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A Study on the Emergence of Ethical Thinking in Nanotechnology

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A Study on the Emergence of Ethical Thinking in Nanotechnology

by

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Abstract

A Study on the Emergence of Ethical Thinking in Nanotechnology

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The purpose of this study is to explore how scientists perceive social and ethical implications (SEI) in the context of nanotechnology and how to best implement SEI training in laboratories. This will be explored through two studies: 1) analysis of open-ended survey data measuring nanoscientists' perceptions and awareness of SEI and, 2) test the effectiveness of an SEI pilot training module among students participating in the NSF Research Experiences for Undergraduates (REU) program on nanotechnology at the University of Texas at Austin. The goal of these two studies is to better understand scientists' perception and awareness of SEI at the nanoscale and introduce training techniques to facilitate increased discussion and implementation of SEI training in the workplace and lab. In doing so, nanoscientists will be equipped with the necessary information to help them meet the SEI requirement outlined in the 21st Century Nanotechnology Research and Development Act, and create a standard for SEI consideration in the nanotechnology field.

Keywords: nanotechnology, nanoethics, SEI

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Chapter 1: Introduction

Nanotechnology is a branch of technology birthed from a combination of diverse fields such as physics, chemistry, engineering, biology and materials science. This technology focuses on the manufacture and design of individual atoms and molecules with dimensions of less than 100 nanometers. To put this in perspective, one nanometer is about as long as your fingernail grows in one second ("What is Nanotechnology?" 2017). The purpose of nanotechnology is to manipulate atoms and molecules to develop and manufacture new technology, devices, applications, consumer products, and medicines to name a few ("What is Nanotechnology?" 2017). By manipulating and controlling particles at such a microscopic level, scientists have the ability to take advantage of the lighter weight, higher strength, larger visible surface area and increased control of light spectrum of these molecules. As a result, the development of nanotechnology has produced faster-recharging batteries for cordless electric tools, clear sunscreens, scratch-resistant glass coatings and improved displays for televisions, cell phones and digital cameras.

Although modern advancements in nanoscience and nanotechnology are relatively recent, the use of nanomaterials have been around for centuries. During the 6th-15th centuries, glass artisans used nanoparticles of silver and gold to reflect red and yellow in stained glass windows found in cathedrals and well-respected buildings. The color change reflects the change in material properties at the nanoscale, demonstrating the early use of nanomaterials and nanotechnology ("Nanotechnology Timeline," 2017). Despite being around for centuries, the current

manipulation and controlling of molecules at the nanoscale is usually linked to a presentation made by Feynman in 1959 ("What is Nanotechnology?" 2017).

Feynman is referred to as the founding father of modern nanotechnology due the conceptual foundations he presented for nanotechnology and his work as a leading physicist in the twentieth century ("What is Nanotechnology?" 2017). His work has inspired much of the research that has contributed to the modern development of nanotechnology.[1] Later, nanotechnology became more widely known in 1986 when Drexler published, *Engines of Creation: The Coming Era of Nanotechnology (*Drexler, K. E., 2000). The readability and engaging style of the book ultimately influenced the popular perception of nanotechnology. In his book, Drexler noted that as nanotechnology advanced, it would produce both beneficial and detrimental effects.

Drexler asserted that although there are risks associated with any technology, nanotechnology could have an especially harmful impact. He highlighted this through a scenario depicting the phenomena of self-assembly, where components of a system spontaneously self-replicate into a larger, functional unit. In Drexler's scenario, the components of this self-assembly system malfunction and began to uncontrollably self-replicate and destroy its material surroundings, transforming everything into copies of itself. This scenario, along with the increased use of nanoparticles and the emergence of products developed by nanomaterials into the marketplace, raised concerns about human, animal, and environmental health and safety *(*Drexler, K. E., 2000). Unique questions about nanotechnology

[1] Some associate Professor Norio Taniguichi of Tokyo University of Science with the founding of nanotechnology. He coined the term nanotechnology in 1974 to describe semiconductor processes that exhibited characteristic control at the nanoscale (Edwards, 2006).

being used for human enhancement and weaponry highlighted a need to understand the ethical and moral implications of nanotechnology.

FEDERAL REGULATION

Breakthroughs in engineering, medicine, neuroscience and many other fields as a result of nanotechnology research and development, presented a compelling opportunity for interdisciplinary advancement and an increasing need to evaluate concerns related to the societal and ethical implication (SEI) of nanotechnology on humans, society, and the environment. In 2000, President Clinton proposed the National Nanotechnology Initiative (NNI) to advocate for nanotechnology research and development, and encourage funding to maintain the nation's competitiveness within the field. The NNI involves 20 departments and independent agencies across academia, government and industry laboratories. These departments work together to create a framework for shared goals, priorities, and strategies to help leverage the resources of each agency. President George W. Bush further increased funding and support for nanotechnology and signed into law the 21st Century Nanotechnology Research and Development Act (P.L. 108-153) in 2003 (U.S. Government Printing Office, 2003).

This law developed a National Nanotechnology Program that would: (1) establish the goals, priorities, and metrics for evaluation for Federal nanotechnology research, development, and other activities; (2) invest in Federal research and development programs in nanotechnology and related sciences to achieve those goals; and (3) provide for interagency coordination of Federal nanotechnology research, development, and other activities undertaken pursuant to

the Program. This law provided a foundation for the National Nanotechnology Initiative, established programs, designated agency responsibilities, sanctioned funding levels, and promoted research to address key issues. The 21st Century National Nanotechnology Program also states that researchers are required to take into account ethical, legal, environmental, and societal concerns, especially concerns related to enhancing human intelligence and developing artificial intelligence that exceeds human capacity. In 2006, the Nanotechnology Task Force was formed and charged with determining regulatory approaches that encourage persons to develop innovative, safe and effective FDA-regulated products from nanomaterials. The task force identifies and recommends ways to address knowledge and policy gaps to better evaluate potentially unfavorable health risks from FDA-regulated products that use nanomaterials.

