposed to viewpoints different from their own, that they enjoyed being exposed to different viewpoints, and that they added their own viewpoints to the group discussion. Participants also "agreed" that the discussions effectively considered both risks and benefits of nanotechnology. Agreement with these statements was independent of the classification variables.

Table 8. Mean and Median Ratings of Agree/Disagree Statements (N = 32)

Agree/Disagree Statements	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
	1	2	3	4	5	6	7
I enjoyed being exposed to different viewpoints.	Post Mean Rating= 6.3 Post Median Rating= 6.0						
I added my own viewpoints to the group discussion.	Post Mean and Median Rating= 6.0						
I was exposed to viewpoints different from my own.	Post Mean Rating= 5.7 Post Median Rating= 6.0						
Our discussions effectively considered risks or potential risks of nanotechnology.	Post Mean Rating= 6.2 Post Median Rating= 6.0						
Our discussions effectively considered benefits or potential benefits of nanotechnology.	Post Mean and Median Rating= 6.0						

Perceived Impact of Forum Format

Before and after the forum, participants rated their agreement with four statements related to the discussion and dialogue format of the forum, as indicated in Table 9. After their forum experience, participants felt significantly more comfortable expressing their viewpoints about nanotechnology in a group discussion[29] and more assured that they could support their viewpoints in a conversation about risks and benefits of nanotechnology.[30] Attendees also felt that the forum significantly increased their familiarity with diverse points of view related to nanotechnology[31] and increased their feeling that it is important for citizens to discuss risks and benefits of nanotechnology.[32]

In the pre-forum survey, familiarity with diverse viewpoints related to nanotechnology was significantly higher for those more aware of nanotechnology prior to the forum (median = 5) compared with those less aware (median = 2).[33] This difference disappeared in the post-forum ratings.

Table 9. Mean and Median Ratings of Agree/Disagree Statements (N = 32)

Agree/Disagree Statements	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
	1	2	3	4	5	6	7
I feel comfortable expressing my viewpoints about nanotechnology in a group discussion.	Pre Mean Rating = 5.0 Post Mean Rating= 5.7 Pre Median Rating = 5 Post Median Rating = 6						
I can support my viewpoints in a conversation about risks and benefits of nanotechnology.	Pre Mean Rating = 3.9 Post Mean Rating= 5.6 Pre Median Rating = 4 Post Median Rating = 6						
I am familiar with diverse points of view related to nanotechnology.	Pre Mean Rating = 3.6 Post Mean Rating= 5.3 Pre Median Rating = 3.5 Post Median Rating = 5						
It is important that citizens discuss risks and benefits of nanotechnology with one another.	Pre Mean Rating = 5.5 Post Mean Rating= 6.2 Pre Median Rating = 6 Post Median Rating = 6.5						

Comments on Small Group Discussion

When asked to comment further on their experience with the small group discussion, half of the sample responded. Verbatim answers follow:

Good
I quite enjoyed it.
Nanoriffic.
Extremely interesting

[29] Wilcoxon matched-pairs signed ranks test: N = 29, z = 2.5249, $p = .0058$.
[30] Wilcoxon matched-pairs signed ranks test: N = 29, z = 3.8829, $p \leq .0001$.
[31] Wilcoxon matched-pairs signed ranks test: N = 30, z = 3.9861, $p \leq .0001$.
[32] Wilcoxon matched-pairs signed ranks test: N = 30, z = 3.0711, $p = .0011$.
[33] Mann Whitney U test: z = 1.8257, $p = 0.0339$.

Thought provoking.
It was very pleasant and informative. Very good for solidifying the information.
It was supremely empowering to be with a group of engaged strangers, who had as much to teach as the presenters did. This is civic dialogue at its best. I felt totally renewed mentally. Thank you for hosting it!
It was great to have educated and open discussions with people of above average intelligence.
Excellent ideas floating around, but limited to regulating risks - ways to encourage breakthrough ideas should be discussed further.
I enjoyed the small group discussion but found that as a group we represented a similar viewpoint.
Because we were pretty much in agreement, we may not have hashed through issues as much as we could, but it was very interesting.
Good to share and hear views from other perspectives.
Hard to contribute without background.
I feel like I need to be more informed on the topic to feel comfortable discussing.
It went too fast for me to participate because the others were assertive, and highly educated.
The time to consider was really too short.

