# A Study of Integrating Societal and Ethical Issues into NNIN REU

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## Abstract:

Societal and Ethical Issues (SEI) in nanotechnology have gathered recent attention and importance given its federal focus under the 21st Century Nanotechnology Act [1] (2003). Perceptions of how effective SEI training is, as well as to what extent ethical conceptions penetrate into undergraduate work and beyond, is of particular interest in order to better the Research Experience for Undergraduates (REU) Program of the National Nanotechnology Infrastructure Network (NNIN). Interviews of both current education coordinators at NNIN REU sites and former REUs from the Cornell NanoScale Facility (CNF) are used to accumulate and compare SEI training practices. The review and interview results are used to formulate a summary report of findings and best practices for NNIN sites to use as a program guide.

| Program | REU Program Goals | Skills Learned |
|---|---|---|
| UPenn SUNFEST<br>VaNTH<br>BIO REU Workshop 2010 | Professional presentation | Communicate effectively and professionally, develop appropriate communication for certain audiences |
| Penn State | Think insightfully, problem solve | Personally reflect on ethical topics, develop a moral imagination |
| Carnegie Mellon University | Think insightfully, problem solve | Understand the ethics of care, recognize environmental applications of engineering |
| University of Washington | Study natural disasters | Recognize societal issues; human and economic consequences |

*Figure 1: Goals and projected skill sets common among evaluated programs.*

## Introduction:

The 21st Century Nanotechnology Act [1] (2003) emphasized the need to address societal and ethical issues of nanotechnology. This study set out to contribute to that initiative by first conducting a literature review on Research Experience for Undergraduates (REU) programs. The review compiled educational experiences from the REU programs and other non-REU undergraduate programs that teach societal and ethical issues to students within a science or technology domain. A total of ten institutions or programs were analyzed to contribute to part I of the summary report. As seen in Figure 1, certain program goals and skills targeting undergraduates to think critically about ethical and societal considerations resonate throughout the literature. The specific practiced and evaluated types of activities include PowerPoint presentations, lunch discussions, news articles or legislative documents to read, case studies and role-playing to perform, small panel discussions, societal and ethical issues (SEI) lunches, field trips to industries, or weekly classes on ethics in science.

| NNIN Coordinator Interviews | Former CNF REU Interviews |
|---|---|
| 1. Size of REU program<br>2. Amount of SEI education already in place before you started<br>3. PI/staff interest and support for SEI<br>4. Current program; practices used<br>5. Personal opinion on adequacy of SEI program<br>6. Personal opinion on challenges to presenting effective SEI education<br>7. Amount of information and idea sharing among NNIN coordinators<br>8. Personal opinion on the best practices for SEI education | 1. Relationship with PI<br>2. Relationship with mentor<br>3. Relationship with fellow REUs<br>4. Amount of talk about nanotechnology in casual conversation<br>5. Amount of SEI in casual conversation versus in training discussion<br>6. Source of SEI discussion<br>7. Motivation for SEI consideration during REU summer<br>8. Current opinions; your values regarding SEI<br>9. Suggestions for SEI education |

*Figure 2: Categories encompassing interview questions of each subject group.*

To explore the usefulness of these ideas, interviews with the education coordinators in the NNIN were conducted to gather a comprehensive look at how education coordinators are implementing SEI activities in their respective REU programs. In addition, interviews with previous REUs were conducted to assess what they think about society and ethics, and if they believe their REU experience at all influenced their thinking.

## Results and Discussion:

The NNIN Education Coordinators (EC) participated in phone interviews lasting between 10-20 minutes. Figure 2 provides the categories of questions. Similar to the literature review findings, the ECs also found that lectures and informal discussions were the easiest type of event to organize and most liked by the undergraduate participants. The literature review found that there was an emphasis on training mentors to communicate the ethics of their project to their undergraduates. The ECs commented that although that was a great idea, there was limited time to train the mentors in addition to training the REU participants.

As a suggestion, ECs could work with SEI coordinators to increase the mentors' comfort for such topics, as this could foster a friendlier and more informative relationship between mentors and their respective undergraduate student.