NANOETHICS DEFINED

Most likely spurred by the 21st Century Nanotechnology Research and Development Act of 2003, the ethical, legal, and societal issues (ELSIs) related to technology developed at the nanoscale has been a topic of study for about a decade (e.g., Allhoff et al., 2007; Bennett-Woods, 2008; O'Mathuna, 2009; Macnaghten, Kearnes, & Wynne, 2005; McGinn, 2008, 2010a, 2013). One of the more active researchers in this area is McGinn (2008, 2010a, 2013), who categorizes the ethics of nanotechnology into three levels of influence: the lab (micro-social), institutions and mass communication (meso-social), and society at large (macrosocial). This typology suggests the multiple levels at which scientists must navigate ELSIs in the workplace and beyond. Across those levels of engagement, scholars also have identified specific ELSI concerns ranging from the perceived

secrecy surrounding nanotechnology (Allhoff & Lin, 2006; Ebbesen, Andersen, & Besenbacher, 2006) to issues of human and environmental safety and health related to nanomaterials (Rasmussen et al., 2012) to the exact purpose of using nanotechnology (as inherently good or bad) (Kermisch, 2012). As knowledge about nanoparticles and their ability to possess different chemical, physical, and biological properties and their potential harmful impacts for environmental, human, and animal safety began to reach the public, more emphasis was placed on the morals and ethics of nanoscientists and nanoresearch. In 2007, the journal, *NanoEthics: Ethics for Technologies that Converge at the Nanoscale*, was created to provide a framework for the ensuing research.

One of the major challenges raised by the study of nanoethics is the complexity in defining what, exactly, nanoethics means. In addition to levels of engagement and the specific ELSI topics mentioned above, researchers have also explored whether the ethics of this technology merit a separate field of study or whether it belongs with the ethics of science as a more general field of study (Cutcliffe, Pense, & Zvalaren, 2012; Rasmussen et al., 2012). It has been argued that nanoethics is two-fold and that there needs to be an understanding of the distinction on whether nanoethics refers to ethics *from* nanotechnologists or as ethics *for* nanotechnologists (Bensaude-Vincent, B, 2010). Essentially, there seems to be confusion about whether nanoethics refers to problems that are nanotechnology specific or ethics specific. Defining nanoethics has proved to be problematic as there is a need to draw the line between the unknown, futuristic application of nanotechnology and the currently practiced and applied nanotechnology. This distinction between current and futuristic nanotechnology is important as it relates to what type of research is seen as normal or radical, and can help clarify the role of

ethics within nanoscience since ethical concerns about radical or futuristic nanotechnology could negatively impact normal nanotechnology.

Scholars in favor of keeping the ethics of nanotechnology scholarship separate argue that nanotechnology introduces novel moral problems, such as human enhancement and undetectable privacy invasion (Allhoff & Lin, 2006; Allhoff et al., 2007; Grunwald, 2005). Others argue that the ethical issues emerging from the scholarship are not novel, nor do they differ from other technological contexts such as bioethics (Rasmussen, Ebbesen & Andersen, 2012).

Regardless of how scholars define the ethics of nanotechnology and where we place it in the context of science ethics more generally, discussions of ELSIs primarily seem to be taking place in academic settings (e.g., journals, conferences, etc.), initiated by ethicists and social scientists and published only in journals read within those specific fields (Rasmussen et al., 2012). Some scholars suggest that this amounts to the spinning of wheels without any progress forward; they advocate for more aggressive interdisciplinary collaborations to ensure that the ethics scholarship gains traction with the scientists and engineers who are actually practicing the science (Rasmussen et al., 2012). However, such collaborations would need to proceed carefully; scholars have identified differences in viewpoints between scientists and lay people, and between scientists and industrial practitioners, about the definition and role of ethics in nanotechnology (Davies & Macnaghten, 2010; Nordmann & Macnaghten, 2010; Shelley-Egan, 2010).

In this thesis, I define nanoethics as the consideration of societal and ethical implications by (from) nanotechnologists during the development of (for) nanotechnology specific research and application. Although ethics has uses in other fields, here I use it to take "ownership" as an important consideration of ethical

concerns of the science at the nanoscale. In sum, the advancement of nanotechnology has raised concerns about the societal and ethical implications of nanotechnology on humans, society, and the environment. Along with these concerns is an increasing need to understand nanotechnology from an ethical perspective. The purpose of this paper, therefore, is to present two original studies that explore nanotechnology from an ethical perspective, with a focus on the views and perceptions of the scientists and undergraduates who are working at the nanoscale. Those studies include 1) data collected from an open-ended survey of nanoscientists currently working in academia and industry and their perceptions of nanoethics, and 2) data collected from a focus group of undergraduate students studying nanotechnology who were exposed to a pilot intervention designed to get them thinking about the ethical and social implications of the work they do.

Chapter 2: Literature Review

The research literature focused on the ethics of nanotechnology covers several key areas. Those areas include the relevancy and awareness of social and ethical implications (SEI) within nanotechnology, and interdisciplinary training and integrative design interventions for teaching SEI in nanotechnology.

In terms of relevancy, effective communication of the ethical, legal, and social issues (ELSI) associated with emerging technologies and the specificity of those issues of societal concern are essential to those engaged in nano-scale research. For example, Costa (2011) performed a study that explored the debate around the role of ethics in the field of nanomedicine, and sought to understand scientists' perception of the ethical issues and risks associated with their research. The results revealed that scientists have a positive attitude towards ethics and were willing to engage with the topic if presented in a context relevant to their research (Costa, 2011). To provide effective communication that impacts members of the nanoscale science community, Shumpert (2013) recommends that ELSI scholars incorporate specific technical and application-related forms of work to their work and writings. In other words, ELSI scholars need to be able to identify and discuss specific science, technology, and application characteristics that are relevant to members of the nanoscience community, so that they may be able to understand the role societal and ethical considerations play in nano-related research and development. Further research by Eosco (2014) measured the attitudes of interns participating in research experience for undergraduate programs (REUs) about social and ethical issues. This study explored how work environment contributes to thinking, discussion, and attribution responsibility to consider SEI in

nanotechnology. Participants agreed that there were societal and ethical issues related to nanotechnology. Along with high recognition of SEI, students slightly agreed with the statement that they think a lot about SEI related to science and engineering (Eosco 2014). Based on these findings, it can be concluded that both interest of and recognition of SEI exist, providing an opportunity and critical insight for future research on what motivates consideration of ELSI and ethical behavior among scientists'.

