# NanoSense: The Basic Sense behind Nanoscience

## YEAR 4 REPORT: FINDINGS

**Executive Summary**

We have categorized our observations, conclusions, and recommendations from the fourth year of the NanoSense grant in terms of 3 main findings: External evaluation of the June 2007 NanoSense teacher workshop, participant evaluations of the workshop, and NanoSense web site statistics. These findings are summarized below and described in more detail in the body of the report. Data from the classroom implementations are currently being analyzed and will be reported in the final project report, to be submitted in 2-3 months.

*External Evaluation of June 2007 Teacher workshop*. Over the four days, 11 workshop participants engaged in a number of workshop activities, including hands-on labs, group activities, and individual reports. The activities were well received, although some were too long for the time allotted. Participants report time as the biggest impediment to classroom implementation.

*June 2007 workshop participant evaluations.* In a post-workshop survey, virtually all of the participants reported that the workshop was interesting and a good use of their time, that the content was of value and they planned to use it in their classes (with adaptations for their students' needs). The most frequently mentioned recommendations related to improvements to the Fine Filters lab procedures (which were been implemented).

*Classroom implementations*. Data from six classroom implementations are currently being analyzed, and will be reported in the final project report.

*Web statistics on downloads*. The NanoSense Web site has received over 225,000 requests since it opened in February 2005. It receives about 200 requests per day on average, the vast majority (about 90%) of which are for specific NanoSense lessons posted on the site.

### Finding 1: External Evaluation of the June 2007 Teacher Workshop

**Report on the June 2007 NanoSense Workshop for High School Teachers held at San Jose State University by External Evaluator, Ellen Mandinach, Center for Children and Technology**

The staff from the Nanosense Project at SRI convened a four-day workshop at San Jose State University for interested Bay Area science teachers. The SRI staff consisted of PI Dr. Patricia Schank, Tina Stanford, and Dr. Alyssa Wise. They were ably assisted by Dr. Maureen Scharberg of San Jose State University, Doris Mourad of the Castella School in Palo Alto and Maria Powell of Gunn High School in Palo Alto. A dozen teachers attended all or part of the workshops, including one university instructor and one community college instructor.

The four days consisted of several types of activities. First, there were formal presentations by staff members. Second, there were hands-on laboratory activities. Third, there were small group activities and group projects. Fourth, there were individual reports. Finally, there was a guest speaker. In addition, time was spent with debriefing and feedback sessions with the external evaluator and individual interviews with workshop participants to obtain valuable information about perceptions of the workshop, its activities, and to provide feedback to SRI on the materials and the structure of the workshop.

The presentations and laboratory activities were well received by the participants. They were engaged and enthusiastic. The participants eagerly asked relevant questions and seemed motivated by the materials. Some minor issues occurred with the laboratories. Participants expressed confusion about some of the instructions and the feedback was passed on and noted by SRI staff. The impression of the evaluator was that the laboratories were engaging and interesting, but some of the activities were far too long to be used in their entirety with students. The labs will have to be customized to academic schedules or even demonstrated in front of the class rather than having students approach the tasks hands-on. An issue raised by many of the participants was the potential costs of the materials needed to conduct the laboratories. Teachers' material budgets are constrained and additional costs required of the materials may surpass the benefits of doing the activities. To that end, one participant asked if there were potential funding sources or grants that they might seek to provide the needed monies for the activities.

The small group activities were a hit. It was obvious that the teachers were engaged and interested in the work. These activities culminated in presentations on the last day of the workshop. Although the participants were pretty drained by that time, everyone gave 100% effort and the audience received the materials with interest, asking challenging questions about content and pedagogy. Individual projects were similarly well conceived and executed. The observation that could be made about the projects and presentations was that there was a noticeable lack of hard feedback from project staff on the substance and the pedagogy. It is hard to imagine that the participants understood all the content to the point that no constructive feedback was needed. Similarly, no difficult questions were asked by staff about how the materials would be used, integrated, and taught. The projects seemed to be more of an engaging and motivational tool. This observation might also be due to time constraints. The project reporting was left to the last day with not enough time devoted to the presentations and discussion. Additionally, people were pretty well exhausted by the time the presentations occurred. If future workshops are to occur, better time management for the presentations would be beneficial.

Similarly, having the lunch speaker on the final day was probably not the best use of time for the project staff and participants. Frankly, the speaker was not engaging and failed to deliver his message in an effective way.