There are three main findings from both the EC interviews and the previous REU student phone interviews. To better the communication of ethics and increase societal awareness, mentors and ECs should focus on the connections, conversations, and critical thinking skills of the undergraduates REU participants. The *connections* break down into the student's work environment, which is a critical for motivating and engaging SEI discussion. Students need to feel that their mentors and principal investigators (PIs) are approachable and friendly to spark the second finding, *conversations*. *Conversations* refer to the length and frequency of societal and ethical discussions between an undergraduate and their mentor or PI on their respective project. The friendliness and amount of socialization during the internship between undergraduate and mentor, PI, or other facility users, and the nature of such casual narrative with those involved in the research project influence how the student thinks about SEI.

Both the connections and conversations maintain the third domain for better SEI education, which is the level of *critical thinking* for undergraduates to develop. Raising awareness about their research projects' ethics and societal implications during the summer builds a framework of thought for their future careers. The challenge of communicating the paramount topics of SEI is a process that is continually built upon tried practices and current successes.

To further study the motivation and degree of ethical considerations by REU interns, a short survey was conducted of the 2012 REU participants. The survey tested such factors as motivation and its relationship to one's personal sense of moral responsibility.

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## References:

[1] 21st Century Nanotechnology Research and Development Act, 108th Congress Public Law 153 (2003).

# Nanotechnology Companies in the U.S.A: A Web-Based Analysis of Companies and Poverty Alleviation

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## Abstract:

In the United States, many firms are expanding their research and development on nanotechnology products. But what products are being developed and who will benefit from them? This study answers these questions by analyzing the goals, nanotechnology experience, corporate social responsibility and products from companies' websites. Based on patent data from the Center for Nanotechnology and Society-Thematic Research Cluster One, we obtained a list of fifty-five firms that are leaders in nanotechnology in water, energy and agri-food. We chose these areas because we think they will have a big impact on the poor and on inequality. Out of the fifty-five companies, twenty-seven mention nanotechnology. Moreover thirty-one firms are developing products that will benefit both the rich and poor, while only seven firms, such as computer and textile industries, focus only on rich consumers. In general, agri-food companies do not discuss nanotechnology on their websites. Most of the companies produced intermediate materials used by other companies; very few of the companies sell nano-products directly to consumers. Overall, we conclude that nineteen out of fifty-five companies are developing nanotechnology products, like low cost water filters or solar cells that could help the poor and reduce inequality.

## Introduction:

Governments spend a large amount of money on research and development for a variety of problems. Three important areas that have received attention are water, agri-food and energy technologies. For example, we are at an extremely critical stage in our energy use portfolio. The world bases much of its energy use on non-renewable fossil fuels and nuclear power, and another potential technology that can ameliorate our dependence on fossil fuels faces a lot of public controversy.

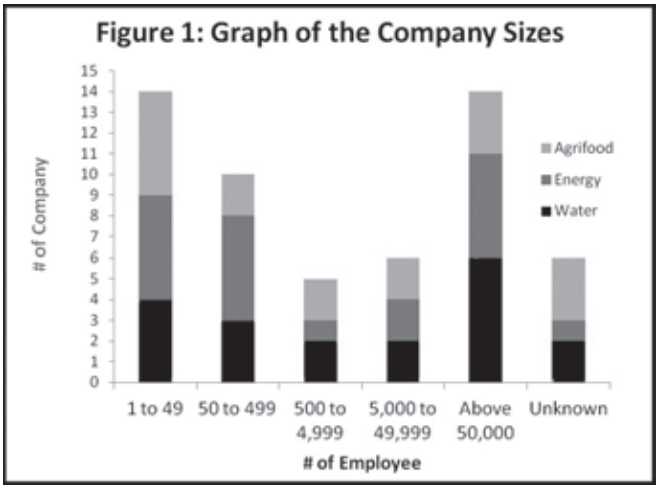
However, there are many solutions to these problems and we think research and development in nanotechnology can address some of these issues. Therefore, the purpose of this research was to perform a web-based analysis of nanotechnology companies in United States: What nano-products are being developed? Who benefits from these products? Does nanotechnology alleviate poverty?