Despite efforts to increase SEI relevancy and awareness among practitioners of nanotechnology, little has been done to develop an SEI education component with a laboratory orientation. Studies have shown that there is a need to increase SEI education among nanoscientists and within the REU program (Eosco 2014). Ethnographic field research conducted by the University of Washington revealed that most graduate students involved with research at the nanoscale had not been exposed to discussions and critical thought of ethical issues in their undergraduate or graduate studies (Olmstead, 2009). Realizing a need for parallel training in the societal and ethical implications of unprecedented technological developments, UW developed an interdisciplinary seminar in nanoethics with the goal of increasing both awareness of SEI and student's confidence to solve ethical issues. Although the seminar was successful, there remains a need for a required interdisciplinary class addressing social and ethical issues in nanotechnology for both students and faculty members.

Building upon this research, Patra (2011) showed how an SEI component can be incorporated into the laboratory orientation schedule of practitioners through a study of nano researchers at the Cornell NanoScale Science and Technology Facility (CNF). Results reported that practitioners enjoyed learning and engaging in

discussions about SEI. Introducing SEI at the orientation level jumpstarted scientists' self-reflection and thought process of their research and its impact on society more largely. Patra concluded that exposure to SEI training should be conducted at nanofabrication laboratories to help increase SEI awareness and consciousness among the larger scientific community.

With the amount of research being conducted on many fronts of nanotechnology, one of the main challenges in communicating the importance of nanotechnology SEI is the ability to discern social and ethical research in a field that is largely hypothetical and inclusive of multiple disciplines (Kjolberg, 2007). Research suggests that there is a need for more integrative approaches to fully grasp the complexity of social and ethical interactions with nano-scaled sciences and technology (Kjolberg, 2011; Allenby, 2006; Fisher, 2014). Since nanotechnology is known as an interdisciplinary technology, proposed methods of increasing interdisciplinary SEI training include partnering with natural sciences and engineering colleagues in laboratories (McGregor, 2009), and integrating topics, research, disciplines and categories to fully understand societal and ethical issues within nanotechnology. To this point, Foley, Bennett and Wetmore (2012) conducted research that compared ethical responsibilities in literature to ethical responsibilities in practice among practicing professionals and academic ethicists. Their results demonstrated that the ethics in practice were not completely unaligned with the literature on emerging technology ethics. By engaging professionals and academic ethicists in a discussion of ethical responsibilities together, participants were able to build trusting relationships with one another and increase their level of mutual reflections.

This falls in congruence with suggestions made in Costa's (2011) research, which proposed harnessing the willingness of scientists to positively engage with ethical discussions to develop training programs for researchers and graduate students. It is important to consider, however, potential limitations to SEI integration. Fisher (2014) assessed the degree to which socio-technical integration was evident in the US and UK during the wake of novel policy initiatives for societal research and engagement. Despite prominent nanotechnology policy discourse in support of socio-technical integration and a surge in attempts to build societal responsiveness into research prioritization, interviews revealed limited evidence for socio-technical integration and research prioritization setting processes. To explain the limitation of integration, Fisher identified two conditions: 1) institutional norms that preclude integration, and 2) concerns that integration would compromise national competitiveness agendas. These findings are important to consider when constructing a framework to be used with nanotechnology laboratories. A successful framework needs to prioritize the need for SEI but ensure nanoscientists that a focus on SEI and socio-technical integration does not hinder research and development processes.

Building upon this, Ferrari (2010) examined more recent nanoethics debates that call for a more broadened ethical discussion that includes values such as sustainability and responsibility. These debates have renewed reflection over the need to reconstruct and build a more appropriate framework for nanoethics. Ferrari explains that concentrated efforts that confront present and past technological experiences can help understand the ethical issues at stake and offer a way to learn from the governance and the social context in which policies on nanotechnology are developed. However, the difficulty in discerning what emerging technology looks

like and the precise issues it can create, presents a challenge for ethicists who aim to address the social implications of emerging science and technology (McGregor, 2009).

Although ethical structures and frameworks currently exist, the current structures in place are typically used to address arising issues at individual and institutional levels. A case study conducted by Allenby (2006) covered the development of a new Internet router to analyze ethical considerations and responsibilities as they arose. The analysis revealed that there are many unpredictable intervening decisions and theoretical events between technology and economic, cultural, and social evolution that have impacts across society. As a result, the current ethical systems in place are inadequate when applied to emergent behaviors and inherent unpredictable complex adaptive systems such as nanotechnology. These findings presented a gap between the ability of society to respond to ethical considerations raised and the need to do so. Analysis of this reveals that there is a need for an appropriate ethical framework that includes individual ethical responsibility and can be applied to emergent and unpredictable, complex systems such as nanotechnology (Allenby, 2006). One way to discern and assess ethical issues within nanotechnology is to use a network approach (Poel 2008). The network approach would help identify differences between problem definitions, agendas, belief and value systems of actors and stakeholders, and the dynamics of the network to help identify ethical issues specific to nanotechnology. In doing so, this approach could possibly utilize ethical insights to direct nanotechnology research and development. Multiple studies have acknowledged the lack of a specific or concrete approach to implementing SEI training within

nanotechnology from a theoretical framework. This presents a need to develop a new framework to be used.