The external evaluator conducted a debriefing on the second day of the workshop and again at the very end, constrained by time. She also individually interviewed each participant. The objectives of the debriefings were to provide feedback to SRI on the materials and the activities, and gain insight into what the challenges to and opportunities surrounding the implementation of the lectures and laboratory activities would be. The objective of the interviews was to obtain information from participants specifically to address some of the needs of the National Science Foundation. There were two specific needs. First, questions were asked about the probability that the activities would be used in the coming year and whether it would be possible for project staff and/or the evaluator to observe and collect data about classroom and student level reactions and impact. The second question focused on diversification. There is a concern that the materials may be useable only for the most advanced high school students.

All but one of the participants welcomed the idea of having staff and the evaluator visit their classes when they use the nanoscience materials in the coming year. The one reluctant participant admitted that she would not be in the classroom next year. All of the participants saw the applicability of the activities and materials, but expressed the need to customize them to their

particular needs. Despite saying how good the Power Points slides were, the participants did not feel that they could use everything as a whole for a variety of reasons: they would take up too much time, had an unclear fit with standards, they strayed too far away from the existing curricula to which they had to teach, the could not be used until after accountability measures such as the SAT2 or Advanced Placement tests were administered, or that they preferred to excerpt relevant aspects of the materials. The participants definitely recognized the potentials of the materials and would enthusiastically adapt them to their needs next year.

In terms of the diversity issue, some of the participants teach only high-level courses, whereas others have a diverse teaching load and were willing to implement the materials into lower-level courses. In only two instances were there participants where there were no opportunities to reach a diverse student populations. In one public high school, the student population was almost exclusively upper middle to high SES. This high school had over 50% Asian American students who were highly motivated and had rather aggressive parents in terms of student advocacy and input into what the teaching staff does. In the second instance, the participant was a teacher as a very high end private school. When asked about diversity, his response was: "Oh yes, we have diversity. There are the rich, the richer, and the richest." All other participants had teaching circumstances in which there was ethnic, language, and special needs diversity. In fact, a teacher at perhaps the school that has the highest academic rating, taught science to special needs students, had used the Nanosense materials with them with positive results, and would enthusiastically use the materials again to reach these students.

In sum, the workshop was a success in many respects. First and foremost, it brought awareness of the topic to motivated educators who will adapt and use the materials and activities in their classes. Second, it gave SRI staff yet another opportunity to pilot their materials and receive feedback on their applicability. Third, the participants were motivated by the thought that they would be teaching a cutting edge topic, but were sobered by the many realities and practicalities that face teachers in this age of accountability. There is very little wiggle room in today's curriculum when teachers are increasingly being forced to teach to the tests. That means that they have little room in the academic year to introduce new and innovative materials, no matter how good they may be. The teachers struggled a bit when asked to link the nanoscience topics to specific science standards. If the materials don't easily fit the standard, then it is difficult for teachers to make a compelling case to administrators for their use, especially when other teachers who are teaching the same courses are not using them. The biggest impediment is TIME. There simply is not time. This is not the first instance nor will it be the last where excellent resources have been provided to willing and motivated teachers and the practical challenges become too much for the teachers to effectively use the materials. In particular, it will be difficult for the teachers to use all the materials as originally developed. Perhaps a reasonable suggestion for SRI staff to consider is how to provide a guide to excerpted materials as they more broadly disseminate the resources. Good teachers do this as they recognize how materials can be customized for their needs. However, some teachers might struggle with this customization and a roadmap provided by the developers might assist less gifted and astute educators. It will make the materials more broadly useable. On the whole, it is safe to say that the four days at San Jose State provided excellent learning experiences for participants and project staff. They were days well spent.

**Finding 2: Participant Evaluations of June 2007 Teacher Workshop**

Participants were asked to complete a workshop evaluation survey at the end of the four-day workshop. Fourteen teachers pre-registered, 11 teachers attended, and 10 completed surveys were collected. Participant responses are summarized below. Virtually all of the participants reported that the workshop was interesting and a good use of their time, that the content was of value and they planned to use it in their classes (with adaptations for their students' needs), and that they were fine with us contacting them about their use of the materials and future NanoSense professional development opportunities. The most frequently mentioned recommendations related to improvements to the lab procedures and to the Fine Filters unit.

*Teacher Demographics and Background*

Eleven teachers from 10 different schools attended the workshop. All of the teachers were from the San Francisco Bay Area, most within 20 miles, but some came from as far away as Walnut Creek and Castro Valley. Nine attendees were women, and 2 were men. All participants taught high school except for two who taught at the college level. Biology, physics, and integrated science were the most frequently taught subjects, but chemistry and geoscience were also represented (see Chart 1).

