AC 2011-874: INCORPORATING SOCIETAL AND ETHICAL ISSUES OF NANOTECHNOLOGY INTO AN INTEGRATED USER NETWORK RESULTS FROM THE NATIONAL NANOTECHNOLOGY INFRASTRUCTURE NETWORK

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Incorporating Societal and Ethical Issues of Nanotechnology into an Integrated User Network – Results from the National Nanotechnology Infrastructure Network

Abstract

Nanoscale science and engineering (NSE) is viewed by many to be the next "technical revolution" which will transform science and industry in the 21st century. It is important that society and the researchers bringing forth this technology understand the societal and ethical implications of this new technology. The National Nanotechnology Infrastructure Network (NNIN) is an integrated collective of 14 universities with open facilities that support nanoscale science and engineering research. The NNIN facilities train and support approximately 4,800 users per year. The network offers a unique opportunity for research in societal and ethical issues (SEI) as well as providing SEI information to users. The goals of the NNIN's SEI efforts are to: 1) develop societal and ethical consciousness within the user community and the broader NSE community and 2) broaden the exploration of the ethical and societal implications of NSE at NNIN and in the broader NSE community. To achieve these goals, we have developed three primary activities: 1) providing SEI training and educational opportunities for NNIN users; 2) stimulating SEI research on NNIN users and technologies; and 3) disseminating the outcomes of SEI research at NNIN and in the broader NSE and scientific community. Regarding the first activity, this presentation will discuss the type of training we do at each site to engage users in thinking about SEI issues related to nanotechnology. Regarding the second, the NNIN has established a set of guidelines for investigators who want to initiate SEI research at one or more of our sites. In 2010, NNIN had seven projects examining issues ranging from diversity to conflicts of interest among our users. Cross-cutting all three activities, we also sponsor approximately 80 participants per year in the Research Experience for Undergraduates program which includes SEI in two ways. First, all sites are required to have their interns read *Nanotechnology & Society: Ideas for Education and Public Engagement*[1] and discuss the material. This activity also takes place in preparation for the NNIN REU Convocation, a three-day meeting where REUs present their research. At this meeting, we have a panel session on SEI issues and interns present results on SEI-related research. This talk will provide an overview of the results from this aspect of our program. Finally, based on the REU project, we have developed a series of posters - *Responsible Research in Action* – that are available to all who are interested. Information on the development and distribution of these posters will be presented.

Introduction

As with any new and emerging technology, societal and ethical issues play an important part in their development and incorporation into society and industry. Nanoscale science and engineering (NSE) will be one of those technologies which will have a significant impact on science, engineering, industry, and society. To address the issues brought forth with NSE, the National Nanotechnology Infrastructure Network (NNIN) seeks to integrate and develop a social and ethical consciousness throughout the breadth of network activities while becoming the nation's leading open-access research facility for the study of science.

NNIN is an integrated partnership of 14 universities geographically distributed across the US. (Figure 1; http://www.nnin.org). The NNIN is funded by the National Science Foundation (NSF) to support nanoscience researchers by providing state-of-the-art NSE facilities, training, and resources. NNIN's mission is to support the NSE research and development needs of academic, industrial, and governmental users by providing tools, training, and process knowledge. In addition to researcher support, the NNIN has an integral Societal and Ethical Issues (SEI) program, which has two primary goals: 1) to develop a societal and ethical consciousness with the NNIN user community and the broader nanoscale science and engineering community, and 2) to broaden the exploration of the societal and ethical implications of NSE at NNIN and in the broader nanoscale science and engineering community. The NNIN SEI programs are coordinated at the Cornell University NNIN site, but each site has at least one SEI coordinator/contact for their lab. We also have an SEI portal (http://sei.nnin.org/), which provides relevant information on SEI related to NSE with numerous resources, materials, and information on past and upcoming events.

