Global NSEE Workshop
Nanoscale Science and Engineering Education
2008

A Report of
The Global Nanoscale Science and Engineering Education Workshop
Washington, DC
November 13-14, 2008






Table of Contents

Appendices

Acknowledgements

The GNSEE team gratefully acknowledges the funding and visionary leadership of the National Science Foundation (NSF) and thanks them for the honor of organizing this essential event.

We would also like to thank…

…Sir Harry Kroto, Nobel Laureate, 1996, for his inspiring, interactive plenary presentation and for gracing us with his company and insightful comments throughout the Workshop;

…the speakers who set the tone and expectations for this event: Dave Ucko, Mike Roco, R.P.H. Chang, Fuh-Sheng Shieu, and Christophe Vieu;

… our panelists for sharing their critical insight and sparking our conversations: Lynn Bryan, Michael DeMiranda, Luis Fuentes, James Hone, Tadashi Itoh, Joseph Krajcik, Frances Lawrenz, Sebastian Lourdudoss, Paul Martin, Teri Odom, Jim Pellegrino, Christine Reich, John Ristvey, Jr., Linda Schadler, Martin Schubert;

…all of the members of the NCLT for their many contributions to this event and to the NanoEd Resource Portal;

…the Guardians of Honor team for their attention to detail in executing this event;

…Sarah Dugan and Jennifer Shanahan for the photographs;

…Melinda Wong and Megan O'Sullivan for their assistance in the Workshop planning and editing of this report.

We look forward to many more Workshops!

The GNSEE Planning Committee,

R.P.H. Chang, Chair, *Northwestern University* (NCLT)

Larry Bell, *Museum of Science in Boston* (NISE)

Joseph Krajcik, *University of Michigan* (NCLT)

Mark Tuoimen, *University of Massachusetts* (NSEC)

John Ristvey, *Mid-Continent Research for Education and Learning* (NIMD)

Frances Lawrenz, *University of Minnesota*

Manuel Gomez, *University of Puerto Rico* (EPSCoR)

Craig Hawker, *University of California at Santa Barbara* (MRSEC)

James Yardley, *Columbia* University(NSEC)

Executive Summary

The Nanoscale Science and Engineering Education (NSEE) community assembled recently for its third annual Workshop exploring the opportunities for and challenges of communicating nanoscale science and engineering (NSE) to students, educators, and the general public. The Global Nanoscale Science and Engineering Education (GNSEE) Workshop took place near Washington DC at the Key Bridge Marriott in Arlington, VA on November 13-14, 2008. In attendance were 140 educators and researchers in the formal and informal nanoeducation sector. In an effort to reach an even broader audience, for the first time this Workshop was presented via a live-webcast to individuals and groups across the globe. By the first day of the event, 91 people had registered for the live, online viewing. On-demand webcasting is still available for those unable to attend the Workshop in Washington DC. Archived webcasts as well as PowerPoint presentations and the full transcripts from this Workshop can be found at www.nclt.us.

The first two Workshops in October 2005 and January 2007 established the importance of networking and collaboration in the NSEE community. Participants sought advice from one another about developing classroom resources, situating them in crowded curricula, and promoting engagement from the public and other diverse audiences. After the second successful Workshop in 2007, NCLT and NSF decided to expand the Workshop this year to include global participants who bring their unique, international perspectives. Advances in nanoscience and nanotechnology are creating a surge in the demand for nano-literate workers all over the world. Responding to this global workforce challenge, it is critical to bring together these educators and scientists to develop best practices in NSE curriculum development, professional development and educational research to equip and engage the next generations in NSEE.

The National Science Foundation (NSF) currently supports multiple Nanoscale Science and Engineering Education (NSEE) projects that (1) develop and research instructional resources for grade 7-12 students and their teachers, (2) develop and research undergraduate NSE programs, (3) promote public education and NSE engagement through museum exhibits, media presentations, and web sites, (4) offer outreach programs in conjunction with NSE research centers, (5) provide nano research opportunities to teachers and students, and (6) study the impact of these NSEE efforts. These goals, along with the previous two Workshops, helped define the purpose and program for the 2008 Workshop.