Of the 32 forum attendees, 40% offered suggestions to improve the forum experience for future participants. The verbatim responses below suggest more time for presentations and discussion as well as a larger group of more diverse participants:

It was excellent - just more time for presenters to get through their talks - I came to be more deeply educated and feel that the presenters had to rush through some.
(2 respondents) Longer time for presenters
Presentations to be longer - especially on the risk evaluation
I wish the second talk was longer (he had to whiz through his graphics and they were cool).
More time for discussions and presentations. Perhaps some specifically informed member of the presentation team at each discussion table for a more directed discussion.
Sub-topic presentations/discussions about specific research in nano technology.
Allow more time for discussion.
I thought the forum would have been more helpful both to me and to the forum organizers if there were a way to attract a more diverse and representative sample of the population. Also, I would have enjoyed a bit more time for Q&A, and I think some of the questions might have helped the forum organizers gather more information based on the questions asked.
Perhaps if the forum were more widely advertised a wider group would be represented.
Great ideas. Too bad there wasn't a larger group.
Great forum - hopefully more of the public attends.
The scenarios don't really set up enough risk vs. benefit issues to provoke a really hard discussion. Perhaps try to beef them up to generate a more difficult evaluation of cost vs. benefit.
Shorter

RESULTS: VALUE OF FORUM EXPERIENCE

Half of the forum sample responded to a survey two weeks after attending their forum. They described one of the most valuable aspects of the forum experience as learning factual information about nanotechnology and its potential. Reinforcing this qualitative observation are respondents' quantitative ratings of the forums' opening two expert presentations as "very" valuable.

Attendees also wrote that hearing other's diverse viewpoints about nanotechnology's ethical and societal implications was most valuable. They rated as "very" valuable the forum's various discussion and dialogue components (i.e., overall small group discussion and big group sharing). However, one-quarter of respondents wrote of disappointments with the small group component and rated the overall small group dynamics as "not particularly" or "slightly" valuable to them.

The Q&A period, the two scenarios, and the overarching small group discussion question were rated as "moderately" valuable components in the forum model.

Two weeks following a forum, 17 of the 23 attendees who volunteered their email addresses completed a follow-up online survey. Respondents were asked to reflect back on their experience at the forum and describe what was most valuable and least valuable for them.

Most valuable to forum attendees was learning factual information about nanotechnology and its potential as well as hearing the diverse viewpoints that others have about its ethical and societal implications. Verbatim responses appear below:

I gained the most from the talks by the two doctors.
Listening to both Dr's lectures.
The presentations by the two researchers.
The lectures before the discussion were most helpful since I knew very little about nanotechnology. It gave me enough information to feel like I could join the discussion.
Learning additional facts and concerns about nanotechnology.
It was a good way for me to get a bit of an idea about the forms of nanotechnology and the different mind sets that people have regarding it. I have always been interested in the subject but have never had the opportunity to really have any in-depth information on it.
I most appreciated becoming better informed about the wide variety of uses of nanotechnology, and also getting a better sense of where we are (or aren't) with making the theoretical become reality.
The exciting possibilities for curing or eliminating Cancer!
I have heard about nano here and there, but I was not sure how much information is available. The Forum gave me a chance to learn about the overall picture of how much is known about nanotechnology. Also, I am glad to have the opportunity to connect with people who are interested in educating the public about nanotech. I think the forum was an excellent activity and would be very interested in future events like it.
Getting a general feel for nanotech, learning that it couldn't solve cholesterol deposits, being around this intelligent, articulate crowd.
Learning facts about Nanotechnology and also seeing what sort of potential emotions/points of view might arise from the technology.
The conversations with other intelligent people after learning about some of the uses and cautions to have with nanotechnology.

The interaction with different members of industry, academia and doctors who were at the forum was invaluable in terms of the diverse perspectives that will soon be responsible for regulating the technology that drives the next industrial revolution, i.e. nanotechnology.

