NanoSense: The Basic Sense Behind Nanoscience

YEAR 4 REPORT: ACTIVITIES

Executive Summary

We have categorized activities conducted during the fourth year of the NanoSense project in terms of 5 activities: materials development, teacher meetings and workshops, evaluation, dissemination and outreach, and synergistic activities. These activities are summarized below and described in more detail in the body of the report.

Materials Development. Based on feedback, the Size Matters, Clean Energy, and Clear Sunscreen units underwent minor revisions, and the Fine Filters unit was significantly revised. A Scale Diagram poster was created and received with great enthusiasm by partner teachers. Alignment charts or "roadmaps" that show where specific activities are tied to key science topics were created for each unit to enable teachers to more easily choose very short activities. Pre- and post-tests (along with a test rubric) were also created for each unit, to aid evaluation of classroom implementation. Finally, NanoSense materials were made available on the project web site under a Creative Commons Attribution 3.0 United States license, which allows others to adopt and modify the materials at no cost.

Teacher Meetings. We held 6 meetings with our partner teachers to gather feedback on materials and use of the materials in the classroom and in workshops. We also held a 1-week workshop with a dozen teachers at San Jose State University. A separate USDE Teacher Quality Enhancement grant covered teacher stipends for the week.

Evaluation. Evaluations were conducted of a NanoSense workshop for high school science teachers at San Jose State University and six classroom implementation studies. All NanoSense units were implemented in local classrooms. Pre- and post-tests were administered before and after each intervention to shed light on our first core question: Does the NanoSense curricula increase students' understanding of nano-related concepts? A *Thoughts about Science* survey was administered before and after four of the interventions to shed light on a second core question: Does the NanoSense Curricula change students' attitudes and beliefs towards science in general? Several NanoSense adopters also completed an evaluation form available on the project web site.

Dissemination and Outreach. We engaged in numerous dissemination activities, including the local San Jose State University "Nanotechnology in Schools" initiative and local teacher workshops. NanoSense materials were also used and promoted by others. For example, Dr. Rob Snyder at the University of Massachusetts at Amherst (UMass) used NanoSense materials (in addition to other materials from a variety of sources) in a one-week STEM Education Institute for educators on the UMass campus. After the institute, Rob emailed us saying, "The summer institute was a great success, thanks in part to the Nanosense materials that you provided." A ranking of the institute activities based on participant surveys showed that the Nanosense materials were the highest ranked institute activities. They plan to continue the institute, using more NanoSense materials, for the next six summers. Numerous other organizations (e.g., Stanford University, Southern Connecticut State University, Christopher Newport University, Bergen County Technical Schools, University of Wisconsin-Madison) contacted the NanoSense team and reported positive experiences with their use of NanoSense materials.

Synergistic Activities. Under NSF STTR funding, completed a formative evaluation (with college-level instructors as the subjects) of an online educational resource system that provides automatically-constructed courseware in the area of nanoscience.

Activity 1: Instructional Materials Development

In the final year of the grant, we implemented minor revisions to our Size Matters, Clean Sunscreen, and Clean Energy units, and major revisions to the Fine Filters unit. These units and the changes implemented in the final year of the grant are described in more detail below. The Size Matters, Clear Sunscreen, and Clean Energy units were described in detail in past reports, so only the changes are described here.

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Size Matters: An Introduction to Nanoscience

Exhibit 1 shows the enduring understandings and outline for the Size Matters unit, which provides an introduction to nanoscience, focusing on concepts related to the size and scale, unusual properties of the nanoscale, tools of the nanosciences, and example applications. The unit is available for download at http://nanosense.org/activities/sizematters/

Based on feedback from teachers, in the final year we revised the Card Sort activity (changed some of the example items to be more familiar) and worked with scientists and a graphic designer to improve the Scale Diagram (i.e., make it more scientifically accurate and aesthetically pleasing) and created a poster-size version of the diagram.

Clear Sunscreen: How Light Interacts with Matter

Exhibit 2 shows the enduring understandings and an outline for the Clear Sunscreen unit, which explores issues related to size and scale, specifically the effect of the size of nanopowders on the interactions of energy and matter (e.g., the absorption of light, addressing the electromagnetic spectrum and associated wavelengths). The unit is available for download at http://nanosense.org/activities/clearsunscreen/

In the final, year we implemented some fine-tuning revisions to the unit based on comments made by our site visitor Larry Woolf, observations made during an implementation of the unit conducted in March 2008, and suggestions given to us by Molly Yunker and Nikki Guthrie, two doctoral students in education at the University of Michigan who conducted a review of the unit with reference to the criteria from Project 2061 and Davis and Krajcik's (2005) design heuristics for educative curricular materials. The changes primarily included the following:

- Expanded teacher's notes to facilitate teacher use of the PowerPoint presentations
- Added student handouts to use in conjunction with the PowerPoint presentations
- Fine tuned images, increasing consistency between visual representations
- Elaborated teacher's versions of lesson reflection sheets
- Expanded version of the final quiz
- Added the formula R+T+A=1 as an organizing framework for the interaction of light with matter
- Adjusted the explanation of the scattering mechanism to not refer to geometric optics that are not rigorously applicable at this size level

Clean Energy: Converting Light into Energy

Exhibit 3 shows the enduring understandings and an outline for the Clean Energy unit, which explores the issue of energy production as a pressing global issue and how nanoscience could

enable important breakthroughs in energy generation and conversion. The unit is available for download at http://nanosense.org/activities/cleanenergy/

In the final year, we incorporated suggestions from Larry Woolf to better motivate why we want to use nanocrystalline solar cells and why they are designed the way they are (i.e., incorporating an engineering design perspective). Besides minor updates to existing slides, animation, and readings, two major items were added to the unit: an 8-page teacher reading about how solar cells work (based upon discussions with Larry Woolf and Maureen Scharberg, and reviewed and edited by Larry Woolf and our partner teachers), and a worksheet to accompany the silicon and nanocrystalline solar cell animations to scaffold productive discussion of the animations.

Fine Filters: Nanofiltration

Exhibit 4 shows the enduring understandings and an outline of the Fine Filters unit, which focuses on the (uneven) scarcity of safe drinking water across the world, how water can be cleaned through a series of filtration steps, and how nanofiltration can be used as a cost-effective way to solve filtration problems. The unit is available for download at http://nanosense.org/activities/finefilters/

In the final year of the project, this unit underwent major revisions based upon feedback in our teacher meetings, from a May 2007 pilot study, and from use of the unit by Tina Stanford in her class at Fremont High School. The changes included major revisions to the lab procedures to improve and clarify the methods, significant changes to the PowerPoint slides and readings based on teacher and team input, creation of teacher keys for all labs and quizzes, and completion of the unit overview and teacher lesson plans.