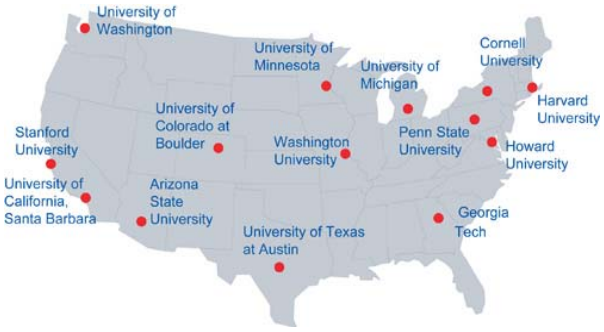


Figure 1 Distribution of NNIN sites

As part of its original Request for Proposals (2002), NSF required that the NNIN include societal and ethical implications in its program agenda. In addition, the 21st Century Nanotechnology Research and Development Act of 2003 (which established the National Nanotechnology Initiative) required all federally-funded nanoscience and nanotechnology centers to address SEI in their research. The NNIN facilities train and support approximately 4,800 users annually from academia, industry, and federal laboratories. As the largest single group of nanotechnology researchers in the world, NNIN has both a unique opportunity as well as responsibility to assure its users have awareness of societal and ethical obligations. Further, because of this vast user base, NNIN offers unique strengths and opportunities for research in SEI through the presence of its large academic and industrial community, the breadth of scientific directions being pursued, and the connections of the research and development being undertaken to issues of societal impact of technology and of human resources.

Further, because of its NSF funding, NNIN remains independent to foster questioning and stimulate research on topics that might check our enthusiasm for unbridled progress and innovation in nanotechnology. As long as researchers meet institutional review board requirements for the ethical use of human participants in research, as well as follow the guidelines for SEI research at NNIN, published on the SEI web portal, they may freely pursue their research questions.

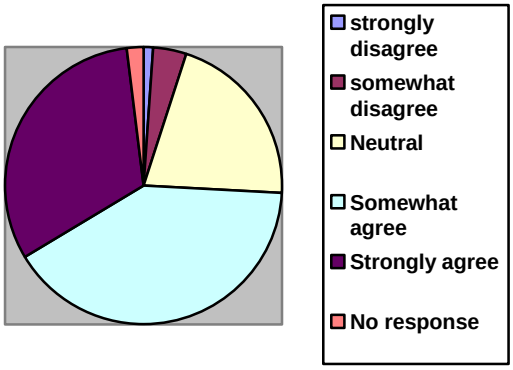
Since its 2009 renewal, NNIN has placed particular emphasis on making the NNIIN user base available as a research source for social scientists and humanists to conduct interviews, surveys, and archival work. It has established a goal of becoming the nation's first open-access research facility for the social study of science. With this goal, the NNIN maintains a commitment to facilitating SEI research on NNIN users and technologies. It opens itself to outside SEI

researchers from outside the network for data collection, ethnographic study, experimentation, and other types of research. A fundamental objective of the federal SEI initiative is to develop national self-awareness and self-reflection regarding the impact of NSE research. We believe that this approach will allow for responsible development of this emerging field which has the potential of influencing and impacting many aspects of society.

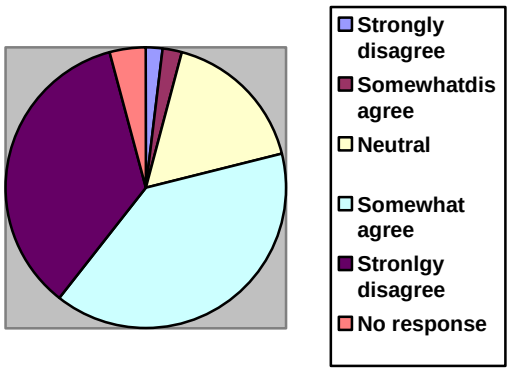
To attain its broad-minded goals, NNIN has designed three primary activities to address SEI: 1) providing SEI education and engagement opportunities for NNIN users; 2) stimulating SEI research on NNIN users and technologies; and 3) disseminating the outcomes of SEI research at NNIN and in the broader nanotechnology and scientific community. This paper will provide an overview of these endeavors, including lessons learned through the process.

SEI orientation at NNIN sites

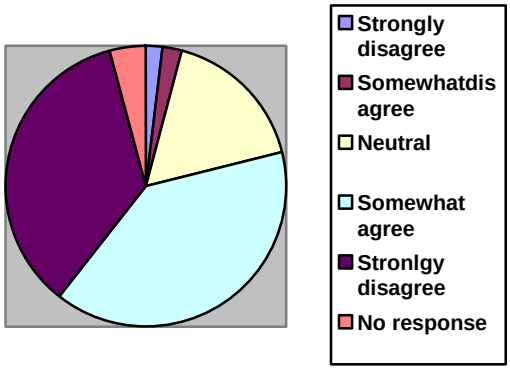
NNIN has developed an SEI component for its new user orientation, which is required of all sites to gain access to the research facilities. Beginning in 2007, the users were required to view a video developed by Dr. Douglas Kysar, then of Cornell University, entitled *Societal and Ethical Implications of Nanoscale Science and Engineering* (http://nnin.org/nnin_ethicstraining.html). In Fall 2008, the NNIN surveyed its SEI orientation coordinators and found mixed support for the video presentation yet unanimous agreement that SEI education was important to continue. From this feedback, the NNIN SEI orientation underwent revision led by Dr. Debasmita Patra, the NNIN SEI post-doctoral associate, who was assisted by faculty and staff associated with the Cornell Nanoscale Science and Technology Facility (CNF). In 2009, Dr. Patra developed a module for a live, interactive presentation during the safety orientation.[2] The module (a PowerPoint with a user manual containing notes and commentary) was evaluated by~100 CNF users. Analyses of some of the results are noted below in Figure 2. As shown, there is a positive impact of including SEI topics during safety/cleanroom orientation of new users.