Even with increased attention to the ethical issues and concerns about the development of nanotechnology, there has been very little development in how to help industry professionals and educators give nanoscientists and researchers tools for teaching ethics (Barakat, 2010). There remains a need for development of a framework that helps implement social and ethical training and decision-making into nanoscience research and development. However, understanding of the relationship between design, evaluation features and effectiveness of training and development efforts is important for successfully integrating ethics into engineering's educational curriculum and professional development. Analysis of prior research shows that interventions based on theory are more effective than those without a theoretical foundation. French (2012) argues for a streamlined approach that moves relevant theoretical domains to the implementation problem to behavior change techniques based on a study that examined emerging discussion of ethical reflection on nanotechnology and the need to build a suitable framework for nanoethics. Glanz (2010) also explored the importance of understanding and applying significant theories of behavior change to help design and conduct health behavior intervention strategies, which serves as a good model for the nanotechnology context.

Because of the independence of nanoscientists and researchers, focusing on individual behavior intervention strategies to train nanoscientists about SEI could result in individual behavioral change that would eventually impact the nano industry as a whole. McLeroy (1988) proposed the use of an ecological perspective on health promotion by focusing on individual behavior intervention strategies. This

same approach could be used for the nano industry as it focuses on both individual and environmental factors of behavior as targets to prevent negative outcomes. Since individual and organizational development trainings are necessary for the enhancement of productivity, goal achievement, and success, the ecological framework could be applied when developing SEI training strategies (Arthur, 2003). Regardless of what framework or technique used, the nanotechnology field can benefit from developing a new approach that can be applied to emerging ethical issues in nanotechnology without the presumption that ethical issues are a given, and ultimately help create a standard for SEI implementation techniques.

In sum, there is a need for additional studies and for action, such as the organization of annual training workshops to make SEI training more effective; researchers must be exposed to SEI training more than just once, as is required for safety trainings. Although SEI seminars and trainings have been successful to date, there is also a need for interdisciplinary, integrative training addressing social and ethical issues in nanotechnology for students, faculty, industry and government.

Chapter 3: Study 1

The above literature revealed a need to further understand how to facilitate individual behavioral changes based on changes in researchers and nanoscientists' environment. Several studies have already been conducted to understand why researchers and nanoscientists have difficulty incorporating ethics into their research and development. Our research team sought to enhance the study of social and ethical implications of nanotechnology by examining responsible research behaviors of nanoscientists regarding information seeking and sharing, and decision-making. Additionally, we sought to not only understand this phenomenon but to also identify the best approach for implementing an intervention strategy into mandatory laboratory orientation in response.

At present, it appears that nano-scientists have been somewhat reluctant to incorporate into their work any ethical considerations beyond the micro-social level (i.e., within their lab). This may be the result of intensive and time-consuming safety considerations for those labs. However, as of 2003, the 21st Century Nanotechnology Research and Development Act has mandated that researchers and industrial producers take into consideration the ethical, legal, environmental, and societal implications of nanotechnology (U.S. Government Printing Office, 2003). In order to make progress in meeting this mandate, we needed a better understanding of the potential conflicts that keep scientists from addressing societal implications.

The purpose of this study, therefore, is to further explore nanoscientists' conceptualizations of ethics in nanotechnology. Building upon prior work conducted by the National Nanotechnology Infrastructure Network (NNIN), our research team proposed to engage with nanoscientists by using online survey interviews to

explore their perceptions regarding societal risks, ethical responsibilities to society at large, and professional and social norms related to those responsibilities.

METHODS

Sample and recruitment

Respondents were recruited using a multi-wave survey of research scientists affiliated with the National Science Foundation's National Nanotechnology Infrastructure Network (NNIN), a partnership among university-housed nanoscience and nontechnology research facilities across the U.S. We received a list of 1,009 randomly selected members affiliated with the NNIN along with their contact information (NNIN has a total of 6,054 members). The list was prepared and sent to the study PIs by NNIN staff in 2012. Our research team then conducted an Internet check of all members on the list to make sure their contact information and work locations were updated and removed those who were no longer affiliated with NNIN institutions or whose email addresses were no longer functional. Our final recruitment list included 878 nano-scientists and engineers.

We then ran a four-wave online survey with Qualtrics software using the Tailored Design Method (Dillman, Smyth, & Christian, 2008). The survey, which took about 20 minutes to complete, included a series of closed- and open-ended questions focused on the ethics of nanotechnology. We offered respondents who took the survey an opportunity to receive a $10 electronic gift card. Our research team also tried to call all the non-responders after the second survey wave between July and October 2013. After the final wave of surveys, 216 completed questionnaires were yielded, constituting a 25% response rate. This response rate is common when surveying experts online (e.g., Scott et al., 2011). The final sample

was 27% female and ranged in age from 20 to 82 years (M = 34.17, SD = 10.09). Thirty-nine percent of respondents listed their primary nanotechnology discipline as nanomaterials; 36% as nanoengineering; 27% as nanotechnology enhanced devices; 26% as biology, health, and medicine; 21% as energy nanotechnology; 21% as nanophotonics; 18% as nanophysics; and 6% as analytical nanotechnology.

Results from the closed-ended survey questions have been published (Kahlor, et al., 2015); the open-ended questions within the survey are the focus of this thesis. The purpose of the open-ended questions was to explore further the respondents' conceptualizations of ethics in nanotechnology. Our intent was to capture these conceptualizations in the respondent's own words so that we could analyze the responses qualitatively. The prompts used in the open-ended questions were as follows:

> *In your own words, what does the phrase "ethics of nanotechnology" mean to you?*
>
> *In your opinion, what is the most pressing ethical issue in nanotechnology today?*
>
> *Think about your most recent experience SEEKING information about ethical issues related to nanotechnology. Where did you find the information (e.g., on a particular website, via a colleague, etc.)? If you have not sought information, enter "na."*
>
> *Think about your most recent experience SEEKING information about ethical issues related to nanotechnology. What kind of information did you find? (If you have not sought information, enter "na.")*

Think about your most recent experience SHARING information about ethical issues related to nanotechnology. Where did you share the information (e.g., blog, email, in person, etc.)? (If you have not shared information, enter "na.")