Alignment Charts

Our site visitor Larry Woolf recommended that we create "roadmaps" that show where specific activities in our units are tied to key science topics to enable teacher to easily choose very short activities. In the final year, we completed a set of alignment charts that provide mappings between NanoSense materials and standard science curriculum topics, distributed them to our partner teachers, and posted them to the NanoSense web site. Charts were created for high school chemistry, physics, biology, and environmental science. Unit-specific charts were also included with each unit binder. Our summer IISME teacher intern led this effort, with feedback from our partner teachers and the NanoSense team integrated into revisions. The alignment charts are available under "activities" on the NanoSense web site.

Activity 2: Teacher Meetings and Workshops

In the final year of the project, we held 6 meetings with an expanding base of partner teachers. Primary objectives of the meetings included gathering feedback on activities and planning use of materials in the classroom and in workshops. Meetings lasted from 2 to 4 hours.

June 25-29, 2007: Teacher workshop at SJSU

The NanoSense team held a 4-day workshop for about a dozen local high school teachers at SJSU in late June 2007. The workshop covered all of the NanoSense units (Size Matters, Clear Sunscreen, Clean Energy, Fine Filters). Activities included presentations by NanoSense staff and our partner teachers, hands-on laboratory activities, small group activities, group projects, and individual reports. Participants received 2.0 semester credits from SJSU in chemistry, physical

science, or integrated science (their choice) and a stipend from a separate USDE Teacher Quality Enhancement grant. The agenda for the workshop is available in Exhibit 5, and results—a report by our external evaluator who attended the workshop, as well as participant evaluations—are presented in the Findings section of this report.

August 17, 2007: Review new Clean Energy reading, Fine Filters lab

Anders Rosenquist led a discussion of the new teacher reading for Fine Filters, Tina Stanford led a discussion of revisions to the Fine Filters lab, and our IISME teacher intern, Diana, Theriault, led a discussion of the new high school alignment charts. The teachers provided detailed feedback on the materials. We also discussed classroom implementation schedules.

October 15, 2007: Teacher Workshop at Fremont High School, Sunnyvale, CA

Tina Stanford hosted a teacher workshop on NanoSense materials for three of her colleagues at Fremont High School. Tina distributed California state standards for chemistry, biology, and physics, Fine Filters materials, and the Size Matters unit. After a presentation of Size Matters introduction slides, the teachers did the Number Line/Card Sort activity, and discussed how to integrate the slides, demonstration materials, and activities into their classrooms. Tina then demonstrated components of the Clear Sunscreen unit, including the introductory slides, Flash animation, consumer activity, and UV bead lab. One teacher planned to use the UV Bead lab in her classroom. After a lunch break, Tina presented the Clean Energy introductory slides and an overview of the unit. The teachers thought the unit was "very cool." Finally, Tina presented the Fine Filters introductory slides and an overview of the unit. The group brainstormed about places where these units could fit into their curriculum (e.g., under the topic of solutions). Everyone agreed that environmental science seemed a clear fit for the Clean Energy and Fine Filters units.

October 16, 2007: Review new Size Matters poster, Evaluation Packets, Clean Energy materials

Patricia Schank led a discussion of proposed revisions to the Size Matters Scale Diagram and creation of a poster version. Teachers were excited about the poster version and gave detailed feedback (e.g., on the extent of lines representing forces, tools, and models). We also spoke with 3 scientists to verify the accuracy of proposed changes. Alyssa Wise walked everyone through the new evaluation packets. Anders Rosenquist led a discussion of the improved teacher reading and new worksheet to accompany the solar cell animations. Teachers provided detailed feedback on the animation and worksheet, and some elements of the animation were revised in response.

December 10, 2007: Review of major updates to Fine Filters

We handed out new scale diagram posters to our participating teachers, and everyone loved them and planned to hang them in their classrooms right away. Tina Stanford led a discussion of major revisions to the Fine Filters Science of Water PowerPoint, Water Crisis Student Data Worksheet, and New Nanomembranes Student Reading. Teacher gave detailed feedback (which was incorporated), but generally felt the revisions addressed their earlier concerns quite well.

February 12, 2008: Demo of Nano Kit, Evaluation update, and new Fine Filters binder

Maureen Scharberg demonstrated a nano kit that she and her students have created for the Nanotechnology in Schools Program (see below). They have created and distributed over 30 kits to California universities and community colleges. The kits are described in Activity 4 below. Two of our partner teachers, Maria and Carolina, reported on their use of Size Matters and Clean

Energy, respectively, in their classes. Finally, we handed out the new Fine Filters binders, and Tina Stanford reviewed the three lessons in the unit.

Meeting Participants

Attendees of the teacher meetings above included the following:

- NanoSense Team:
  - Patricia Schank, SRI International
  - Tina Stanford, SRI International
  - Anders Rosenquist, SRI International
  - Alyssa Wise, Indiana University
  - Maureen Scharberg, San Jose State University

- Core Partner Teachers (attended most meetings):
  - Doris Mourad, Castilleja School, Palo Alto, CA
  - Carolina Sylvestri, Gunn High School, Palo Alto, CA
  - Geri Horsma, Gunn High School, Palo Alto, CA
  - Kyle Cole, Stanford University, Palo Alto, CA
  - Robin McGlohn, Menlo School, Menlo Park, CA
  - Maria Powell, Gunn High School, Palo Alto, CA

- Visiting Teachers (attended 1-3 meetings):
  - Resa Kelly, San Jose State University

IISME Summer Fellow

A San Francisco high school science teacher, Diana Theriault, joined the NanoSense team during the summer of 2007 through the Industry Initiatives for Science and Math Education (IISME; iisme.org) Fellowship Program for Teachers. Ms. Theriault, who has expertise in environmental science, biology, and curriculum development, led the effort to create the high school alignment maps, revise Fine Filters lab activities, and create lab kits for use by teachers and for workshop demonstrations.

Activity 3: Evaluation

Workshop Evaluation

An external evaluation was conducted and participant evaluations were collected for the NanoSense workshop for high school science teachers (see Activity 2) held at training facilities at SJSU. The agenda for this workshop is shown in Exhibit 5. Generally, the workshop was very well received. Analyses are presented in the Findings section of this report.

Development of Classroom Evaluation Instruments

In fall 2007, the NanoSense team developed pre- and post-tests for each unit. The goal of these tests was to shed light on our core question: Does the NanoSense curricula increase students' understanding of nano-related concepts? Hence, the tests focused on nanoscale concepts, in particular:

1. What nano-related concepts can students reasonably understand?
2. What nano-related concepts do students often have problems with or misconceptions /

confusions about?

In addition, we created aThoughts about Science survey, drawing on and adapting questions from Sandovol & Morrison (2003) and Siegel and Ranney (2003). The goal of this survey was to shed light on a second core question: Does the NanoSense Curricula change students' attitudes and beliefs towards science in general? In particular,

1. Does use of the NanoSense Curricula make students see science as more relevant to their lives?
2. Does it make them more interested in a career in science?
3. Does it help them better understand the nature of scientific knowledge

The pre- and post-tests were included with each unit binder, and an evaluation packet containing the tests and the Thoughts about Science survey was used to gather data on student learning and attitudes in classroom evaluations, described below. The evaluation packet is available at http://nanosense.org/documents/evaluation/NanoSenseEvaluationPacket.pdf. The packet was posted on the web site as part of an attempt to make it easy for NanoSense adopters to give us feedback by using the materials in this packet or by completing a more general online evaluation form at http://nanosense.org/contact.html. Several NanoSense adopters completed the online evaluation, and their informal feedback is described in Activity 4 below.