R.P.H. Chang and Sir Harold Kroto

The agenda for addressing the global workforce and education challenge is to establish a strong collective approach for developing standards, curriculum and outreach in Nanoscale Science and Engineering Education (NSEE). NSEE is one of the key educational agendas unifying scientists and educators, within interdisciplinary working relationships, to establish key "Big Ideas" in nanoscience and to contextualize these nanoconcepts for the classroom and general public. The ultimate aim is to create a nano-literate workforce and society that will remain competitive in the 21st Century. The Workshop began with a plenary presentation by Sir Harold Kroto, Nobel Laureate, 1996.

The remainder of the Workshop consisted of information sharing through speakers, panel presentations, poster sessions and breakout discussions.

This Workshop connected key leaders from various regions across the globe to advance collaboration and networking on major NSEE initiatives. The goals of the GNSEE Workshop were:

- to generate a systematic approach to assessment and program evaluation;
- to promote the development of curriculum and activities based on best practices and learning research;
- gain knowledge of cutting-edge research to infuse in STEM curriculum and public outreach programs;
- encourage more interactivity between formal and informal education initiatives as well as those addressing societal implications.

The primary and overarching finding of this Workshop is the need for an expansive community, preferably online, to share resources and build excitement around nanoscale science and engineering in education, research, and the general public. In order to bridge the gap between educators and researchers in the NSEE community, there must be engagement at all levels including students, researchers, teachers, and the general public. Among the key recommendations to emerge from the breakout sessions were techniques and strategies to achieve this engagement. A list of recommendations can be found in Section 4 of this report.

Participants

In attendance were 140 researchers, scientists, educators, evaluators and others interested in nanoscience from the United States and 13 other countries (see Appendix 1 for full participant list). Participation at the Workshop was by invitation only. Many veterans of these NSEE meetings felt that this one was the most interesting and best organized. It was energized particularly by the addition of the international dimension. For the first time this year, the Workshop was available over the web as well. Online, 91 people registered in advance to view the live webcast version (See Appendix 2 for webcast participant list). Since the Workshop began, an additional 33 people registered to view the archived versions (as of 11-18-08).

Kristy Brumfield of LSU and Emily Weiss of Northwestern University

R.P.H. Chang and the GNSEE Planning Committee worked conscientiously to assemble a diverse group of attendees from both formal and informal nanoeducation practices from around the world with an emphasis on diversity of gender, ethnicity, career level, discipline, and age. Age was stressed for its importance to gain the youth's attention of such a critical initiative. It is essential for young people to be involved and share new, innovative approaches to nano.

Program Highlights

The Workshop was designed to meet the above mentioned goals. Day 1 began with a plenary presentation by Sir Harold Kroto, Nobel Laureate, 1996. The remainder of the Workshop consisted of information sharing through speakers, panel presentations, poster sessions and breakout discussions.

The Workshop generated valuable insights and perspectives from global nano researchers and educators. For example, the French speaker, Christophe Vieu, described his work integrating nanoeducation with socially acute questions. German panelist, Martin Schubert, presented his work from the German Network of Excellence and its experimental nanotechnology kits being used in high schools. Fuh-Sheng Shieu of Taiwan, a nation leading in nano, described their abundance of formal and informal learning materials for the pre-college level, including comic books, video games, and even Braille instructional materials. Luis Fuentes, from Mexico, told about how his city of Chihuahua successfully implemented nano into their classrooms using the Materials World Modules (MWM). At the higher level, Sebastian Lourdudoss from Sweden, explained how they train advanced graduate students and inform the public through television and newspapers.

Program highlights are given below. The full Workshop program can be found in Appendix 3. The two day agenda included two speaker sessions to begin each day, four panels, four poster sessions, two breakout sessions, and two report back sessions.

Archived versions of the webcast as well as the PowerPoint presentations of the following speakers and panels can be found on the NCLT website at www.nclt.us.