I loved the group discussion experience. It's hard to get focused intellectual engagement and learning outside of school. So I'm most grateful for the format and the discussions generated. I'm also grateful for the opportunity to clarify my understanding / relationship to nanotechnology, in terms of hopes, ethics, and everyday applications.

I am in industry, so hearing a layperson's perception of risks and benefits of nanotechnology is very interesting and helpful.

Looking at the human dimension of nano.

There needs to be a balance between scientific progress and ethical concerns and how it would change our view on how we treat people and our environment.

The few responses that described least valuable aspects of the forum focused mainly on the small group dynamics. These respondents attended the two museum forums that did not use table facilitators.

The conversation with my group was not particularly informative or helpful.

The small group conversation was not well balanced - there were a few who said more than others.

Our group would get off topic and a few members would be talking about something else and it would take us a multiple minutes to get back on track.

Some of the questions posed for group discussion required information to answer that we did not have based on the presentations, although some people in our group had other background to help the discussion.

Current applications, because they are currently unappealing and not innovative or promising, in terms of impact.

I felt that it was just a bit rushed. I felt that I and the speakers did not really have enough time to really get a good feel for the subject.

Follow-up survey respondents also rated on a 1 to 7 scale the value of each of the various forum components, as listed in Table 10. Looking at the central tendencies indicated by median ratings in Table 10, components rated as "very valuable" were the two expert presentations, the small group discussions, and sharing of discussion conclusions in the big group. However, note in Table 10 that the component "discussions in small groups overall" has a skewed distribution in which 24% of the sample rated this component as "not particularly" or "slightly" valuable. These attendees observed in their open-ended responses given on the previous page that their small group discussions were not informative or balanced. Components rated as "moderately valuable" were the Q&A period, the two scenarios, and the discussion of the overarching question.

Table 10. Mean and Median Ratings of Value of Forum Components (n = 17)

Forum Components	**Not at all valuable**	**Not particularly valuable**	**Slightly valuable**	**Somewhat valuable**	**Moderately valuable**	**Very valuable**	**Extremely valuable**
	1	2	3	4	5	6	7
First expert presentation (n = 16; one attendee reported missing or not recalling this)	Mean Rating= 5.8 Median Rating= 6 0%	0%	0%	12%	18%	47%	24%
Second expert presentation	Mean Rating= 5.8 Median Rating= 6 0%	0%	6%	13%	0%	63%	19%
Question and answer period	Mean Rating= 5.2 Median Rating= 5 0%	0%	0%	24%	41%	29%	6%
Discussions in small groups overall	Mean Rating= 5.1 Median Rating= 6 0%	12%	12%	12%	12%	29%	24%
Discussion Scenario A: Nanotechnology in Topical Personal Care Products	Mean Rating= 4.8 Median Rating= 5 0%	6%	6%	35%	24%	18%	12%
Discussion Scenario B: Nanotechnology in Diagnosis and Treatment in the Body (n = 16; one attendee reported missing or not recalling this)	Mean Rating= 5.2 Median Rating= 5.5 0%	6%	0%	25%	19%	38%	13%
Discussion of overarching question: "Under what conditions…" (n = 15; two reported missing or not recalling this)	Mean Rating= 5.1 Median Rating= 5 0%	0%	13%	20%	33%	13%	20%
Sharing of discussion conclusions in big group	Mean Rating= 5.2 Median Rating= 6 0%	0%	6%	29%	12%	41%	12%

RESULTS: SUBSEQUENT ACTIVITIES

A majority of respondents surveyed online two weeks after the forum were motivated by their forum experience to pay more attention to reports of nanotechnology in the media, to explain nanotechnology to others and discuss the benefits and risks. Slightly more than half of respondents searched out more information about nanotechnology generally, 29% of respondents searched out information about the specific forum topics of personal care products and medicine. Post-forum activities concerning nano-related products were reported by a small portion of the respondents.

The 17 forum attendees who completed the follow-up survey were asked what activities, if any, they have engaged in as a result of participating in the forum. Subsequent activities included discussion with others, topic research, purchase of nano-related domain names, attendance at nano meetings, and a search for other forums to attend, as indicated in the verbatim quotes below:

Discussed the forum material with others.