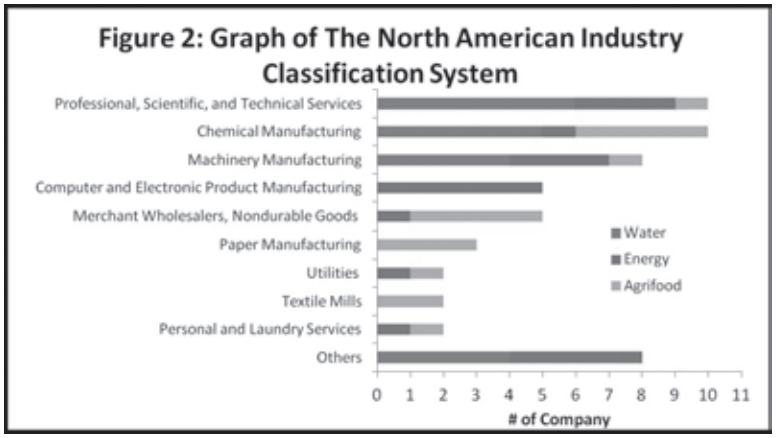
## Methodology:

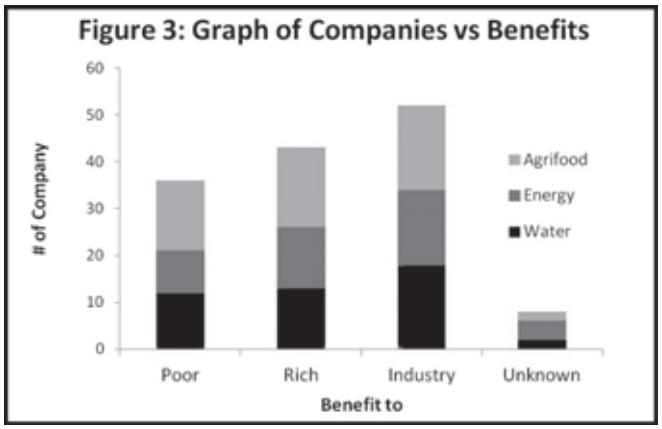
The Center for Nanotechnology and Society-Thematic Research Cluster One provided patent data from 2005 to 2009 of the top companies with nanotechnology patents in United States. We focused on three areas; water, energy and agri-food. We chose theses areas because we think they will have a big impact on poverty and related inequalities. In each of the categories, we selected the top twenty nano-patenting companies — however there were only fifty-five companies total in the sample because some companies were repeated in two different categories. For example, General Electric was a top producer of nanotechnology patents in both energy and water nanotechnology patents.

After compiling a list of companies, we went to each company's website and collect information about their history, research, products and size. In addition to basic company information, we used their search tool to find out what the companies said about poverty and nanotechnology.

A second major source was Nexus Lexus Academic. We used that site to search for the North American Industry Classification System (NAICS) of the companies. Finally we analyzed the information we found.






## Results and Conclusions:

The companies were a variety of sizes; fourteen companies had under fifty employees; while another fourteen had more than 50,000 employees (Figure 1). For example, in 2011, International Business Machines Corporation had 433,362 employees, but at the same time Konarka Technologies Incorporation had only twenty-five employees. Small firms were energies nanotechnology companies usually established late in the twentieth century.

In Figure 2, we used NAICS, "the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy." [1]. Many companies span a variety of different fields. Once we had the list of companies, we examined the types of products they made and who would benefit from those products. We then classified the companies as either helping the poor, rich, or industry (Figure 3).

More than thirty firms develop products that will benefit the poor. For example, Koch Membrane is "helping millions of people live healthier lives by developing better ways to purify the world's water sources, improve food processing, and more." [2]. Nanosolar says, "By printing CIGS-inks on low-cost aluminum foil, Nanosolar is utilizing its proprietary high-throughput roll-to-roll printable semiconductor technology to enable the world's lowest-cost thin-film solar panels." [3].

We found few companies benefit only the rich. Companies that sell products that only help the rich are developing products like expensive apparels or furniture that has anti-static, and spill technology.

We found that twenty-seven companies discuss nanotechnology on their websites. However, none of the agri-food companies mentioned nanotechnology. We suspect these companies are hesitant to talk about nanotechnology because nanotechnology is not well-known by the public, therefore the public might have negative reactions of having nanotechnology in their food.

Most of the products produced by these twenty-seven companies were intermediate materials, like chemicals, used by other companies. Very few companies sold the nano-products directly to consumers.

Only twenty-seven of the fifty-five companies mention poverty. For example, one company said that, "Our membrane filtration elements are in use worldwide, producing enough clean water daily to sustain healthy living for four hundred million people" [4]. However, when we examined the products of the companies, only nineteen out of fifty-five companies were developing nanotechnology products, like low cost water filters or solar cells, that could help the poor and reduce inequality.

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