The SEI orientation helped me to think through some of the issues related to social and ethical issues on NSE.



After attending the SEI orientation, I am more likely to think about social and ethical implications of my own



I learned to value new viewpoints in the SEI orientation.

Figure 2. Results of survey of users who participated in the pilot (May to August 2009) of the new SEI orientation module at Cornell University.

Beginning in 2010, the module was distributed to the other 13 NNIN sites with the intent that they would adopt and adapt the module for use in training of their new users. The module requires approximately 30 minutes to complete, and all participants receive hard copies of the presentation. The presentation includes the importance of SEI, social issues (in general and those associated with NSE), discussion of ethics, examples of past controversial technologies, potential risks of NSE, ethical issues in NSE, perceptions of NSE ethical issues among NSE researchers, current steps to address SEI by US and other countries, and the work of the NNIN SEI and its resources. Most NNIN sites are transitioning to this live interactive module as it allows for more discussion and possible follow-up by the users.

Although the NNIN is making progress in ensuring that all new users have the opportunity to participate in some type of SEI orientation, some ongoing challenges include: 1) having someone to give the orientation; 2) time constraints associated with the orientation; and 3) not all new users may participate in the orientation. With regard to the first challenge, we held two “train the trainer” workshops in 2010, one at Cornell University in January and a second at Washington University-St. Louis in October, to build the capacity of the SEI coordinator/contact at each site to develop and deliver the SEI orientation. Regarding the second, most sites have found that they can carve out 30 minutes for the orientation, as part of the larger lab orientation; however, other sites have opted to hold longer sessions once per academic semester. Although the advantages of a longer time include a greater opportunity to engage in discussions about SEI, this type of SEI

orientation may miss some users, who only come for brief periods to conduct research at NNIN labs. Thus, to address the third challenge, associated with new users not participating in the orientation, we are currently developing a web module version of the SEI orientation, to be finalized in 2011, which can allow more flexibility for some sites and users to engage with the SEI orientation.

Finally, we are also examining ways to evaluate more effectively the impacts of these orientations on NNIN users beyond a simple satisfaction survey. At the October 2010 workshop, we discussed basing our evaluations on the well-known five goals for ethics education suggested by the 1980 Hasting Center working group: stimulating the moral imagination, recognizing ethical issues, developing analytical skills, eliciting a sense of moral obligation and personal responsibility, and tolerating and resisting disagreement and ambiguity.[3] One of the challenges facing a systematic evaluation relates to the decentralized nature of the NNIN. Rather than everyone conducting the same orientation, we have encouraged sites to develop orientations that build on characteristics particular to their site. We are likely approaching a juncture when we must balance the needs for individualization against those of systematization.

SEI Research at NNIN sites

A second strategy of the NNIN SEI program is to stimulate and facilitate SEI research on NNIN users and technologies. Four of the NNIN sites have active SEI research programs, and these include:

- University of Washington. This effort is led by Dr. Suzanne Brainard of the Center for Workforce Development and is focused on interdisciplinary collaborations within NNIN.
- Georgia Institute of Technology. Led by Dr. Marie Thursby in the College of Management, this effort is focused on industrial innovations at NNIN and the relationship of federal funding and technology transfer at NNIN.
- Stanford University. Led by Dr. Robert McGinn in the Department of Management, Science and Engineering, this effort is focused on understanding the ethics of NNIN users and developing guidelines, such as the "Fundamentals Ethical Responsibilities of Scientists and Engineers."
- Cornell University, Led by Dr. Katherine McComas (also the NNIN SEI Coordinator), this effort is focused on understanding how the perceived behavior of NSE scientists and engineers might influence public support for NSE research.