Speaker Session I: Welcome

- *Welcome & Meeting Overview*
  Dave Ucko, Education and Human Resources Directorate, National Science Foundation
- *Overview of Nanoscale Science & Engineering Effort*
  Mike Roco, Senior Advisor for Nanotechnology, Directorate for Engineering, National Science Foundation
- *Vision on Global NSEE*
  R.P.H. Chang, Northwestern University

Plenary Presentation by Sir Harold Kroto

Plenary Presentation

- *Number Patterns in Nanoscience*
  Harry Kroto (Nobel Laureate, 1996), Florida State University and University of Sussex

Panel I: Cutting-edge Nano Research & Concepts

- *"Measuring the Mechanical Properties of Carbon Nanostructures Using Simple Physics"*
  James Hone, Associate Professor of Mechanical Engineering at Columbia University. Hone's current research interests include synthesis, characterization, manipulation, and applications of carbon nanotubes; graphene; nanomechanical devices; and nano-biology.

- *"Nanoscale Patterning: Plasmonic Structures"*
  Teri Odom, Associate Professor and Dow Chemical Company Research Professor at Northwestern University. Odom 's research focuses on controlling materials at the 100-nm scale and investigating their size and shape-dependent properties.

Panel II: International Perspectives on Formal & Informal NSEE Programs

- *"Mexico and Nanoscience Education"*
  Luis Fuentes, Senior Researcher of the Advanced Materials Research Center, Chihuahua, Mexico. Fuentes' research field is Crystal Physics, as well as science education activities focused on Electromagnetism and Crystallography.

International Panelists

- *"International Concept on Nano-science and Nano-engineering Education and Research Training"*
  Tadashi Itoh, Professor, Division of Frontier Material Science, the Graduate School of Engineering Science, Osaka University, Japan. Itoh specializes in experimental research works on laser spectroscopy of nano-structured materials.

- "*Experimental Kit: Chemical Nanotechnology"*
  Martin Schubert, Managing Director, Competence Center cc-NanoChem e. V., Germany. Schubert studied physics and received his doctorate in solid-state-physics within a research program called Phenomena at Miniaturization Limits.

- *"International Perspectives on Formal and Informal Nanoscale Science Engineering and Education Programs"*
  Sebastian Lourdudoss, Professor, Semiconductor Materials, School of Information and Communication Technology, Royal Institute of Technology, Sweden. Lourdudoss' current interests are monolithic photonic integration on InP and III-V's on Si for nanophotonics and optical interconnects.

Panel III: Nano Education Research/Assessment Practices/Evaluation

- *"Learning Research in Nanoscience"*
  Joe Krajcik, Professor, Science Education and Associate Dean for Research in the School of Education, the University of Michigan. Krajckik works with teachers in science classrooms to bring about sustained change by creating classroom environments in which students find solutions to important intellectual questions that subsume essential learning goals and use learning technologies as productivity tools.

- *"Evaluation for Formal and Informal Nanoscience Curricula and Activities"*
  Frances Lawrenz, Psychological Foundations and Quantitative Methods in Education, Associate Vice President for Research, University of Minnesota. Lawrenz has numerous publications including 90 refereed publications, 29 monographs/chapters, four curriculum projects and 175 evaluation reports. She presently is working on five funded evaluation projects.

- *"NISE Network. Evaluation of Nanoscale Informal Science Education Experiences"*
  Christine Reich, Manager of Informal Education Research and Evaluation, Museum of Science, Boston. Reich's efforts continue to focus on issues related to equity and access in museum learning environments, with a particular focus on universal design and female engagement in engineering design activities.

- *"Using Construct-Centered Design to Align Curriculum, Instruction, and Assessment Development in Emerging Science"*
  Jim Pellegrino, Liberal Arts and Sciences Distinguished Professor and Distinguished Professor of Education, University of Illinois at Chicago. Pellegrino's research and development interests focus on children's and adult's thinking and learning and the implications of cognitive research and theory for assessment and instructional practice.

Speaker Session II: International Programs in Nanoscience Education

- *Nanotechnology Human Resource Development in Taiwan*
  Fuh-Sheng Shieu, Director, Program Office of National Nanotechnology Human Resource Development, and Distinguished Professor, Department of Materials Science & Engineering, National Chung Hsing University, Taiwan. Shieu's research interests include thin films and coating technology, electron microscopy, nanomaterials and functional materials with emphasis on transparent conducting oxides and membrane electrode assembly for fuel cells. In addition to materials research and education, he has actively involved in nano-education for K-12 teachers and students in central Taiwan since 2003.