Classroom Evaluation

In spring 2008, the NanoSense units were implemented in six classrooms. Each unit was tested once, except the Clean Energy and Clear Sunscreen units were tested twice. In all cases, classroom periods were about 50 minutes in duration. The unit pretest was administered immediately before each intervention, and the unit post-test was administered immediately afterwards. The Thoughts About Science survey was administered in four of the classrooms, immediately before and after the Clear Sunscreen and Clean Energy interventions. Analyses of the pre- and post- tests and surveys are presented in the Findings section of this report.

Size Matters

In January 2008, the Size Matters unit was implemented over two classroom periods with 36 students in a 10th grade chemistry class taught by Carolina Sylvestri at Palo Alto High School. On Day 1, Ms. Sylvestri presented the one-day PowerPoint slides. On Day 2, she led a full day of class discussion about nanoscience in general, emphasizing the chemistry connection. Pre- and post-tests were administered by Ms. Sylvestri immediately before and after the intervention.

Clear Sunscreen

In March 2008, the Clear Sunscreen unit was implemented over four classroom periods with 21 students in a biology class taught by Geri Horsma at Gunn High School. Dr. Alyssa Wise presented the PowerPoint slides as a guest lecturer, and Ms. Horsma led the other classroom activities. Dr. Patricia Schank visited all days and took observation notes. On Day 1, Dr. Wise presented the introductory Nano Sunscreen slides, and the students shared information that they gathered for the Sunscreen Bottle Labels Activity, done as homework the day before. On Day 2, Dr. Wise presented the All About Sunscreens slides and the students began work on the UV Bead Lab Activity. On Day 3, the students completed the lab. On Day 4, Dr. Wise completed the All About Sunscreens slides, and the students shared their lab activity data (results from each group were superimposed on a transparency for discussion).

In addition, a one-day version of the unit was presented to 35 students in two biotechnology classes taught by Ms. Horsma. The one-day version was a PowerPoint slide presentation by Dr. Wise that incorporated slides from all of the lessons, and a UV light demonstration. In the demonstration, a 50-euro bill was held under two different UV lights to show how different patterns appear under different UV spectra because the embedded chemicals differentially absorb different ranges of UV. (The chemicals are embedded as a way to detect counterfeit bills.)

Pre- and post-tests, as well as the Thoughts about Science survey, were administered immediately before and after the interventions.

Clean Energy

The Clean Energy unit was implemented in two classrooms. The Clean Energy pre- and post-test and the Thoughts about Science pre- and post- survey were administered immediately before and after each intervention.

In February 2008, the unit was implemented over five classroom periods with 44 students in three environmental science classes taught by Maria Powell at Gunn High School. On Day 1, Ms. Powell presented the Introduction to Clean Energy slides. On Day 2, she presented the Solar Energy and Nanoscience slides. On Day 3, the students explored the Silicon and Nanocrystalline Solar Cell Animation and completed the accompanying worksheet, and read the Hybrid Cars, Solar Cells, and Nanoscience Student Reading and completed the accompanying worksheet. On Days 4 and 5, the students completed the Nanocrystalline Solar Cell Lab Activity. Dr. Maureen Scharberg visited the classroom on Days 4 and 5 and assisted with the lab activity.

In April 2008, the Clean Energy unit was implemented over three classroom periods with 16 students in a chemistry class taught by Jennifer Fernandes at Silver Creek High School in San Jose, CA in April 2008. On Day 1, Dr. Maureen Scharberg presented the Introduction to Clean Energy slides as a guest-lecture. Ms. Fernandes led all other classroom activities. On Day 2, Ms. Fernandes presented the Silicon and Nanocrystalline Solar Cell Animation. On Day 3, the students completed the Nanocrystalline Solar Cell Lab Activity. Ms. Fernandes prepped the lab activity by preparing the titanium dioxide slides so that the students could focus on assembling and testing the cells. Anders Rosenquist visited the classroom on Days 2 and 3 and took observation notes.

Fine Filters

The Clean Energy unit was implemented over 4 classroom periods with 44 students in three environmental classes taught by Maria Powell at Gunn High School. Ms. Powell gave all presentations and led all classroom activities. On Day One, Ms. Powell presented the Introduction to the Water Crisis slides and led an interactive discussion as students completed the accompanying Student Data Worksheet. On Day 2, Ms. Powell presented the NanoFiltration PowerPoint Slides and the students completed the Which Method is Best worksheet and the Cleaning Jarny's Water activity. On Days 3 and 4, the students completed the Comparing Nanofilters to Conventional Filters Lab Activity. Tina Stanford visited the classroom on Days 3 and 4 took observation notes. Pre- and post-tests were administered immediately before and after the intervention.

Activity 4: Dissemination and Outreach Activities

We engaged in several dissemination activities, and NanoSense materials were used and promoted by many other individuals and institutions. Below we summarize these activities and

informal feedback on the materials.

NanoSense Web site and Mailing Lists

All NanoSense activities are available on the project web site (http://nanosense.org). The units are also distributed at conferences and teacher workshops. We continued to email updates on workshops and new materials to local mailing lists that reach hundreds of local San Francisco Bay Area teachers. The curriculum materials have been downloaded thousands of times from our web site (see Findings section for statistics on downloads). In the final year of the project, we added a feedback form to the web site to gather input on our materials (e.g., what activities were used, how it went, areas of confusion, questions or suggestions).

University of Massachusetts at Amherst (UMass) STEM Education Institute

Dr. Rob Snyder at UMass Amherst learned of the NanoSense materials at meetings at NSF and at the Museum of Science in Boston. Dr. Snyder contacted us in July 2007 to ask permission to use our materials in a one-week STEM Education Institute for educators held on the UMass campus. The institute focused on integrating existing nanoscale science and engineering activities into middle school and high school STEM programs. Teachers also designed their own nanoscience lessons. The institute used materials from the Size Matters and Clear Sunscreen units. They requested that we send them sets of hard copies, so that they could become part of a permanent collection of resources that would be used on-site during each summer institute for the next six summers. Teachers downloaded activities that they chose to do either at the institute or when they returned to their classroom. After the 2007 summer institute, Rob emailed us saying, "The summer institute was a great success, thanks in part to the Nanosense materials that you provided." He sent us a document showing a ranking of the institute activities based on participant surveys conducted at two callback sessions in the fall (see Exhibit 6) and noted that the Nanosense materials were the highest ranked institute activities. In their summer 2008 institute, they plan to add in our Clean Energy unit. In May 2008, we emailed Dr. Snyder several hard copies of each unit, along with our size and scale poster. He emailed the NanoSense team:

> "Having some hard copies of the updates would be fantastic. We have incorporated your size matters and sunscreen activities into many of our presentations that have included the one week summer institutes at the UMass Amherst campus, a short course at the NSTA National Conference in Boston in March, a session at a conference of the Massachusetts Environmental Education Society in April, and a recent Saturday Seminar at UMass. We always include information about the Nanosense web site in our presentations."