Only discussions on casual conversations w/colleagues or friends.

Discussed with my colleagues about the possibility of including nanotechnology as part of our high school science outreach curriculum.

Talked to my family about nanotechnology.

I have done a bit of personal research on the subject since. Before the forum, I was really just interested in the more sci-fi elements of the subject. however I have since become interested in the practical applications. This has, as I have said, caused me to research the subject more on my own. As for the use of nano in cosmetics and other products, I have not been overly interested, however the use of nano in medicine has become a subject of some considerable interest to me since the forum,

I am looking at sunscreen and other product labels for nano ingredients.

I bought domain names with "nano" or "nanotechnology" in them so that I can hopefully make money off the nano revolution. I am really hoping someone will want to buy my domain name from me in a couple years. What can I say? I don't get to work with nano stuff but perhaps I can still benefit from it monetarily.

I attended the IPRIME seminar at the University of Minnesota on Nanocomposite materials, and I am leaving tomorrow for the Nanotech 2008 conference in Boston.

I'm really digging the forum format, and would love to find other topics (not necessarily nano) that let us examine issues in similar ways.

Looking for other similar forums to attend. I now think twice before using sunscreen, though I still use it.

Given a list of specific follow-up activities as presented in Table 11, about three-quarters of the respondents reported paying more attention to references to nanotechnology in media and discussing with others the benefits of nanotechnology. Two-thirds of the group had explained to others what nanotechnology is and discussed the risks of nanotechnology. Slightly more than half reported that they searched for more information about nanotechnology generally, whereas 29% searched for more nanotechnology information in the areas covered by the forum: personal care products and medicine. Only 12% said they had looked at nano-related product labeling or purchased nano-related products in the weeks following the forum.

Table 11. Activities Experienced After Forum Attendance (n = 17)

Activities	**% experienced**
Paid more attention to references to nanotechnology in print, TV or radio	76%
Discussed with others the benefits of nanotechnology	71%
Explained what nanotechnology is to others	65%
Discussed with others the risks of nanotechnology	65%
Searched for more information about nanotechnology generally	53%
Searched for more information about nanotechnology in personal care products	29%
Searched for more information about nanotechnology in medicine	29%
Looked at nano-related product labeling	12%
Purchased nano-related products	12%

DISCUSSION

Over the previous three years, the Nanoscale Informal Science Education Network has experimented with forum models designed to provide attendees with an opportunity to learn about and discuss the implications of nanotechnology on their lives, society and the environment. For this summative evaluation, the forum, *Nanotechnology in Health Care*, was implemented at three NISE Net museums and evaluated with a pre-post one-group design to address the following seven research questions.

1. *Did the forum experience enhance participants' understanding of nanotechnology?*

Adults felt significantly more informed about nanotechnology after attending the *Nanotechnology in Health Care* forum. Attending the forum enhanced participants' understanding of the nanoscale, yielding a significant and desirable increase in the knowledge that nanotechnology operates on a submicroscopic or smaller scale and a significant decrease in defining nanotechnology as microscopic or larger. The proportion of attendees who noted that nanotechnology properties are dependent upon size or scale also increased significantly from before the forum to after.

Attending the forum affected some subgroups more than others in terms of their definition of nanotechnology. The forum model was effective in positively influencing understanding of nanotechnology in audiences for whom science is not typically a strong interest. Those whose professions were not in science or medicine moved toward understanding that nanotechnology is on a submicroscopic scale or smaller. Significantly more women than men showed an increase in their definition of nanotechnology as involving manipulation at a small scale.

2. *Did the forum experience enhance participants' understanding of nanotechnology's potential impact on the participants' lives?*

After listening to expert speakers and discussing the impact of nanotechnology with their peers, about two-thirds of attendees felt that both benefits and risks of nanotechnology were among the most important ideas to communicate to their family and friends about the potential impact of nanotechnology on their lives. The forum experience significantly increased participants' likelihood of communicating about risks but not about benefits. Prior to the forum, half of the participants felt it was important to communicate nanotechnology benefits to their family and friends whereas only about one-tenth thought it important to talk about risks. After the forum, participants deemed it just as important to share the risks associated with applications of nanoscience as the benefits.