- *Nanotechnologies at School: A New Approach Combining Scientific Knowledges and Ethical Issues*
  Christophe Vieu, INSA de Toulouse & Nathalie Panissal, University of Toulouse, France. Vieu's field of interests are: Nanopatterning, Biopatterning, Nanoscale devices and tools for biodetection and medicine, education in Nanotechnologies. He is also responsible for a bio-nano-technological platform of the Institute of Advanced Technologies for Life Sciences (ITAV), recently created at Toulouse close to the Canceropole.

Panel IV: Best Practices in Curriculum/Course Development/Outreach to General Public

- *"Rensselaer's NSEC for Directed Assembly of Nanostructures Nanotechnology Curriculum Development Institute"*
  Linda Schadler, Professor, Materials Science and Engineering Department, Rensselaer Polytechnic Institute. Schadler received a B.S. in materials science and engineering and a PhD in materials science and engineering.

- *"Best Practices in NanoLeap"*
  John Ristvey, Principal Consultant, Education and Public Outreach, Mid-continent Research for Education and Learning (McREL). Ristvey specializes in technical and science education expertise, instructional materials design, and professional development.

- *"The New…Engineering and Technology Education Partnership. Engineering as the core for Technology Teacher Education for the 21st Century"*
  Micheal DeMiranda, Professor, Engineering Education in the School of Education and College of Engineering, Colorado State University. DeMiranda's expertise in engineering and technology education focuses in the areas related to curriculum selection and use of cognitively-based instructional strategies, materials, and activities that support the integration of science, technology, engineering, and mathematics (STEM) in K-12 classrooms.

- *"Best Practices for the Professional Development of Teachers in Nanoscale Science and Engineering"*
  Lynn Bryan, Professor, Science Education, Purdue University. Bryan is a science educator who has conducted research, teaching, and engagement activities in numerous countries including China, Mexico, Honduras, Japan, and the Philippines.

- *"NISE Network. Nanoscale Informal Science Education"*
  Paul Martin, Vice President for Exhibits, Community Outreach, Science Museum of Minnesota. Martin has been involved in the evolution of exhibitions as a medium for engaging visitors in interactive learning through many innovative museum and exhibition projects.

Poster Session I: Perspectives on Cutting-edge Nano Research & Concepts

Workshop participants during poster session

- "Manipulation of Light in the Nanoworld"
- "Introduction to the Nanoscale: Inquiry into Surface Area and Volume"
- "Student conceptions of size and scale: mapping understanding in the nanoscience context"
- "Lightwave for the Nano World"
- "Interactive software and design projects for teaching critical concepts in nanoscale science and technology"

- "The Two-Year Associate of Applied Science Degree Program in Nanotechnology at Forsyth Technical Community College"
- "Ultra sensitive nanostructured metal oxide gas sensors"
- "Interactive Web-based Multi-scale Engineering Education on Micro-Nano Biomedical Devices"
- "Atomic force microscopy nanomachining for the fabrication of metal nanostructures and its use as a platform for nanolithography education"
- "Bringing Upper Undergraduate Courses to the 21st Century: Integrating Nanoscience Concepts and Skills in the Intermediate Physics and Physical Chemistry Laboratories"
- "NCLT Nanoscholar Research in Nanomedicine"
- "Intrinsic Friction Analysis - A Nanoscopic Method to Extract Submolecular Mobility Information from Complex Organic Structured or Amorphous Systems"
- "Progress in Synthesis of Centimeter Long Aligned Carbon Nanotubes"
- "Thermal Properties of Nano-Scale Materials"
- "Manifestation of the electron-electron interactions in time-resolved ultrafast pump-probe spectroscopy in $\mathbf{C}_{60}$ Theory"
- "Super-strong anisotropic aligned carbon nanotube dry adhesives"