Stanford University Center for Probing the Nanoscale

We continued to collaborate closely with Dr. Kyle Cole, Associate Director of the NSF-funded Stanford Center for Probing the Nanoscale (CNI), to extend both NanoSense and CPN outreach efforts. Kyle attended our NanoSense teacher meetings and workshops, and demonstrated CPN materials to our participating teachers. At his invitation, we led teachers in hands-on NanoSense activities at CPN's Summer Institute for Middle School teachers in late June 2007. Dr. Kole also used the Clean Energy unit in his Tools of the Nanosciences course in fall 2007. The course consists of 15 freshman and sophomores, 70% of which are science majors. Dr. Cole used the readings and solar cell animations, and asked students to pair up and generate

two questions about the animations that neither of them understood. For the silicon solar cells, questions included: Does each photon always liberate an electron? If so, why aren't solar cells 100% efficient? Why isn't light reflected from the surface? Why does light pass thru the N layer? Do electrons ever recombine with holes before they get to the N layer? Could you put a lens over the cell to focus more light onto the cell? For the nanocrystalline solar cells, questions included: How do electrons get to the conducting plate? How does the dye really turn black when it loses an electron? How do the electrons get through the iodine solution? Dr. Cole thought the questions were very good and revealed that the students got a lot out of the reading. He commented, "It was a very effective combination of reading, visuals, discussion and peer learning. Even the history and literature majors got how solar cells work and the role nanoparticles play in organic solar cells…Overall, it is a very nice unit, kudos!"

Southern Connecticut State University Inner-City School Program

Somi Akella, a graduate student at Southern CT State University, contacted the NanoSense team on in December 2007 to report on her use of NanoSense, saying, "Your site is great." Somi was introduced to the NanoSense site by her physics professor, Dr. Broadbridge. Dr. Broadbridge teaches nanotechnology, and also runs a program to introduce inner-city middle and high school students to nanotechnology. Working with Dr. Broadbridge, Somi used elements of the Size Matters and Clear Sunscreen units in a local 7th grade class. In particular, she used the powers of 10 activities, What's New NanoCat? Poster session/performance assessment, the Black Box tool activity, Unique Properties lab activities, and PowerPoint slides. Somi reported that students had the most confusion around the applications of nanotechnology, but generally, the activities went well.

Bergen County Technical Schools, New Jersey

Peggy Frizzell, an outreach specialist for a science and technology magnet high school in northern New Jersey, contacted the NanoSense team in July 2007 to learn more about our materials. Her school was in the process of identifying curriculum resources and knowledge experts to guide the implementation for a new nanotechnology program. The NanoSense team contacted Ms. Frizzell and discussed several issues (e.g., she asked about guidelines from NSF or elsewhere about nanoscience learning goals, equipment needs, and what other schools are offering nanotechnology curriculum). We directed her to NCLT, NNIN, and the NanoEd resource portal for additional information. She also downloaded our materials and said that she planned to use it in their new curriculum initiative.

Christopher Newport University, Virginia

Dr. Raj Chaudhury, a physics professor at Christopher Newport University in Virginia, continued to use NanoSense materials in his Elementary Physics survey course (PHYS 104) and his more advanced course, The Mystery and the Magic (PHYS 143) in fall 2007. In his PHYS 104 course, he used the PowerPoint slides from the Size Matters unit, and gave the students the "Scale of Objects" instructions and asked them to predict the answers using clicker technology. Students were then given the Scale Diagram and revised their predictions. Dr. Chaudhury has used NanoSense materials for 2-3 years, in mainly lecture-discussion mode, focusing on scale and the unique properties at the nanoscale. He has provided suggestions for improvement (usually minor wording changes, or the inclusion of more driving questions in the slides, which we implemented) after each use in his classroom.

San Jose State University's Nanotechnology in Schools Program

A Nanotechnology Summer Institute hosted by Dr. Maureen Scharberg at San Jose University was held in summer 2007 to provide middle school and high school teachers with a basic understanding and knowledge of nanoscience and nanotechnology. NanoSense materials were used in the workshops and outreach efforts. Dr. Scharberg has incorporated the NanoSense materials into kits for outreach to middle schools and high schools by two-year college students who are interested in becoming math and science teachers. To date, date, 20 kits have been distributed to local two-year colleges, including Foothill College (3 kits), Evergreen Valley College (3 kits) and Cabrillo College (2 kits). Dr. Scharbert has also distributed kits to UC Riverside (to distribute to San Bernardino City College, Chaffey College, Pasadena City College, Santa Monica City College), UC Santa Cruz and San Jose City College. Each kit, which costs about $175, contains:

- A nanotube model made of chicken wire
- A powers of 10 video
- One nanosecond ruler (represents how far light goes in one nanosecond)
- Ferrofluid and magnets
- A solar cell ($15)
- Refridgerator magnets with probe
- Gold legos (to illustrate cutting down gold, surface area to volume)
- Nanogold and bulk gold in tubes
- Nanosilver and bulk silver in tubes

Finally, Dr. Scharberg is serving as a consultant on the Aerospace Education Research Operations Institute's proposed Interest in Careers in Nanotechnology (I-CAN) Project, and reports that they also plan to use the NanoSense curriculum and materials developed.

University of Wisconsin-Madison

Janice Tomasik, a graduate student with Dr. John Moore at the University of Wisconsin-Madison, is using the Size Matters, Clear Sunscreen, and Clean Energy units in an online course about nanoscience for teachers. Ms. Tomalsik has run the online course 3 different semesters from 2006 to 2007. She contacted the NanoSense team on in March 2008 to report on her use of NanoSense, saying, "every semester, our teachers compliment these materials, saying they're finding them very useful and informative." She reports that most of the teachers take the units and modify them for use in their classrooms. Ms. Tomalsik is publishing an introductory article about the online course (an evaluation of its success), referencing the NanoSense project and "the great materials, and how useful they have been."

Massey University in Palmerston North, New Zealand

Dr. Mark Waterland, Nanoscience Major Leader at the Institute of Fundamental Sciences at Massey University in New Zealand, leads new Nanoscience major that the school recently introduced as part of their Bachelor of Science program. The school has a program to promote and develop nanoscience in local high schools. In February 2008, Dr. Waterland contacted the NanoSense team to let us know that they are using the Size Matters and Clean Energy curriculum materials for much of their local high school program. He reports that the materials are "ideal for this purpose."

Papers and presentations

In the final year of the project, the following articles were published by NanoSense team members and about the NanoSense project.