**Chart 1: Teacher Demographics**

| Grade Level Taught | | Courses Taught* | | Gender | |
|---|---|---|---|---|---|
| Grade | Number of Teachers* | Biology/Biotech | 5 | Female | 9 |
| 9 | 8 | Physics | 4 | Male | 2 |
| 10 | 6 | Chemistry | 2 | | |
| 11 | 5 | Integrated/Gen Science | 3 | | |
| 12 | 5 | Geoscience | 1 | | |
| College | 2 | | | | |

* Note that teachers often taught multiple grade levels and courses.

Participants had, on average, 10 years of teaching experience, ranging from 3 years to 18 years for two teachers. Half of the participants had previous experience with nanoscience. The teachers teachers who reported some background mentioned exposure at a conference (2), working in a nanofabrication facility (1), and a one-day workshop or seminar (2). The most common college major represented was biology (see Chart 2).

**Chart 2: Teacher Background**

| Years of Teaching | | Previous Experience with Nanoscience? | | College Major | |
|---|---|---|---|---|---|
| Mean | 10.1 | Yes | 5 | Chemistry | 1 |
| Median | 10 | No | 5 | Biology | 5 |
| Min | 3 | | | Physics | 2 |
| Max | 18 | | | Mechanical Eng. | 1 |

*Workshop Feedback*
Overall, participants liked the workshop, found it well-organized, interesting and a good use of their time. A breakdown of responses to specific questions is shown in Chart 3, and written responses are summarized below.

**Chart 3: Summary of Overall Workshop Feedback**

| | Yes | Somewhat | No | No Response |
|---|---|---|---|---|
| **Did you like the workshop?** | **8** | 0 | 0 | 1 |
| **Was it interesting?** | **8** | 0 | 0 | 1 |
| **Was the workshop well organized?** | **7** | 2 | 0 | 0 |
| **Was the workshop a good use of your time?** | **8** | 1 | 0 | 0 |

*What did you like best or find most useful about the workshop?*
Teacher generally like the materials, mixture of presentations, hands-on activities, and working with colleagues:

- You provided so many resource binders, engaging and thought-provoking powerpoints, and broke us up into labs to help us be engaged. I loved it!
- I found the sunscreen unit really awesome because it directly correlated size of nanoparticles with an observable difference in physical properties.
- Labs.
- Mix of lecture and lab activities. Was great to allow a "pick and choose" for adapting to curriculum.
- Presentations and labs that to into detail, solar cells, water, and sunscreen.
- Animations, CD with all items.
- Powerpoints, labs, opportunity to work and talk with other teachers.
- I gained awareness of applications and unlikelihood of "nano robots".
- All the materials, and how to use them. Sharing ideas with colleagues.
- The binder of materials and powerpoint presentations was very useful. The lab activities were helpful in reinforcing the concepts presented in lecture—especially the nanocrystalline solar cell lab.

*What changes would you make to the workshop to make it better next time?*
Teachers most frequently requested more clarity in lab procedures and limiting labs to those that work reliably and are most relevant. On teacher thought we tried to cover too much material, and another suggested subdividing activities more clearly by grade and content area.

- The only issue was providing more clear instructions in the lab stations. The materials we often had to find or were hard to use.
- I didn't find the filtering activity very helpful.
- Some of the experiments didn't actually work, e.g., nanofiltration.
- Limit lab activities to one that work and ones that are most relevant.
- Too much material. Slow down! Have teaching materials (water unit) complete before us trying it.
- Have each teacher be able to take home necessary equipment for one of labs.

- Improve on water filtration lab, show more details (graphics) on hw nanowater filters work, and what they are made of. Station lab for water should be timed so each is the same # of minutes.
- Perhaps consider sub-dividing activities based on either academic grade (LS, MS, HS) and/or subject content area (bio, chem., physics, geosciences).

*What topics did you find the most interesting?*
Teachers most frequently mentioned the sunscreen (7) and solar cell and energy (6) activities and presentations:

- Solar cell lab, water as a resource powerpoint, energy powerpoint, sunscreen.
- Sunscreen, solar cells—liked the correlation to energy crisis in the world, make it more relevant.
- Applications, easy labs for in class or lab.
- Physical properties that change at the nanoscale. Nanosunscreens and sunscreens in general. Solar cell lab and presentations.
- Solar and sunscreen.
- Sunscreen.
- Electromagnetic spectrum.
- Clean energy—solar cell lab.
- All of it, especially the powerpoints. Size Matters, teacher presentations, sunscreen absorbance.
- Nanocrystalline solar cells.