Poster Session II: Nano Education Research/Assessment Practices/Evaluation

- "Student understanding of surface-area-to-volume ratio and its relationship to property change at the nanoscale"
- "NanoSense: The Basic Sense Behind Nanoscience“
- "3 Years of Teacher Nanoeducation Professional Development"
- "An instrument to assess attitudes and perceived knowledge about nanotechnology"
- "Engaging middle school students in collaborative, problem-solving using nanotechnology and electron microscopy"
- "Graduate-level Career-up Programs in Nanoscience and Nanotechnology"
- "Implementing an Undergraduate Interdisciplinary Concentration in Nanomaterials Science and Engineering at Rutgers University"
- "Assessing the Impact of an Introductory Course on Nanotechnology for Freshmen"
- "The College of Nanoscale Science and Engineering at the University at Albany: A New Partnership Model for Education in Nanotechnology"
- "Evaluation for Research and Development"
- "DNA Three Ways: Domain content learning and representational affordances in a middle school classroom"
- "Design First: Instructional Strategies and Tool Affordances in the Introduction of Nanoscale Self-Assembly to Middle School Learners"
- "NanoLeap Field Test Findings"
- "Nano-EDC: a project-based introduction to Nano"

Discussion during poster session

Poster Session III: Best Practices in Curriculum/Course Development/Outreach to General Public

- "A Rubric for Post-Secondary Degree Programs in Nanoscience and Nanotechnology"

- "Traveling Nanotechnologies: An Undergraduate Internship Program in Nanotechnology and Society"
- "Education and Public Engagement in the Center for Nanotechnology and Society, UCSB"
- "The Nanomedicine Explorer: A Unique Multimedia Resource"
- "Talking Nano: Nano 101 in a Box"
- "A Teaching Unit on 'Size and Scale' that makes Variations in Conceptual Understanding Salient to Students"
- "Nanoscience education for freshmen and pre-service teachers at UNC"
- "Top Down Nanoscience Curriculum Development Throughout the Undergraduate Chemistry Curriculum at James Madison University"
- "Our Nanoworld: Introduction to Nanoscience and Nanotechnology for middle and high school teachers"
- "Bringing Nanoscience to the General Public: success story of the IFN Education and Outreach Program"
- "Using nanoparticle assembled capsules (NACs) to illustrate self assembly and bottom up design on the nanoscale"
- "NUE UNIQUE: Hands-on Teaching of Nanoscale Fundamentals with the Light Microscope Equivalent of this Century - Scanning Probe Microscopy"
- "Successful High School and Undergraduate Education Programs of the Cornell NSEC Emphasize Hands-On Activities"
- "Genetically Engineered Materials Science and Engineering Center (GEMSEC)"
- "Teaching Nano with Experimental Kits in Germany"
- "Science Camps for Students who are Blind or Visually Impaired"
- "Nanotechnology Education at Colorado State University - Pueblo"
- "Nanoscience education: Curriculum/Course Development"
- "The College of Nanoscale Science and Engineering at the University at Albany - Nano High Educational Program"
- "The University of Wisconsin-Madison Nanoscale Science and Engineering Center and Discovery Center Museum Partnership: Big Ideas for Teaching Small Science"
- "Field Test Results of High School Nanoscience Curriculum"
- "The Nano-CEMMS Program for Workforce Development"
- "Utilizing Novel Methods to Engage Non-Expert Audiences in Nanotechnology"
- "Training Undergraduates in the Broader Context of the Research Enterprise"

Poster Session IV: Networking & Collaborations – NNI Networks

- "NCLT: Center Highlights and Future Initiatives"
- "Overview of NISE Net"
- "The Materials World Modules in Mexico: From Bulk to Nano"
- "NanoDays 2009, March 28-April 5 - A week of community-based educational outreach events to raise public awareness of nanoscale science and engineering"
- "Boiling Heat Transfer Enhancement Using Surface Microstructures"
- "Center for Nanotechnology"

Poster presentation: NISE Network

- "Working group of the Centers of Competence of Nanotechnology in Germany: AGeNT-D"
- "MatDL: The NSDL Materials Digital Library Pathway"
- "Emerging Nanophotonics: The European Network Of Excellence "PhOREMOST""
- "Forsyth Technical Community College, Winston-Salem, North Carolina"
- "SPEAKER DVD Presentation"
- "Global Biomimetics Network"

Breakout Session I: Engagement of Students, Teachers and General Public
Breakout Session II: Best Practices Curriculum/Course Development/Outreach to General Public

Prior to the Workshop, participants chose which breakout session they would be interested in attending. At the Workshop, each group breakout session was provided a list of questions to discuss and answer. Each group was assigned a leader and a scribe. The scribe was asked to take notes and provide a summary of their discussion at the end of the 90 minute session.