- The book chapter by Schank & Krajcik, "Can Nanoscience Be a Catalyst for Education Reform?" was published by Wiley Publishers in *Nanoethics: The ethical and social implications of nanotechnology*.
- The book *Nanotechnology 101*, by John Mongillo, was published by Greenwood Publishers. The book features NanoSense materials on Clear Sunscreen and an interview with Wise & Schank on commonly-asked student questions and answers about nanoscience.
- NanoSense was featured in the local (paper and online) *Palo Alto Weekly* on March 26, 2008, as part of a special issue on nanoscience research in the Silicon Valley. In the article, authored by Arden Pennell and titled *Coming soon to a classroom near you,* Alyssa Wise and Gunn High School teacher Geri Horsma were interviewed about the 4-day implementation of the Clear Sunscreen unit in 3 of Geri's classrooms (March 4-7).
- NanoSense materials on size and scale from the Size Matters unit were included in a "Visualization in Technical Education" CD for high school and community college students in various science and graphics disciplines. The CD was published by Thomson Delmar Learning, a publisher of educational textbooks and CD ROM projects located in Clifton Park, NY.

Activity 5: Synergistic Activities

Evaluation of auto-constructed nanotechnology education system

The NanoSense team completed three formative evaluation studies of an online resource system called Courseware Self-Assembly (CSA) created by Taxonomize. CSA supports the categorization of search results and provides an automatically constructed "syllabus" based on the results. Nanotechnology was chosen as the subject area for this evaluation. Impressions were mixed on how helpful the CSA system was in assembling course materials. Subjects liked how it organized search results in a hierarchical structure, but the tool did not seem to be able to relieve them of the work of distinguishing relevant from irrelevant material. The overall usability of the tool and the effectiveness of the auto-categorization were also of concern. Taxonomize made revisions to their system based upon our evaluation, and in a followup study, subjects reported that the revised system was seemed more functional. However, the auto-sorting still did not always make sense to participants. In a third, heuristic analsyis of the system, usability experts reported some benefits of the CSA system but noted numerous places where the interface should be changed to improve the usability of the system. We provided a final report and brief literature review to Taxonomize, on three topics of core interest to them: search within the education community, how people make sense of large document collections, and methods for studying search behavior. We also contributed NanoSense content to a Wiki space on nanoscience, developed by Taxonomize. The Wiki draws together and summarizes core topics in nanoscience, and is used to help structure CSA search results. We are discussion a possible follow-on proposal that would focus on supporting educators in their search for nanoscience materials on the web.

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Exhibit 1. Size Matters unit enduring understandings and outline of materials.

Enduring Understandings

1. The study of unique phenomena at the nanoscale could vastly change our understanding of matter and lead to new questions and answers in many areas, including health care, the environment, and technology.
2. There are enormous scale differences in our universe, and at different scales, different forces dominate and different models better explain phenomena.
3. Nanosized materials exhibit some size-dependent effects that are not observed in bulk materials.
4. New tools for observing and manipulating matter increase our ability to investigate and innovate.

Overview of Unit

Teacher Materials

- For Anyone Planning to Teach Nanoscience…Read This First!
- Size Matters Overview and Learning Goals
- Unit at a Glance: Suggested Sequencing of Activities
- Alignment Chart: Enduring Understandings
- Alignment Chart: Key Knowledge and Skills
- Size Matters Pretest/Posttest: Teacher Answer Sheet

Student Materials

- Size Matters: Pretest
- Size Matters: Posttest

Lesson 1: Introduction to Nanoscience

Teacher Materials

- Introduction to Nanoscience: Teacher Lesson Plan
- Introduction to Nanoscience: PowerPoint with Teacher Notes
- Introduction to Nanoscience Worksheet: Teacher Key

Student Materials

- Introduction to Nanoscience: Student Reading
- Introduction to Nanoscience: Student Worksheet
- Scale Diagram: Dominant Objects, Tools, Models, and Forces at Different Scales
- The Personal Touch: Student Reading
- The Personal Touch: Student Worksheet

Lesson 2: Scale of Objects

Teacher Materials

- Scale of Objects: Teacher Lesson Plan
- Number Line/Card Sort Activity: Teacher Key
- Scale of Objects Activity: Teacher Key
- Cutting it Down Activity: Teacher Key
- Scale of Small Objects Quiz: Teacher Key

Student Materials

- Visualizing the Nanoscale: Student Reading

- Scale Diagram: Dominant Objects, Tools, Models, and Forces at Different Scales
- Number Line/Card Sort Activity: Student Instructions
- Scale of Objects Activity: Student Instructions
- Cards and Line Markers for Number Line and Scale of Objects Activities
- Cutting it Down Activity: Student Instructions
- Scale of Small Objects: Student Quiz

Lesson 3: Unique Properties at the Nanoscale
Teacher Materials
- Unique Properties at the Nanoscale: Teacher Lesson Plan
- Unique Properties at the Nanoscale: PowerPoint with Teacher Notes
- Unique Properties Lab Activities: Teacher Instructions
- Unique Properties at the Nanoscale: Teacher Reading
- Unique Properties at the Nanoscale Quiz: Teacher Key

Student Materials
- Size-Dependent Properties: Student Reading
- Unique Properties Lab Activities: Student Instructions
- Unique Properties Lab Activities: Student Worksheet
- Unique Properties at the Nanoscale: Student Quiz

Lesson 4: Tools of the Nanosciences
Teacher Materials
- Tools of the Nanosciences: Teacher Lesson Plan
- Scanning Probe Microscopy: Teacher Reading
- Scanning Probe Microscopy: PowerPoint with Teacher Notes
- Black Box Activity: Teacher Instructions
- Seeing and Building Small Things Quiz: Teacher Key
- Optional Extensions for Exploring Nanoscale Modeling Tools: Teacher Notes

Student Materials
- Black Box Lab Activity: Student Instructions and Worksheet
- Seeing and Building Small Things: Student Reading
- Seeing and Building Small Things: Student Quiz

Lesson 5: Applications of Nanoscience
Teacher Materials
- Applications of Nanoscience: Teacher Lesson Plan
- Applications of Nanoscience: PowerPoint with Teacher Notes
- What's New Nanocat? Poster Session: Teacher Instructions and Rubric

Student Materials
- What's New Nanocat? Poster Session: Student Instructions
- What's New Nanocat? Poster Session: Student Topic List
- What's New Nanocat? Poster Session: Peer Feedback Form

One Day Introduction to Nanoscience
Teacher Materials
- One Day Introduction to Nanoscience: Teacher Lesson Plan

- One Day Introduction to Nanoscience: Teacher Demonstration Instructions
- One Day Introduction to Nanoscience: PowerPoint with Teacher Notes

Exhibit 2. Clear Sunscreen unit enduring understandings and outline of materials.