*What topics were least interesting?*
Several teachers were unclear on the relevance or benefit of the nanofiltration unit (4). A couple of teachers mentioned elements of the sunscreen unit as being less relevant to them (3).

- Nanofilters… didn't feel the same clarity connecting "why nano is better for this filter"… I wanted to hear more about unique properties of nanofilters other than they're small holes.
- Consumer choice pamphlet—which is fine because it is not the most appropriate for college students.
- Not sure I understand nanofiltration benefits.
- Water.
- Filtration of water.
- Nano sunscreen.
- None were not interesting. However, some lacked sufficient detail to soundly apply the scientific principles under study. Ex: Sunscreen unit didn't cover enough about photon energy principles.

*What would you change about the workshop organization?*
Two teachers reiterated how much they liked the workshop; two reiterated improving labs, and one suggested sticking to the times in the agenda better:

- Good job adjusting in response to time needs. Good job starting and ending on time and respecting us!
- We did run out of time on some exercises.
- Try out lab activities beforehand.

- Stick to the times better. Have lab materials better organized.
- Exceptionally well organized! The weekly outline was very helpful and the wealth of materials invaluable! The congenial atmosphere made the seminar enjoyable and conducive to learning. Thank you! Good Job! Also a big thank you for your consideration of dietary choices for those of us who did not consume the "S.A.D" (standard American diet)! Thank you! Thank you! Thank you!

*What improvements need to be made to make this workshop a better use of your time?*
Most teachers left this blank; two made positive comments, one mentioned a desire for wireless internet access, and another mentioned some labs could have been shortened.

- Loved the constant food!
- Need wireless access.
- Some things could've been shortened. Some of the labs could have been abridged.
- None, it was great.

*Feedback on Content and Materials*
Overall, participants found the content to be of value and planned to use the materials in their classroom, with some minor modifications to adapt them to their particular students' needs. Most felt the explanations given for understanding the scientific ideas were sufficient, but some felt that a few parts were still confusing. A breakdown of responses to specific questions regarding the materials is shown in Chart 4, and written responses are summarized below.

**Chart 4: Summary of Feedback on Content and Materials**

| | Yes | Some what | No | No Response |
|---|---|---|---|---|
| **Was the content of value?** | **9** | 1 | 0 | 0 |
| **Do you plan to use the materials in any of your classes?** | **7** | 3 | 0 | 0 |
| **Was sufficient explanation given for you to understand the scientific ideas being presented?** | **6** | 4 | 0 | 0 |
| **Were there parts of the workshop that were confusing?** | 1 | **5** | 3 | 1 |
| **Are the materials in their current form useful for you in your classroom?** | **6** | 4 | 0 | 0 |

*What one or two ideas from the workshop do you feel most likely to apply, and how?*
The most frequently mentioned were, in order, the solar cell activities (6), various activities from the size matters unit (5), sunscreen activities (4), and water activities (2):

- Nanocrystalline solar cells and lab, and all activities relating to estimating orders of magnitude.
- Size matters: whole unit, bringing a new unit to metric system, and the nano properties of sunscreen.
- Size Matters activity, solar cell activity: I will try to use glass from LCD displays such as old calculators. Scanning probe microscopes.
- Size Matters, electromagnetic spectrum.
- Energy—nano solar cell—I will use when teaching about photosynthesis.

- Solar, in physics after electricity unit, and sunscreen, in chemistry after electron structure unit.
- Refer to nanoscale, solar cells, absorption by sunscreen ingredients.
- Water labs and solar cell.
- Water as a resource, solar cell lab, sunscreen.

*If you do not plan to use the materials in any of your classes, what are your concerns?*
Most teachers left this blank. One mentioned available time and need to cover existing content standards, two others mentioned that they would use and modify pieces as needed for their classes:

- Time restraint for using all? Concern for covering content standards.
- I'll use it (solar cell lab) after STAR testing—but it needs a good bit off scaffolding.
- I will use powerpoints and activities but will modify.
- Probably more in pieces and not in intact units. So, I'll apply it when it has relevance to biology.

*For which sections/topics would you have liked more explanation?*
Most teachers reported that the explanations were adequate and their questions were answers, but a few wanted more coverage of specific topics from physics and chemistry, and more explanation of the benefits and mechanisms of nanofiltration.

- All questions answered.
- Most was adequate. However, more coverage of heat transfer mechanisms, E-M radiation transfer and particle interactions—especially absorption, emission, and scattering in photon energy exchange.
- The physics and chemistry were a little fast for me. I need to do more homework.
- Nanofiltration benefits or principle of operation.
- Alyssa was great whenever I had any specific scientific Q's… in some cases, info was given so quickly that it was hard to assimilate at one time. I'm a little rusty on physics and electrochem.