Think about your most recent experience SHARING information about ethical issues related to nanotechnology. What kind of information did you share? (If you have not shared information, enter "na.")

Do you have any other general comments that you'd like to share about the ethical dimensions of nanotechnology?

DATA ANALYSIS

Following data collection, our team analyzed the responses to the open-ended questions using the quasi-grounded theory approach. For this method, we used open coding to identify themes within the responses. As codes were developed, informal notes were documented on the side to further explain and describe each code. These notes, also known as memos to grounded theorists, were essential to our analysis, allowing our team to draw connections in the data and identify interrelationships. These notes would also serve as the basis for our theoretical framework.

Although nanoethics has been heavily discussed and researched as of late, the unpredictability of the societal and ethical impacts of emerging technology calls for methodology that includes both inductive and deductive modes. The use of a quasi-grounded theory analysis[2] was appropriate for this study to fully investigate

[2] We use the term quasi-grounded theory as our methodology for analysis because we did not hold true to all procedures of a grounded theory analysis. In particular, our data was collected prior to analysis, as opposed to concurrent with analysis (the latter being a hallmark of a true grounded-theory approach). The purpose of a grounded-theory approach is to generate a theory that is inductively derived from the study of phenomena and grounded in data. This enables researchers to study topics and related behaviors from many different angles to develop a comprehensive explanation of why certain events occur. Grounded theory is

and gain a new perspective of nanoethics. Furthermore, we wanted to explore the social context of the responses as appropriate for a grounded theory analysis (Stern, 1980). We sought to not only understand the social context but to also identify the best approach for implementing an intervention strategy within mandatory laboratory orientation.

The interaction between concepts within the data began to appear within the first analysis of the data. As the analysis proceeded, the concepts were fleshed out and confirmed and coded into subsequent categories within the data. By conducting a thematic analysis within a grounded theory framework, the process allowed themes to appear and be directed by the content of the data. From the emerging themes, we developed a theoretical framework to help understand the societal and ethical implications of nanotechnology for each category. The use of a thematic analysis allowed us to analyze and code the data several times. The responses were read and reread to elicit and then confirm the merging themes until a saturation point was reached. The resulting themes were then discussed by the lead researcher and research assistant to confirm that the categories were inclusive and exhaustive. This method captured respondents' conceptualizations of ethics in nanotechnology and would be used to further explain the themes and its implications for the future of nanoethics. The results are presented below in the same order that the prompts were offered in the survey.

RESULTS

The first prompt asked what the "ethics of nanotechnology" means to the respondent. Several respondents indicated that the ethics of nanotechnology refers

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not used to extend an existing theory rather to develop a theory derived from data that offers insight, enhance understanding, and provide a meaningful guide to action (Strauss & Corbin, 1990).

to guidelines for safely handling and manipulating nanotechnology. This was seen in responses like, “this refers to the responsible use, handling and packaging of nanomaterials and nanodevices.” Others indicated the ethics of nanotechnology was also interpreted as moral decision making and using ethical principles as seen in responses like, “responsibilities and moral issues surrounding the use of nano-scale technologies,” and “the moral guiding principles relating to the decision whether or not to engage in research, develop products.” Building on this, some participants interpreted ethics as research integrity when reporting research data and information. Responses included, “Honest analysis and reporting of original nanotechnology data obtained,” and “Do not fake your data.”

Despite some confusion over the meaning of ethics of nanotechnology, several responses indicated that a relationship between ethics and SEI did exist for some of the respondents. For example, one respondent stated that, “Ethics of nanotechnology means to me as a researcher to be aware of the current and future implications of my research on the health of people, animals, and natures, as well as its possible impact on day to the day life in todays' and tomorrows society,” while another respondent reported, “Understanding the societal environmental impact of nanotechnology and using nanotechnology in a way that does not harm the society or environment,” and “being cognizant of the impact of your research on society.”

Themes of public safety and awareness, and concerns of malicious intent or weaponry also emerged. These responses included, “applying nanotechnology that will not individually target or negatively impact the public,” “properly educating the public of the benefits and risks” and “not meant for making weapons or harming the environment.” Several respondents did not want to imply that nanoethics is a part of nanotechnology or distinct from science ethics. This was evident in responses such

as, “I don't really think there are huge moral/ethical issues specific to nanotechnology,” and “I don't see a difference in ethics of nanotechnology and a more general ethics of science,” and “this is meaningless phrase to me, as it is equivalent to the ethics of any scientific or engineering field.” Four respondents also did not wish to recognize ethics as a part of nanotechnology, saying things like, “this is people with too much time on their hands,” and “It means some bureaucrats and admins have nothing important to think about.”

Regarding the most pressing ethical issue, a majority of the sample stated unknown societal, environmental, and world impacts. For example, one respondent stated, “unexplored and unknown effects of nanoscale materials on health,” as the most pressing ethical issue. Several themes from the first open-ended question re-emerged here including lab and personnel safety “the use of proper precautions to prevent accidents,” public safety “biological safety of humans when implementing nanotechnology,” and research integrity “fabricating data and making untrue claims,” and “stealing ideas.” Only a handful of participants stated that no ethical issue existed.

In terms of seeking information about ethical issues related to nanotechnology, half of the respondents chose not to answer. Among those who did answer, colleagues, faculty presentations, conferences, mass media and coursework were the common sources for information about ethical issues related to nanotechnology. Several participants included newsletters, websites (NNIN, CNS, NISE, EPA), scientific journals, and posters located throughout their labs. Half of the participants reported not finding information about ethical issues related to nanotechnology because they did not seek it. However, those who did seek information reported that they researched information about societal and

environmental impacts of nanotechnology including the impact of animal testing, human health and risk factors, and ethical practices in the lab and safe handling practices. Concerns of bio-terror "consequences of bioterror technologies," surfaced along with themes from the first question such as research integrity "making up fake research results and put it into peer reviewed paper."