Enduring Understandings

1. How different wavelengths of light interact differently with different kinds of matter.
2. Why particle size can affect the optical properties of a material.
3. That there may be health issues for nanosized particles that are undetermined at this time.
4. That it is possible to engineer useful materials with an incomplete understanding of their properties.
5. There are often multiple valid theoretical explanations for experimental data; to find out which one work best, additional experiments are required.
6. How to apply their scientific knowledge to be an informed consumer of chemical products.

Overview of Unit

Teacher Materials

- For Anyone Planning to Teach Nanoscience…Read This First!
- Clear Sunscreen Overview, Learning Goals & Standards
- Unit at a Glance: Suggested Sequencing of Activities
- Alignment of Unit Activities with Learning Goals
- List of Sunscreen Products that use Nanoparticle Ingredients
- Clear Sunscreen Pretest/Posttest: Teacher Answer Sheet

Student Materials

- Clear Sunscreen: Pretest
- Clear Sunscreen: Posttest

Lesson 1: Introduction to Sun Protection

Teacher Materials

- Introduction to Sun Protection: Teacher Lesson Plan
- Nano Sunscreen – The Wave of the Future?: PowerPoint with Teacher Notes
- Clear Sunscreen Initial Ideas: Teacher Instructions
- Ultra-Violet (UV) Protection Lab Activity: Teacher Instructions & Answer Key

Student Materials

- Summary of Sun Radiation: Student Handout
- Clear Sunscreen Initial Ideas: Student Worksheet
- Ultra-Violet (UV) Protection Lab Activity: Student Instructions & Worksheet

Lesson 2: All About Sunscreens

Teacher Materials

- All About Sunscreens: Teacher Lesson Plan
- Sunscreen Ingredients Activity: Teacher Instructions & Answer Key
- All About Sunscreens: PowerPoint with Teacher Notes
- Reflecting on the Guiding Questions: Teacher Instructions

Student Materials

- Light Scattering by Three Sunscreens: Student Handout
- Sunscreen Ingredients Activity: Student Instructions & Worksheet
- Summary of FDA Approved Sunscreen Ingredients: Student Handout
- Reflecting on the Guiding Questions: Student Worksheet

Lesson 3: How Sunscreens Block: Absorption (Optional Extension)
Teacher Materials
- How Sunscreens Block: Absorption: Teacher Lesson Plan
- How Sunscreens Block: The Absorption Mechanism: PowerPoint with Teacher Notes
- Reflecting on the Guiding Questions: Teacher Instructions

Student Materials
- Absorption of Light by Matter: Student Reading
- Reflecting on the Guiding Questions: Student Worksheet

Lesson 4: How Sunscreens Appear: Scattering (Optional Extension)
Teacher Materials
- How Sunscreens Appear: Scattering: Teacher Lesson Plan
- How Sunscreens Appear: The Scattering Mechanism: PowerPoint with Teacher Notes
- Ad Campaign Project (ChemSense Activity): Teacher Instructions & Rubric
- Sunscreens & Sunlight Animations: Teacher Instructions & Answer Key
- Reflecting on the Guiding Questions: Teacher Instructions

Student Materials
- Scattering of Light by Particles: Student Reading
- Ad Campaign Project (ChemSense Activity): Student Instructions
- Sunscreens & Sunlight Animations: Student Instructions & Worksheet
- Reflecting on the Guiding Questions: Student Worksheet

Lesson 5: Culminating Activities
Teacher Materials
- Culminating Activities: Teacher Lesson Plan
- Consumer Choice Project: Teacher Instructions & Rubric
- The Science Behind the Sunscreen: Quiz Answer Key
- Clear Sunscreen Final Reflections: Teacher Instructions

Student Materials
- Consumer Choice Project: Student Instructions
- Consumer Choice Project: Peer Feedback Form
- The Science Behind the Sunscreen: Student Quiz
- Clear Sunscreen Final Reflections: Student Worksheet

Exhibit 3. Clean Energy unit enduring understandings and outline of materials.

Enduring Understandings

1. Clean alternative energy technologies must be developed to provide sufficient energy to meet growing global demand, and must be sustainable both environmentally and economically.
2. Nanoscience could enable important breakthroughs in solar energy technology through low cost, novel energy conversion mechanisms.
3. Surface area to volume ratio is a function of particle size and shape. Increasing surface area normally increases the rate of reaction because there are more sites available for simultaneous reaction.
4. Energy is neither created nor destroyed—it can only be converted into different forms.

Overview of Unit

Teacher Materials

- For Anyone Planning to Teach Nanoscience…Read This First!
- Clean Energy Overview, Learning Goals & Standards
- Unit at a Glance: Suggested Sequencing of Activities
- Alignment of Unit Activities with Learning Goals
- Clean Energy Pretest/Posttest: Teacher Answer Sheet

Student Materials

- Clean Energy: Pretest
- Clean Energy: Posttest

Lesson 1: Introduction to Clean Energy

Teacher Materials

- Introduction to Clean Energy: Teacher Lesson Plan
- Clean Energy – The Potential of Nanoscience for Energy Production and Use: PowerPoint with Teacher Notes
- Clean Energy Initial Ideas: Teacher Instructions
- Hybrid Cars, Solar Cells, and Nanoscience: Teacher Key

Student Materials

- Clean Energy Initial Ideas: Student Worksheet
- Hybrid Cars, Solar Cells, and Nanoscience: Student Reading and Worksheet

Lesson 2: Solar Energy and Nanoscience

Teacher Materials

- Solar Energy and Nanoscience: Teacher Lesson Plan
- Clean Solar Energy–The Impact of Nanoscale Science on Solar Energy Production: PowerPoint with Teacher Notes
- Solar Cell Technology: Teacher Reading
- Silicon and Nanocrystalline Solar Cell Animations: Teacher Instructions and Answer Key
- Nanocrystalline Solar Cell Lab Activity: Teacher Instructions & Answer Key
- Reflecting on the Guiding Questions: Teacher Instructions

Student Materials

- Silicon and Nanocrystalline Solar Cell Animations: Student Instructions

- Nanocrystalline Solar Cell Lab Activity: Student Instructions & Worksheet
- Reflecting on the Guiding Questions: Student Worksheet

Exhibit 4. Fine Filters unit enduring understandings and outline of materials.

Enduring Understandings

1. A shortage of clean drinking water is one of the most pressing global issues.
2. Solutes can be separated from heterogeneous and homogeneous solutions by a variety of filtration methods.
3. The smaller the particle that is to be separated from a solution, the smaller the required pore size of the filter. The smaller the pore size of the filter used for separation, the higher the cost of the process.
4. Nanotechnology can solve critical filtration problems in a cost-effective way that allows for widespread use.