3. *Did the forum influence participants' awareness of and assessment of nanotechnology's risks and benefits?*

Participating in the forum significantly increased attendees' reported awareness of both the risks and benefits of nanotechnology in personal care products and medicine. The forum experience

also significantly raised attendees' assessments of both the risk and benefit levels of nanotechnology for U.S. society as a whole. Respondents rated nanotechnology as significantly more beneficial than risky both before and after the forum.

4. *Did participants feel that the forum discussion and dialogue format effectively covered both risks and benefits of nanotechnology and exposed them to viewpoints different from their own?*

Participants agreed that the forum discussions effectively considered both risks and benefits of nanotechnology. They further agreed that the forum exposed them to viewpoints different from their own, that they enjoyed that exposure, and that they added their own viewpoints to the group discussion. The forum experience also significantly influenced their familiarity with diverse viewpoints related to nanotechnology. Those attendees with suggestions for improvement in the format recommended more time for presentations and discussion as well as gathering a larger group of more diverse participants.

5. *Did the forum discussion and dialogue format increase attendees' confidence in participating in public discourse about nanotechnologies and increase their assessment of the importance of citizen discussion of nanotechnology?*

Participation in the forum significantly increased attendees' self-assessed confidence in expressing their viewpoints about nanotechnology and in supporting their viewpoints about risks and benefits. The forum also increased attendees' assessment of the importance of citizen discussion of the field.

6. *Upon reflection of several weeks, what did participants consider most and least valuable in the forum experience?*

Half of the forum sample answered an online survey two weeks after attending their forum. They described one of the most valuable aspects of the forum experience as learning factual information about nanotechnology and its potential. Reinforcing this qualitative observation are respondents' quantitative ratings of the forums' opening two expert presentations as "very" valuable. Attendees also wrote that hearing other's diverse viewpoints about nanotechnology's ethical and societal implications was one of the most valuable aspects of the forum. They rated as "very" valuable the forum's various discussion and dialogue components (i.e., overall small group discussion and big group sharing). However, one-quarter of respondents wrote of disappointments with the small group component and rated the overall small group dynamics as "not particularly" or "slightly" valuable to them. These respondents attended forums that did not use table facilitators. The Q&A period, the two scenarios, and the overarching small group discussion question were rated as "moderately" valuable components in the forum model.

7. *Did participating in the forum encourage any activities in the subsequent weeks?*

About three-quarters of those reporting on activities two weeks after the forum were motivated by their experience to pay more attention to reports of nanotechnology in the media and to discuss with others the benefits of nanotechnology. Two-thirds of those responding to the follow-up survey noted that after the forum they explained nanotechnology to others and

discussed risks. About half of this group searched out more information about nanotechnology generally, and three-tenths of the group searched out information about the specific forum topics of personal care products and medicine. A small portion of respondents had looked at nano-related product labeling or purchased nano-related products since the forum.

The one-group pretest-posttest design implemented in this summative evaluation is not an experimental design; thus, we need to consider extraneous variables that can jeopardize the validity of the results. Of the possible threats to validity, the one that applies to this evaluation is a testing effect. This refers to the idea that the pre-forum survey may have focused attendees on certain parts of the forum experience and/or provided motivation to listen and learn in ways that might be different from forum attendees not answering a pre-forum survey. Thus, the evaluation findings can be generalized only to forum attendees who are exposed to a similar pre-survey as part of the forum model. Acknowledging this restriction, the NISE Net's public forum model, *Nanotechnology in Health Care,* is successful in positively influencing attendees' definition of nanotechnology; their awareness, assessment, and understanding of both the benefits and risks of nanotechnology; their awareness of viewpoints different from their own; and their confidence in participating in public discourse about nanotechnology. Additionally, the forum model shows an important multiplier effect during weeks after the forum by inspiring significant proportions of attendees to discuss with others what nanotechnology is and the associated benefits and risks.