In regard to sharing information about ethical issues related to nanotechnology, half of the respondents chose not to answer. For those who did answer, in-person conversation, emails, social media websites, training seminars, class lectures, and journal articles were common channels used to share information about ethical issues related to nanotechnology. In person conversations appeared to be the most commonly used method for sharing information. Respondents also reported sharing information with audiences of undergraduate students, interns, colleagues and research partners, family members, and the public.

Chapter 4: Study 2

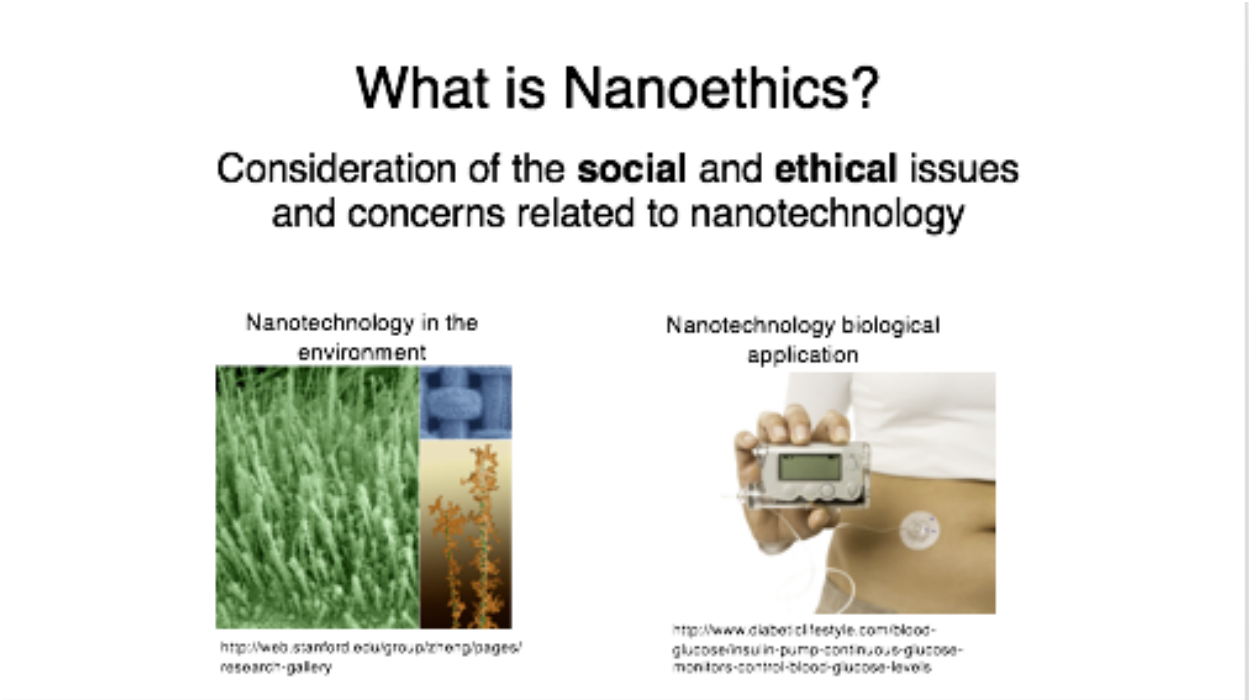
Study 2 builds on the results from study 1 and attempts to meet the need identified in the literature to develop effective training techniques and message strategies to get nano-scientists thinking about the social and ethical implications of the work that they do (Ferrari, 2010). Indeed, studies have shown that nanoscientists are willing to positively engage in ethical discussions, yet there is no effective training program to help them do so (Costa, 2011).

After reviewing the results of the open-ended survey, as well as the aforementioned research literature, our research team developed an intervention message strategy in the form of an interactive training module. We used an ecological model to develop the pilot (test) module as studies have shown that integrative approaches to complex social and ethical decision-making is needed for researchers to fully grasp and understand potential issues related to their work (Kjolberg, 2007). Furthermore, the use of an ecological framework allows us to highlight both individual and environmental factors that contribute to factors of behavior (McLeroy, 1988). The module, therefore, provides a framework that explains how nanoscientists can begin thinking of societal and ethical implications of their work. We also developed examples that demonstrate how to think about and integrate SEI into their current work at each level. Once the pilot module was developed, the overall purpose for study 2 was to gain a better understanding of the potential conflicts that keep scientists from currently addressing SEI, and their receptivity to the pilot.

THE INTERVENTION

The content of the pilot module was developed over the course of many months, after reviewing survey data fielded in 2015 from study 1 and prior research conducted by the National Nanotechnology Coordinated Infrastructure. The pilot module is roughly 15 minutes long, and is composed of PowerPoint slides, video, visually interesting graphics and a nice voice over. The first slide covers the purpose of the module by introducing viewers to the issue of ethics as it relates to the work they do, followed by an overview slide of the module's learning objectives. The next two slides then focus on explaining what nanoethics is and how it is used to take ownership and consideration of science at the nanoscale.

Image 1



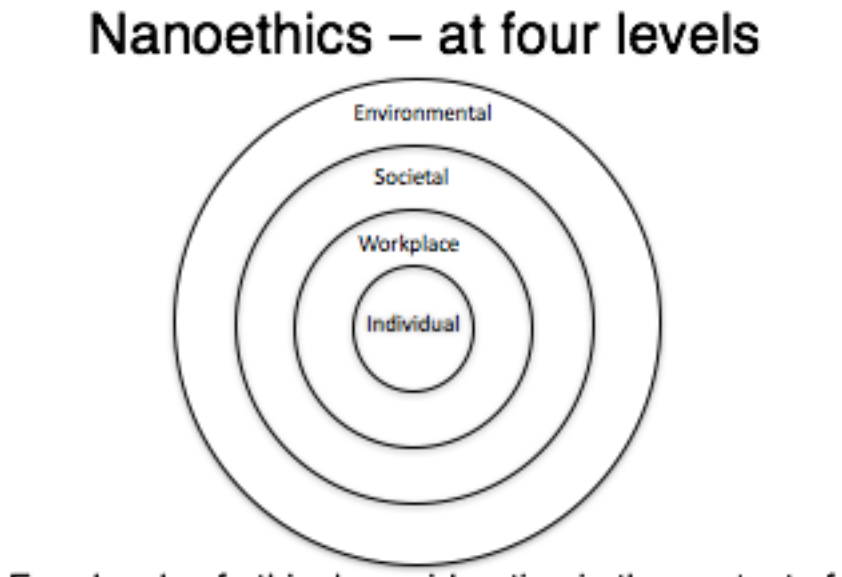
The module then moves to provide context as to why there is a need for ethics in the nanotechnology field and presents the SEI requirement as a result of the 21st Century Nanotechnology Research and Development Act. We then walk through the importance of considering SEI, and demonstrate how nanoscientists can become ethical leaders. To increase interaction and engagement, we pause at several moments throughout the module to pose discussion questions pertaining to the information already covered. The aim is for students to reflect on what they have learned thus far and have a discussion with fellow students.