Overview of Unit

Teacher Materials

- For Anyone Planning to Teach Nanoscience…Read This First!
- Fine Filters Overview, Learning Goals & Standards
- Unit at a Glance: Suggested Sequencing of Activities
- Alignment of Unit Activities with Learning Goals
- Fine Filters Pretest/Posttest: Teacher Answer Sheet

Student Materials

- Fine Filters: Pretest
- Fine Filters: Posttest

Lesson 1: The Water Crisis

Teacher Materials

- Introduction to The Water Crisis: Teacher Lesson Plan
- The Water Crisis: PowerPoint Slides & Teacher Notes
- The Water Crisis Student Data Worksheet: Teacher Instructions & Answer Key
- Fine Filters Initial Ideas: Teacher Instructions
- The Water Crisis: Quiz Answer Key

Student Materials

- The Water Crisis: Student Data Worksheet
- Fine Filters Initial Ideas: Student Worksheet
- Water Crisis: Student Quiz

Lesson 2: The Science of Water (Optional Extension)

Teacher Materials

- The Science of Water: Teacher Lesson Plan
- The Science of Water: PowerPoint Slides & Teacher Notes
- The Science of Water Lab Activities: Teacher Instructions
- The Science of Water: Quiz Answer Key
- Reflecting on the Guiding Questions: Teacher Instructions

Student Materials

- The Science of Water Lab Activities: Student Instructions & Worksheet
- The Science of Water: Student Quiz
- Reflecting on the Guiding Questions: Student Worksheet

Lesson 3: Filtration and Nanofiltration

Teacher Materials

- Nanofiltration: Teacher Lesson Plan
- Nanofiltration: Teacher Reading
- Nanofiltration: PowerPoint Slides & Teacher Notes
- Which Method is Best? Answer Key
- Comparing Nanofilters to Conventional Filters Lab Activity: Teacher Instructions & Rubric
- Cleaning Jarny's Water: Teacher Instructions & Rubric
- Reflecting on the Guiding Questions: Teacher Instructions

Student Materials

- Nanofiltration: Student Reading
- The Filtration Spectrum: Student Handout
- Which Method is Best? Student Worksheet
- Comparing Nanofilters to Conventional Filters Lab Activity: Student Instructions & Worksheet
- Cleaning Jarny's Water: Student Instructions & Report
- New Nano-Membranes: Student Reading
- Reflecting on the Guiding Questions: Student Worksheet

Exhibit 5. Agenda for June 25-29 nanoscience workshop for high school teachers.

Introduction to Nanoscience: Workshop for High School Teachers
All events in Duncan Hall 505, SJSU, unless otherwise indicated.

Sponsored by the NSF-funded NanoSense project at SRI International and San Jose State University

Monday June 25, 2007 - AGENDA	
8:45 am	Arrival, Check-in and Continental Breakfast
	Arrive, pick up materials, and make a name badge. Enjoy muffins and juice while you check out the nanoscience demonstrations.
9:00 am	Welcome, Introductions, & Workshop Overview
	Tina Stanford, Patti Schank & Maureen Scharberg
	Meet us and your fellow workshop participants. We'll discuss goals and expectations for the workshop, and lay out the plan for the day.
10:00 am	Introduction to Nanoscience & its Applications - Presentation
	Doris Mourad & Tina Stanford
	How small is a nanometer? What are some unusual properties of the nanoscale? How might nanotechnology impact our lives? These and other questions will be addressed through presentation and hands-on activities.
10:45 am	BREAK
11:00 am	Unique Properties at the Nanoscale – Hands-on Lab
	Diana Theriault, Doris Mourad & Tina Stanford
	We'll do some hands-on labs designed to demonstrate how properties change at the nanoscale.
11:45 am	Lunch (provided) and Debrief
	We'll have sandwiches, chips and drinks. Yum. (Vegetarian available.)
12:15 pm	Guest Speaker and Demonstration
	Kyle Cole, Stanford Center for Probing the Nanoscale
	Kyle will demonstrate some of the cool models and activities he has developed to "see" particles and forces at the nanoscale.
12:45 pm	Unique Properties at the Nanoscale – Presentation
	Doris Mourad & Tina Stanford
	An introduction to what, and how, properties change at the nanoscale.
1:30 pm	BREAK
1:45 pm	Explorer Stations
	Walk around to different stations (on your own or in your small group, at your own pace) to explore more nanoscience activities. Bring your Reflection Worksheets with you and complete Part 1 of the worksheet as you visit stations.
	Station 1: Tools of the Nanosciences
	Kyle Cole
	Explore models of tools that help us "see" at the nanoscale.
	Station 2: Size and Scale

	Diana Theriault & Doris Mourad
	Explore some sorting and number line activities for understanding size and scale.
	Station 3: Applications of Nanosciences
	Tina Stanford
	Discussion around a PowerPoint slide set that summarizes some exciting applications of nanoscale science. See also the "What's New Nanocat? Poster Session: Student Topic List" for application examples and URLs.
3:00 PM	Form Small Groups
	Participants form into groups of 3, based on subject area. These small groups will meet each day to discuss what they are learning and how they can use it in the classroom. Discussion will be scaffolded by a Reflection Worksheet. On Thursday, each group will present briefly (15 minutes, plus 5 minutes for discussion) on their ideas for using the activities they have seen, and on an in-depth lesson plan.
	In small groups, complete Part 2 of the Reflection Worksheet for the day. You'll have 15 minutes tomorrow morning to finalize them, too.
3:20 pm	Whole Group Discussion
	We'll reflect on the day as a group.
3:30 pm	Adjourn
	We'd like to make copies of your reflection worksheets! If you can give them to us before we go, we'll give them back tomorrow morning.
Evening	Homework
	Spend at least an hour reading, surfing the web, and thinking about your WOW project (see the WOW project worksheet; will be handed out). Each individual will pick some unique, exciting application of nanotechnology, and create a short handout and presentation (5 minutes) about it to share with the group on Thursday afternoon.

Tuesday June 26, 2007 - AGENDA	
8:45 am	Arrival, Continental Breakfast
	Enjoy muffins and juice and chat with your colleagues.
9:00 am	WOW Project Check-In and Questions
	Tina Stanford
	We'll discuss any questions or concerns you might have regarding goals, expectations, materials, etc.
9:15 am	Small Groups Meet
	Meet to finalize yesterday's Reflection Worksheet.
9:30 am	Introduction to Clear Sunscreen - Presentation
	Alyssa Wise
	How do "nano-sunscreens" differ from traditional sunscreens? What is the best kind of sunscreen to use and why? Alyssa will introduce the clear sunscreen unit and issues related to such questions.
10:00 am	Ultra-Violet Beads – Hands-on Activity
	Maureen Scharberg & Alyssa Wise