*If you found parts of the workshop confusing, which parts were they?*
The labs instructions were most frequently mentioned as not being clear. Teachers also mentioned the need to understand topics in multiple subject areas (bio, chem, physics):

- Water filtration lab. Not sure if we used the small filters correctly.
- As indicated above, more detail is needed on energy transfer mechanisms (radiation, absorption, emission, scattering). The sunscreen unit needs more on background information and explanation of terminology germane to physics of interactions.
- Bio and chem. Since there are physics and we all have different knowledge and experience, so some things were hard to follow.
- Some labs were not clear.
- The reflections on each day—we had some confusion if we needed 3, one for each day, or just one.
- Lab station instructions and location of equipment.
- I asked later but we didn't talk at the time about why nanosized TiO2 particles are necessary (as opposed to non-nano) for nanosolar cells. The filtering directions were unclear. I don't quite understand why or what forces move electrons in the solar cells

(i.e., what pushes/pulls them through circuits).

*If the materials in their current form are not useful for you in your classroom, explain why.*
Generally, teachers mentioned that they always adapt materials for their classes; some specifically mentioned needing to adapt and clarify the labs:

- I will need to modify a few to make them suitable for the high school physics classes I teach.
- I will always adapt materials. That is a "given".
- Will do some editing to meet my and student needs.
- Labs need to be rewritten and shortened and clarified.
- Would not be able to dedicate a lot of time to each topic, but will easily pick and choose from lecture and lab resources.
- Thanks for the e-copies!

*How can the developers make the materials more useful?*
Generally, the teachers found the materials fine as is. One noted that we should index them by grade and subject area, another that we should add tabs to the binders, and a third that activities be indexed to California standards. (Note that the NanoSense team has already begun the creation of a "roadmap" of the materials by topic area.):

- This is great. I will definitely use them.
- Implement the suggestions I've made throughout this evaluation form: (1) Group activities by grade and/or subject content area (color code tabs for lab activities), and (2) expand discussion of physics of nano structure of materials.
- Nothing; both hard and electronic materials are provided.
- As long as given in form that can be edited.
- Good as is—a teacher may always need to change based on type of class and level (honors, regular).
- Tabs on the binders.
- Tailor it to specific classes in CA K-12 system.
- I haven't looked at all of them, but they look excellent, thorough, and very user friendly! Thank you!

*Follow-up Feedback*
All participants were fine with us contacting them about their use of materials in the classroom and with information about other NanoSense professional development opportunities, as shown in Chart 5. For those who said "maybe" or did not respond to the third question about becoming more involved in developing curriculum—clearly a greater level of commitment—time availability was mentioned as the core constraint ("Yes but no time", "possibly, depends on time availability").

**Chart 5: Summary of Follow-up Feedback**

| | Yes | Maybe | No | No Response |
|---|---|---|---|---|
| **We are interested in hearing about any experiences you have using NanoSense materials in your classroom. Would it be okay for us to contact you about this?** | **10** | 0 | 0 | 0 |
| **Would you like us to contact you with information about other NanoSense professional** | **10** | 0 | 0 | 0 |

| | | | | |
|---|---|---|---|---|
| **development opportunities for teachers?** | | | | |
| **Are you interested in becoming more actively involved in developing nanoscience curriculum?** | **6** | 1 | 2 | 1 |

**Finding 3: Classroom Evaluations**

In spring 2008, the four NanoSense units were implemented in six classrooms (see Activity 3). Data from these implementations is currently being analyzed, and will be reported in the final project report, to be submitted in 2-3 months.

**Finding 4: Web Statistics**

The NanoSense Web site has received over 225,000 requests (with web "spiders" filtered out) since it opened in February 2005. On average, the site receives about 200 requests per day. The overwhelming majority of referring URLs are from Google searches. The top search terms (often used in combination with each other) are: nanosense, electrical properties, nanoscience, solar, nano, sunscreen, properties, and nanorobot.

Requests for the NanoSense homepage account for about 5% of web site activity, followed by requests for the Size Matters unit (4%), an overview of all NanoSense activities (2%), requests for the Clear Sunscreen unit (2%), workshops (1.5%), and papers (1%). The vast majority (about 90%) of requests are for specific NanoSense lessons posted on the site. Note that requests from SRI staff and web indexing robots are excluded from these analyses; that is, the reported site statistics aim to reflect requests from legitimate third parties.