The first discussion question, "what is nanoethics?" follows the slides about being an ethical leader. Slides 15-18 discuss potential risks and negative impacts as a result of not making ethical decisions. This point is driven home by presenting the Flint, MI lead water crisis as an example of unethical decision making. We then pause for another discussion question, asking students to reflect on any ethical leaders they may know and to discuss the qualities he/she had that allowed them to lead effectively. Following the discussion question we move forward to explain the concept of ethical doubt as a way for nanoscientists to consider societal and ethical implications. This concept was first introduced by Dr. Leela Prasad, Faculty Director of the Duke Center for Civic Engagement. According to Prasad, ethical doubt is a feeling of uncertainty about a moral position, which is often marked by things like missteps, doubt, and correction and includes experimentation and reflection. We walk through the concept of ethical doubt in slides 21-24, and encourage nanoscientists' to explore their ethical doubt and increase their reflection on alternative possibilities as we consider the societal and ethical promise and risk of the work we all do.

Image 2

Slides 25-42 offer an easy way to think about the typology of all the ways in which we can think about SEI in the nano context. The typology is presented as four concentric circles, with each circle representing a level of ethical responsibility that should be considered. The levels are individual, workplace, societal and environmental.

Image 3



Four levels of ethical consideration in the context of science conducted at the nanoscale

The pilot module then walks through each level of ethical responsibility and provides relevant examples on how nanoscientists' can become more engaged and informed about SEI. Slides 26-30 focus on individual responsibilities such as adhering to high standards of honesty and integrity in nanoscientists' profession and scholarship. These slides provide examples of how nanoscientists can take ownership of their individual responsibilities such as promptly reporting chemical exposures to the appropriate office, meeting training requirements related to the responsible conduct of research as required by sponsors and host institutions, and being familiar with the emerging research on the ethics and societal impacts of nanotechnology.

Slides 31-35 explain how nanoscientists can practice ethical responsibility in the workplace. This includes ensuring a safe working environment for those who

come into contact with their research and making sure their work environment is compliant with Federal and State regulations, University policies and procedures associated with the research, and matters related to chemical/biological safety, security, and disposal. The slides go into further detail of workplace responsibilities by encouraging nanoscientists to be an ethical role model in the workplace by raising questions about issues of ethics and societal impacts in meaningful ways. For example, the module provides questions an ethical leader should consider such as, "how would this development effect the environment?" and "Will this finding create potential privacy concerns?" The workplace section is then concluded with a slide that acknowledges that the workplace might not have all the answers, and explains that simply asking ethical questions can help build a more ethics-focused work environment.

The pilot module continues to ethical responsibilities on the society level in slides 36-40. Here, we explain how nanoscientists are responsible for understanding the social world that hosts and sustains their work. We then present a video composed by the College of Art and Sciences at the University of Washington that focuses on how neuroscientists and ethicists are having meaningful conversations about emerging technologies and their potential impacts. This video suggests that through active exploration of ethical doubt, we can become aware of the potential social and ethical impacts of their work.

The last level of ethical responsibility, environmental, is covered in slides 41-42. Here we place importance on understanding the environmental world that hosts and sustains the work nanoscientists do, including thinking about flora, fauna, air and water. We illustrate these environmental responsibilities on slide 42 by showcasing an ammonium nitrate explosion occurred at the West Fertilizer

Company storage facility in Waco, TX. The result of this explosion had tremendous long-term impact on the community and the environment, highlighting the need for scientists to consider the environmental consequences of products created by nanotechnology once they are released into the atmosphere and/or water streams.

Ultimately, our goal was to clearly communicate information about ethics in nanotechnology in a relevant manner to elicit conversation about thinking ethically and incorporating into their work ethical considerations beyond the micro-social level (i.e., within their lab). See Appendix A to view the PowerPoint slides used in the pilot module.

Methods

Data was collected in two ways. First, we solicited feedback from the training coordinator at the Microelectronics Research Center (MRC) at the University of Texas. Then, after editing the pilot training module based on that feedback, we hosted a focus group with undergraduate researchers working in the MRC. The focus group allowed us to gather observation data from nonverbal responses to the module and questions. Additionally, we wanted to gain pertinent insight on the most appropriate length for a training module, the relevancy of the examples included, and how the intervention message related to their current work in the nano labs. Insight on these matters would help guide our research team on how to best enhance the existing module message strategy and format.

The initial feedback from the MRC training coordinator included suggestions on the types of relevant examples to include in the pilot module that would relate to nanoscientists. These suggestions mainly focused on including everyday examples going on in the world to show the consequences of unethical decision making and its impact across the four levels of ethical responsibility. Feedback also included

developing ways to explain how scientists can best transfer ethical principles into their work. Additionally, the MRC training coordinator offered advice on the best way to integrate the pilot module into lab orientation. This included providing audio/visual interaction such as a video, and removing the closed captions from the slides. Lastly, we discussed creating a quiz to test the knowledge of lab attendees following module exposure. This would also be used to provide viewers an opportunity to pause and reflect on the information learned.