The following questions were provided to the groups for Breakout Session I:

1. From your experience, what strategies have worked the best to engage students with NSE curricula?
2. Do we have a need for a standardized model as a curriculum in academia for students who are interested in nanoscale science and technology?
3. How can we incorporate cutting-edge NSE research into STEM curricula?
4. What are the best practices/ideas for implementing nanoscale experiments?
5. What professional development is needed for teachers to successfully implement nanoscale science and concept curricula?
6. What are some specific examples of professional development strategies that have worked? What strategies have not worked?
7. What strategies have worked well to engage the general public to understand nanoscience and technology and its impact around the world? Note: The Global Nanotechnology Network has an existing strand in NSEE.

The following questions were provided to the groups for Breakout Session II:

1. What are some best practices/ideas for implementing nanoscale science in the classroom and/or to general public?
2. What resources are available for the global NSEE community to use in sharing and implementing these best practices?
3. Is there a need to form a nanoscience education community amongst a range of products and countries? If so, how can we build stronger community ties and share information among this community of nano-educators?
4. How can groups and meetings such as this collectively work together to improve STEM Education through nanoscale science and engineering? Please provide specific examples. Note: The Global Nanotechnology Network has an existing strand in NSEE.

Group Recommendations

Again, the primary and overarching finding of this Workshop is the need for an expansive community, preferably online, to share resources and build excitement around nanoscale science and engineering in education, research, and the general public. In order to bridge the gap between educators and researchers in the NSEE community, there must be engagement at all levels including students, researchers, teachers, and the general public. Among the key recommendations to emerge from the breakout sessions were techniques and strategies to achieve this engagement.



Key recommendations for the *engagement of students* included:

- Relevance – students must be able to make a connection between nano and the world around them
- Use of inquiry and design based approach is best to gain interest and prolong their attention
- Hands-on applications are critical to build self esteem
- The use of new media and technologies such as digital media models and remote instrumentation is important to capture the attention of students
- Standardization of curriculum not practical, but there should be a consistent framework
- Certificate and minor programs are preferred over degree options
- Employ early career researchers who can bridge the gap between secondary schooling and graduate work

Key recommendations for the *engagement of teachers* included:

- Continuous professional development over time with follow up throughout the year; builds self confidence in ability to teach nano materials
- Nano curriculum should be taught over longer programs instead of short experiences
- Team teaching is most successful with the use of nano case studies.
- Interdisciplinary approaches allow the students to relate and comprehend nano best
- Engaging administrators is crucial to provide faculty professional development and nanoeducation opportunities

Key recommendations for the *engagement of the general public* included:

- Use hooks including television news, hands-on demonstrations and Nobel Prize winners as star power to garner interest
- Build on the work that museums and other non-profits are currently employing
- New settings and formats such as YouTube, Nano cafes, forums and seminars are excellent ways for outreach

- Integrating nano into TV programs and Hollywood (ie CSI) would bring attention to the subject and its current uses
- The use of a clearing house to upload/download nano content and make it accessible

Implementation Strategy

The Workshop was an opportunity to consider near-term improvements to existing strategies and long term improvements for solving the challenge of bridging the gap between educators and researchers in nanoeducation. The NCLT proposes the following implementation strategy based on their review of the group recommendations. Feedback and leadership from the community is welcome.

Resource Sharing iCommunity: The main finding from this Workshop is the need for an expansive community, preferably online, to share resources and build excitement around nano. Many participants noted how much work is being done in the nano field and how that work should be shared. This virtual space, dubbed the iCommunity, will save on duplicating efforts and also aid in the speed and effectiveness of research efforts. The space will also allow partnerships to foster between research centers and informal science educations institutions to leverage expertise and resources.

Implementation: The NCLT is currently working to expand the NanoEd Resource Portal, a repository for the collection and dissemination of information for the NSEE community. Expansion efforts include: attracting more resources for those interested in NSEE, uploading more information to the site from researchers and educators, creating new applications for outreach to the community. For the NCLT iCommunity, as well as the informal educated based NISE Network to succeed, word of mouth marketing is essential. The NCLT and NISE ask that all nano educators and researchers get involved in these virtual spaces.