APPENDIX A: SCENARIO A

Scenario A: Nanotechnology in Topical Personal Care Products

♦ Manufacturers currently use nano-sized particles of zinc oxide in sunscreen. This formula is as effective or better than traditional zinc oxide sunscreen, and the size of the particles makes the sunscreen invisible, sparing users the white-nose effect of traditional zinc oxide. This may encourage people to be more diligent about applying sun block for protection against skin cancer.

♦ In addition to sunscreens, a wide variety of topical lotions, cosmetics, hair conditioners, anti-wrinkle creams, and similar products containing nano-sized particles to enhance their effectiveness are currently on the market.

Potential Issues and Historical/Regulatory Context

What are the long-term impacts of these nano-sized particles on the body and the environment?
Will they be absorbed into the skin and accumulate more deeply inside tissues and cells because of their small size? If so, could they cause harm to those cells or tissues? What happens when these particles are washed off into the waste stream? Unlike food and medicine, topical cosmetics are not required to gain safety approval from the FDA prior to entering the market.

What kind of public disclosure is necessary?
There are no reporting regulations for nano-based cosmetics. This means that manufacturers can make any claim regarding nano-technology in their products. Should products with nano-sized particles be labeled differently?

Historical context: Many consumers are frustrated that GM (genetically modified) foods don't require labels, denying consumers the opportunity to make informed purchasing decisions. Others point out that those who do not want GM food can purchase organic. The same would be true with sunscreens—producers of sunscreens without nano-sized particles could voluntarily label their products as non-nano.

What are the consequences of not pursuing this technology?
One in five Americans will develop skin cancer during their lifetime. The costs, both social and fiscal, of skin cancer are enormous and some people argue that sunscreen is used more when it is invisible.

APPENDIX B: SCENARIO B

Scenario B: Nanotechnology in Diagnosis and Treatment in the Body

♦ In current research there is a diagnostic technique that involves injecting nano-sized iron oxide particles into the bloodstream prior to an MRI (magnetic resonance imaging). The presence of the iron oxide nanoparticles serves to greatly enhance MRI ability to detect the spread of cancer from its point of origin to lymph nodes in the body. Human clinical trials show that this new technology substantially improves diagnosis in a range of pelvic cancers, including prostate, bladder, and cervical cancer.

♦ Researchers are currently developing a variety of other novel solutions in medical diagnosis and treatment that involve internal use of engineered nano-sized particles. Injections of gold-coated silica nanoshells are being tested in mice. The nanoshells collect in tumor tissues. The nanoshells can be selectively heated when illuminated from outside the body with near infrared light. The heat destroys the adjacent tumor tissue without damaging nonadjacent healthy body tissues.

Potential Issues and Historical/Regulatory Context

What are the long-term impacts of nanoparticles on the body?
Iron oxide nanoparticles were thought to be safe, however, recent research suggests that the particles may be toxic to nerve cells. Might there be longer-term effects that cannot be measured for many years? Can they accumulate in unintended places in the body?

Will the expense of the new technologies unfairly limit their use?
Some worry that any new medical technologies will be so expensive that they will further increase the cost of medical care and insurance. Others argue that early detection could greatly reduce the costs of treatment.

What are the consequences of not pursuing or delaying these technologies?
Earlier and more accurate detection of diseases like cancer will save money and lives. Localized treatment of tumors may spare patients the harmful side effects of radiation and chemotherapy. It can take years for FDA approval processes, to address all issues that may be raised about a new medical procedure.

APPENDIX C: OVERARCHING QUESTION

Under what conditions should nanotechnology applications in personal care and medicine be made available to the public?

Sample Conclusion 1: Nanotechnology applications in personal care and medicine should be made available to the public only after they have been rigorously investigated and all possible risks are identified and examined.

Sample Conclusion 2: Because potential benefits may outweigh decades of scrutiny required to identify all risks, nanotechnology applications in personal care and medicine should be subject to limited review by government agencies (such as the FDA).

Sample Conclusion 3: Because of potentially life-saving benefits, nanotechnology applications in personal care and medicine should be made available to the public immediately, regardless of potential risks.

What is the conclusion for YOUR group?