As noted above, the NNIN has a large and diverse user base that offers a unique resource for research in SEI issues. To stimulate and facilitate SEI research on NNIN users and technologies beyond the four NNIN SEI research sites, we have developed two programs: travel grants and seed grants. In addition, we have promulgated a set of guidelines for conducting SEI research at NNIN. These guidelines are published on the NNIN SEI portal (http://sei.nnin.org/).

In March 2009, NNIN announced the NNIN SEI travel grants. The purpose of these funds is to assist others to conduct SEI research at NNIN sites. The programs provides one-time per project funding of up to $15,000 to support travel to one or more NNIN sites to conduct research on NNIN users and/or technologies. Applications of the funds are accepted on an ongoing basis. An

external review panel of SEI researchers reviews all submitted proposal and makes the selection of projects for funding. In 2009, two awards were made:

- Nanoscale Research Communities and Interdisciplinarity – a joint research project of Rice University and UC Santa Barbara
- Documenting the Integration of Social and Ethical Considerations into Nanoscale Research – a research project of Arizona State University

A second research program was initiated in 2010, the NNIN SEI Seed Grant program. This program awards up to $20,000 to SEI investigators located at NNIN sites. For the initial competition, seven proposals were received and two were awarded funding:

- Nanotechnology's transition from discovery to commercialization in small and medium size enterprises: An exploration of evidence – Georgia Tech
- Mental models of nanotechnology: A sunscreen case study – University of Washington.

As with the SEI orientation, there was a need to build the capacity of each NNIN site to respond to requests for research. Thus, we developed protocols for initiating research at NNIN sites, which are available on the SEI web portal. One consequence of the success of the research effort has, therefore, been the development of an infrastructure at each NNIN site to handle requests for research. As noted above, each site has an SEI contact/coordinator that assists with the orientation and can help serve as a point of contact for outside researchers. Until 2009, however, this infrastructure had never actually been used, as there was little external research of NNIN users. Thus, during these first two years, the sites have become much more competent with handling requests for research. In addition, each site now has a link to the SEI web portal on its home page, as well as a statement describing NNIN's goal to foster SEI research (www.nnin.org/nnin_society_ethics.html):

> "At NNIN, we are committed to fostering research on the societal and ethical implications of nanotechnology. NNIN users are at the forefront of nanotechnology and can offer unique insight into this research. To this end, from time to time, users may be invited to participate in a research project, such as by answering a survey or participating in an interview. Although users are free to decline, and their decision to participate or not to participate will have no bearing on their ability to use the NNIN, we sincerely hope that users will consider each request and accept as many invitations as they can in the spirit of advancing knowledge on societal and ethical issues and helping to ensure that NNIN remains a leader in nanotechnology innovation.
>
> We are also committed to ensuring that these projects are relevant to NNIN, unburdensome to its users, and have met appropriate ethical standards. Thus, we will only release users' contact information to projects that have received prior approval from NNIN."

Another objective of the travel and seed grant program was also to raise the visibility of the NNIN as a destination for social science and humanist research on NSE. Lessons learned from the first two years of the funding effort include the need to publicize more widely the availability of funds, as our second solicitation for travel grants received no applications. In response, we are currently preparing a brochure, which can be handed out at appropriate academic and professional meetings, which contain information about the funding possibilities.

SEI and the NNIN REU program

The NNIN has a large and varied Research Experience for Undergraduates (REU) program with up to 80 participants each summer. To develop SEI awareness and understanding among these undergraduates we have developed several approaches. First, all participants are required to read *Nanotechnology and Society: Ideas for Education and Public Engagement*[1]. This paper from the Center for Nanotechnology in Society at Arizona State University provides an excellent introduction to SEI and NSE. Each site sets aside time for group discussion of the article. The discussion format varies by site with some REU coordinators leading the discussion while other sites invite SEI experts from their campus to lead the discussion. This is followed up with a panel discussion at the NNIN REU Convocation. The convocation is a three day meeting held at the end of the program where students present their research results.

The connection of the REU program with SEI began in 2005 with the first NNIN REU SEI project. The student conducted interviews of CNF staff, students, faculty, and external users. The project resulted in a video that reflected some of the themes which emerged including economics, politics, definitions, safety, uncertainty, and safety - with safety being the most common recurrent concern. The video was shown at the 2005 convocation and provoked one of the liveliest discussions of the meeting. Following this, we did not have any SEI REUs until the summer of 2010 when we had three (one supported by NNIN and two by other resources). Even during the period where we did not have SEI REUs, we continued to have either panel sessions on SEI at the convocation or network-wide webinars presented by SEI researchers. The 2010 external SEI REU project involved students from the Colorado School of Mines working in collaboration with the University of Colorado NNIN site. These students developed a framework for "Responsible Conduct in Research" that provides a series of questions that a undergraduate or graduate student could use to help guide research from the beginning of a project, during regular research meetings, and before submission for publication.