Community Organizers: In conjunction with the need for a more collaborative online community, there is an obligation for a tangible one as well. A prerequisite is people to head and steer these efforts while strengthening and expanding the network of students, teachers, researchers, and the general public to get involved in NSEE.

Implementation: In response to these needs, the NCLT team at Northwestern is working to identify community organizers across regions to serve as partners in their efforts. The NCLT and NISE will take the lead for both formal and informal education as they look for volunteers to serve as community organizers to head regional groups in the NSEE community; which will essentially function as working groups. Community organizers will work to build these communities in order to bridge the gaps among educators, researchers, and the general public. They will achieve this by working jointly with the NCLT and NISE to create mutually shared and beneficial relationships, ideas, and contributions. Each community will be responsible for supporting information exchange and getting visibility for their research by utilizing the NCLT NanoEd Resource Portal and the NISE Network.

Regional Meetings: The NCLT needs assistance on more local levels to encourage the use of the NanoEd Resource Portal for formal education and the use of the NISE Network for informal education as a central resource for nano educators and researchers.

Implementation: With the advent of the community organizers, there will be a need for smaller groups to meet and function. Regional meetings as well as possible future virtual meetings (due to the success of the webcast of this Workshop) will help to bring together the NSEE community.

Creating more societal awareness and a broader network of NSEE: Engaging the general public is one of the crucial steps to garner interest and gain credibility for the advancement of nanoscience education.

Implementation: Each of our newly formed regional community groups will be responsible for creating an annual event using various publicity efforts such as star speakers (ie Nobel Laureates) or young researchers. One key issue encountered is that scientists are not generally the best trained people to create media, exhibits, and other informal science education experiences. Resources that scientists produce on their own often fail to engage the intended audiences on the appropriate cognitive, emotional and/or social parameters. These newly formed regional community groups must partner with other professionals (writers, producers, exhibit designers, educators, etc) to ensure that their efforts successfully speak to the general public.

Conclusions

This GNSEE Workshop successfully met its goals, thanks in great part to the careful selection of diverse attendees from the US and all over the world who contributed diligently to the discussions and group reporting processes.

This third annual Workshop was especially beneficial this year as it was able to host global participants to gain a universal perspective. Strong representation from nanoeducators and researchers in 14 different countries opened up the opportunities for advanced collaboration and networking. Another benefit of this year's Workshop was the extended audience it was able to reach with the advent of the webcast version being available live and in archive format for all of those who were unable to attend in Washington DC.

Participants were asked to complete a survey at the end of the Workshop based on three main criteria: workshop management and logistical support, hotel and meeting facility, and the Workshop overall. Participants were asked to rank from 1-5 and provide open-ended answers. Feedback from the participants, both in attendance and via webcast, has been overwhelmingly positive. One improvement for the next Workshop will be to expand the meeting room and adjoining space to accommodate such a large group. Participant comments include:

"[The Workshop] was a really valuable & stimulating event."

"I have been working on nanoscience projects and teaching a nanoscience course. It is very helpful to have such a meeting. I cannot wait to see the next Workshop. I will do my part to engage the community [in] nanoscience."

"Thank you for inviting me to attend the Global NSEE Workshop last week. The experience was useful and inspiring!"

"The most valuable parts were the international ones… I work on research in nanoeducation, and it is very important to me to see what was done, or what is being done, over the world, in this area."

“The poster sessions allowed me to learn about so many different programs. Each one seemed to have a unique aspect that might be applied at our Center. The presenters were enthusiastic and eager to share details of what has worked and what has not.”

“Dr. Kroto was inspiring and personable.”

“The breaks were strategic for powerful networking! I made so many positive contacts for collaboration.”

“[The most valuable part was] meeting new people working in the field of education in all of its aspects - sharing ideas and many examples of creative ideas to engage students and the general public.”

“The poster sessions were very useful because they provided rich opportunities to interact and mingle with people who shared similar ideas and passions.”

Archived webcasts as well as PowerPoint presentations and the full transcripts from this Workshop can be found at www.nclt.us.