	We'll investigate whether the appearance of a substance (its opacity) relates to its ability to block UV light.
10:45 am	BREAK
11:00 am	All About Sunscreens – Presentation
	Alyssa Wise
	A presentation and discussion of the core ideas behind how sunscreens block UV light and why they appear the way that they do.
12:00 pm	Lunch (provided) and Debrief
	We'll have pizza and drinks. Yum. (Vegetarian options available.)
12:30 pm	Guest Speaker and Demonstration
	Bob London, Taxonomize
	Bob will demonstrate a new nanoscience wiki with some nice resources.
	See http://nano-wiki.com
1:00 pm	Explorer Stations
	Walk around to different stations to explore different hands-on activities. Bring your Reflection Worksheets with you and take notes!
	Station 1: Sunscreen Labels
	Maureen Scharberg
	What kinds of chemicals are used to block the suns rays? Do different sunscreens use different ingredients to block the sun? How might the different ingredients affect us?
	Station 2: Scattering of Light by Particles: Sunscreen Animations
	Tina Stanford and Patti Schank
	View and discuss animated models of how visible light interacts with "large" and nano-sized zinc oxide particles. Play with a tool that you can use to create an animation to show how nano sunscreen particles don't scatter visible light and thus are transparent.
	Station 3: Consumer Choice Pamphlet
	Alyssa Wise & Diana Theriault
	Create a pamphlet to inform consumers about nanoparticulate sunscreens, how they work, and their benefits and drawbacks.
2:30 pm	BREAK
2:45 pm	Small Groups Meet
	In small groups, complete Part 2 of the Reflection Worksheet for the day.
3:15 pm	Whole Group Discussion
	We'll reflect on the day as a group.
3:30 pm	Adjourn
	We'd like to make copies of your reflection worksheets! If you can give them to us before we go, we'll give them back tomorrow morning.
Evening	Homework
	Spend at least an hour working on your WOW project handout and presentation for Thursday.

Wednesday June 27, 2007 - AGENDA	
8:45 am	Arrival, Continental Breakfast
	Enjoy muffins and juice and chat with your colleagues.
9:00 am	WOW Project Check-In and Questions
	Tina Stanford
	We'll discuss any questions or concerns you might have regarding goals, expectations, materials, etc.
9:15 am	Introduction to Clean Energy - Presentation
	Maria Powell
	An introduction to the issue of energy production as a pressing global issue and how nanoscience could enable important breakthroughs in energy generation and conversion.
10:00 am	BREAK
10:15 am	Explorer Stations
	Walk around to different stations to explore different hands-on activities. Bring your Reflection Worksheets with you and take notes!
	Station 1: How Solar Cells Work: Solar Cell Animations
	Maureen Scharberg
	View and discuss animated models of how traditional and nanocrystalline solar cells work.
	Station 2: Nanocrystalline Solar Cell Lab
	Maria Powell
	Build a nanocrystalline solar cell and use it to generate electricity.
11:30 am	Fine Filters Introduction – Presentation
	Maria Powell & Tina Stanford
	An introduction to the global water crisis: where and why clean drinking water is scarce, and the impact of water scarcity.
12:00 pm	Lunch (provided) and Debrief
	We'll have Chinese chicken salad and drinks. Yum. (Vegetarian available.)
12:30 pm	Fine Filters Membrane Technology – Presentation
	Tina Stanford
	An overview of common filtration technologies and how nanofiltration differs.
1:00 pm	Explorer Stations
	Walk around to different stations to explore different hands-on activities. Bring your Reflection Worksheets with you and take notes!
	Station 1: Science of Water Labs
	Diana Theriault
	Explore aspects of the unique chemistry of water, including surface tension, of cohesion and adhesion of water, boiling temperature and the heat capacity of water, and density of water

	versus ice. Station 2: Filtration Labs *Tina Stanford* Begin with a mixture of substances and run them through a series of filtration systems, ending with nanofiltration. Station 3: Jarny Activity *Alyssa Wise* Plan a method to provide drinking water to the people of Jarny, who are having a serious problem with their drinking water.
2:15 pm	BREAK
2:30 pm	Small Groups Meet In small groups, complete the final Reflection Worksheet and prepare presentation (3 PowerPoint slides or 3 flip chart pages) for tomorrow.
3:15 pm	Whole Group Discussion We'll reflect on the day as a group.
3:30 pm	Adjourn We'd like to make copies of your reflection worksheets! If you can give them to us before we go, we'll give them back tomorrow morning.
Evening	Homework Complete your WOW project handout and presentation notes.

Thursday June 28, 2007 - AGENDA	
8:45 am	Arrival, Continental Breakfast Enjoy muffins and juice and chat with your colleagues.
9:00 am	Small Group Presentations Each small group presents to the larger group on their on their ideas for using the activities they saw over the week, and one lesson plan they developed. Plan on 20 minutes per group, including discussion. Presentations will be collected and disseminated to all participants electronically.
10:30 am	BREAK
10:45 am	Small Group Presentations - Continued
12:00 pm	Lunch (provided) and Debrief We'll have sandwiches, chips and drinks. Yum. (Vegetarian available.)
12:45 pm	Individual WOW presentations Each individual participant presents to the larger group on their on their WOW application. Plan on 5 minutes per presentation, including discussion. Presentations will be collected and disseminated to all participants electronically.
2:15 pm	BREAK
2:30 pm	Cookies and Workshop Survey Enjoy cookies and drinks while completing a short survey about the workshop.

2:45 pm	Reflection *Ellen Mandinach* Reflect on the workshop and discuss ideas that were particularly interesting or perhaps unclear.
3:15 pm	Get Certificates, Stipend Forms, and Ajourn Get your certificates of participation, and a form to complete to receive your workshop stipend. Before you go, please give us electronic copies of your presentations so that we can share them with the group!

Exhibit 6. (Sent to use from Dr. Rob Snyder, UMass Amherst.) Rankings of materials used in the STEM Education Summer Institute, which used nanoscience curriculum from a variety of sources. The top 3 activities (in bold) are NanoSense activities.

STEM ED/CHM Nanotechnology 2007

Summary of Nanotechnology Callback Evaluations

Two callback sessions were conducted for teachers who attended the Nanotechnology Summer Institute. During the first callback session, teachers were asked to evaluate how well activities of the summer institute could be integrated into their STEM programs. During the second callback session, teachers were asked to evaluate how well activities of the institute advanced their understanding of nanoscale science and engineering. The following data table provides a ranking based on an analysis of surveys administered at the two callback sessions.

Nanotechnology Institute Activity	Effectiveness in the Classroom	Advanced Teacher's Understanding
Going up and down the Powers of Ten scale using a variety of measurement instruments.	**1**	**2**
Determining the types of substances that can effectively act as a sunscreen.	**2**	**3**
Using playing cards, wood blocks, and alka seltzer to explore why "Size Matters".	**3**	**6**
Conducting research as a part of a societal jig saw activity.	4	9
Using disc magnets to simulate the memory capacity of computers.	5	4
Forming a nanoscale layer of oleic acid on a layer of water.	6	1
Forming a nanoscale layer of zinc metal on a copper electrode.	7	8
Manipulating a ferrofluid as a model of the delivery of nanoscale medicines.	8	5
Gelatin Diffusion as a week-long study of the affect of particle size on diffusion rate.	9	7
Evaporating a solvent to form synthetic opals from nanoscale polystyrene spheres.	10	12
Using LEGOS to construct a model of an Atomic Force Microscope.	11	10
Synthesizing a ferrofluid in a laboratory setting.	12	11