The NNIN SEI REU in 2010 developed a series of SEI posters "Responsible Research in Action" suitable for posting in research labs. These posters are available from the NNIN (http://sei.nnin.org/sei_posters.html). The posters were developed by REU intern Chloe Lake, University of Buffalo, working at Cornell University under the direction of Dr. Katherine McComas and Norman Porticella. The messages for each poster were developed from discussions with the CNF users during the summer and expanded and refined by Ms. Lake through several focus groups of CNF users.

These posters are intended to be a small part of a NNIN SEI campaign to promote awareness within the NSE technical community of the broader impacts of advanced NSE research and everyone's responsibilities to the larger community. Providing resources to increase awareness of social and ethical issues related to nanotechnology is an important part of the NNIN training effort as noted in the discussion above regarding user training. An example of one of the posters is seen in Figure 4.

Figure 4. NNIN SEI poster "Pride in your Work." The caption states: "Discoveries in nanotechnology introduce both benefits and potential risks to society. What kind of impact will your discoveries have?"

As we look toward the future and ways to increase and maintain the particpation of SEI students in the REU program, some of the lessons learned from the previous years speak to the need to expand the number of possible SEI projects that could host REU interns. A related challenge speaks to the need to advertise for these REUs using non-traditional channels, given that the social science students will unlikely encounter the internship information through science and engineering publications.

International Winter School for Graduate Students

The International Winter Schools for Graduate Students (iWSG) are organized jointly by NNIN and institutions in third world countries with the goal of promoting international bridge building and understanding by bringing together students and faculty in an intense teaching and societal experience. Each year, 10 graduate students and faculty participate in a rigorous course in an emerging and research-intensive interdisciplinary direction that is not part of U.S. graduate curriculums. This lasts six days and includes laboratory sections, followed by travel to a rural part of the country (~4-5 days) where students spend time observing, experiencing, and discussing the societal challenges and the part science and technology can play. A large group of students from the host country participate in the teaching part and a smaller group joins in the rural experience. Since 2008, NNIN has sponsored three of these events in India and hopes to expand to other third world countries. Each year, a faculty member with SEI expertise has joined the event.

Participants on the field trip portion of the trip completed an essay on their thoughts and observations. These essays indicated that students were extremely positive about the workshop and the field trip. The visits to rural villages in India were "eye-opening" events for all participants and helped them to see how technology can help the poorest people in the world. Sample comments are in the boxes below.

"I feel that I had a great opportunity to see the contrasts of Indian life and technology. The trip was very informative, absolutely amazing, and was an excellent compliment to my technical training back home at Northwestern and during the IIT conference. I will remember this trip for many, many years and hope to kept the ramifications of technology in the world throughout my career."

"From the trip to the rural area in India, I learned that we, as engineers and scientists, must share the responsibility of increasing people's quality of life in rural areas. The reason is that we do have the infrastructure and knowledge needed to investigate solutions to daily problems (and people from villages do not)….. The iWSG provided an excellent experience in understanding people's lives in rural areas and in

"To visit the communities, to see the conditions in these rural parts of India, to speak and interact with the different members of the community, to see the use of technology (or lack thereof) was quite eye opening for me personally…. Even with just a brief exposure to the conditions and everyday realities of many, many people living in rural communities throughout the world, it is quite

The benefit of this program is that it creates and enhances cross-cultural connections by offering a joint course but more importantly allowing US graduate students to learn first hand the impact NSE can have on the developing world. With a strong SEI connection, the course places NSE in the context of the developing world and encourages a global perspective to the graduate participants.

Summary

Nanoscale science and engineering is believed to be a technology that will have an impact on all areas of society from the development of new medicines and drug-delivery systems to changing the workforce. As part of its mission, the NNIN has developed programs to develop societal and ethical consciousness within the user community and the broader nanotechnology community. We have opened our large and unique user base for researchers to examine and analyze the SEI of NSE and its technologies. Through these varied programs we hope to develop NSE researchers with a conscious understanding of SEI and thoughtful research on NSE and nanotechnologies.

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