The revised pilot module was then presented to the undergraduate researchers in a focus group. Participants were asked to answer some initial questions, view the 12-minute module video, and then answer a few more questions. The focus group participants were recruited using a convenience sampling technique of undergraduate students participating in the 2016 Research Experiences for Undergraduates (REU) Internship Program at the University of Texas at Austin. We chose to use a convenience technique due to the timeliness of data collection and our ability to quickly contact students affiliated with nanotechnology research facilities and/or the National Nanotechnology Coordinated Infrastructure Network. The students were contacted via email to sign-up for participation. The email included information that explained the purpose of the study and participation guidelines. Our final recruitment list included 9 of the 11 students participating in the internship program, falling within the optimal range for an effective focus group. Of the participants, 18 percent were female and 81 percent were male; ages varied from 18-27. As an incentive for participation, focus group participants had the option to receive a hard copy of the book "Good Germs, Bad Germs," a book about the delicate balance between humans and microorganisms written by celebrated science journalist Jessica Sachs.

Focus Group Logistics

To eliminate accessibility barriers to participation, the focus group was held in-person at the UT Microelectronics Research Center, which was where the REU interns reported for work daily. We selected a room that was equipped with audio and visual capabilities and arranged for small breakfast items and refreshments to be provided. At the conclusion of the focus group, lunch was provided. Prior to the focus group, participants were asked to respond to initial open-ended questions to gauge their information seeking behavior of science ethics. The prompts used in the pre-focus group email included:

Have you received any information on ethics in your time as an undergraduate?

Has it had an impact on your studies? (Engagement question).

What have you seen in the media that has brought the issue of ethics to your attention?

During the focus group, participants were asked to view a 12-minute training pilot module on ethical considerations related to the conduct of nanotechnology research. Following the module, participants were then asked a series of open-ended questions in a conversational format to gauge their level of understanding of nanoethics following their exposure to the training module. The prompts used in the discussion were grouped into categorical sets and are as follows:

Initial thoughts

What are your initial thoughts on the video?

Did you learn anything? If so what?

Can you envision yourself using this knowledge in your decision-making? How?

Information retained

What is your definition of an ethical leader?

Why is it important to consider the societal and ethical implications of your work?

In your opinion, what role does ethics have within your research?

What do you think the role of ethics is?

How might you implement ethics within your research?

What are some consequences of ignoring societal and ethical implications in research?

What negative effects could nanotechnology have on the environment? (if no one brings up the environment in question)

Ideas for improvement

How could this module be improved?

How does this module relate to your work?

Is there a way it could relate more?

Was the length of this module appropriate?

What could be included to help you retain the information?

What would help you as a researcher to stay up to date with SEI information?

What examples were most helpful to you?

Final thoughts

Of all the things we discussed today, what is the most important to you? (Exit question)

What examples were most helpful to you?

ANALYSIS

Analysis of the focus group discussion began immediately upon the close of the session. Notes written by the facilitator and note taker were combined into comprehensive summaries. Observations such as body language, tone, and differing opinions were noted to help fully conceptualize emerging themes. Additionally, audio recorded during the focus group was transcribed twice, once by the note taker and once by the facilitator. The transcriptions were then cross referenced for accuracy and then transcribed for a third and final time.

From the transcription and notes, we were able to use a qualitative thematic analysis to develop insights and categorize emerging themes from the data for each question. A concept map was constructed to help summarize themes for each question. The data was then extensively analyzed until emerging themes were finalized and then re-analyzed to ensure accuracy. The cornerstone of the focus group was to further explore participants' reaction and understanding of nanoethics after being exposed to the training module. The results are presented below in the sequence that the questions were discussed in the focus group.

RESULTS

Responses to the first pre-focus group question revealed that students were unfamiliar with and lacked education on ethics specific to nano research and development. This was evident through responses like, "I have received very little information on ethics in my time at the University of Pittsburgh," or "I had one course that briefly touched on ethics. We discussed how mechanical failure could be the engineers fault due to negligence." Two students reported receiving training on ethics regarding safety handling and storage while another student reported, "plagiarism is the primary focus," in regard to teaching ethics. Only one student had

been exposed to information about ethics pertaining to nanotechnology stating, "I have received a little ethical insight concerning nanomaterials in a few of my classes." Based on these responses, it was evident that the pilot module would be the first encounter with nano specific ethical education and training during the students' undergraduate education. For example, one student stated, "I have not had any ethical training during my science or physics classes."

Regarding the second prompt, responses showed that media coverage of issues that arise from poor management and crisis mishandling were a prominent feature that increased attention to ethics. For example, one student said, "a lot of news comes from people who make unethical decisions and mess up, whether it is politicians, CEOs, or scientists." Students also reported politics, presidential elections, climate change issues, and crises such as the Flint, MI water crisis as news that caused them to think about ethics. Several students reported concern about the lack of understanding of the issues of ethics in sciences by the general public and professionals outside of science fields. Statements like, "laypeople really just don't realize that the issues are often multifaceted and can have multiple interpretations/ethical implications," and "the general public doesn't understand the complex engineered systems around them," were given. One student stated that, "nothing in the media has brought science and ethics to my attention outside of a few TED talks," while another reported rarely seeing media coverage of science ethics questions.

During the focus groups, the first category of questions prompted participants to reflect on their initial thoughts after watching the pilot training module. Immediately, several students expressed frustration regarding their lack of prior training about SEI in the context of nanotechnology. For example, one student

exclaimed, “Ugh, this is not taught at all,” while another student stated he had “zero education on SEI whatsoever.” Despite frustration, all nine participants agreed that they saw being exposed to SEI training as important. This was revealed through comments like, “I think it’s important. It’s not covered enough. I know professors I work with think about it but it is not their primary focus,” and “it’s important to think about SEI and (it) should be applied to research in the making.” Students also revealed that prior to being exposed to the training module, they typically separated science and ethics, associating ethics with wrongdoing prevention and workplace safety as seen through statements like, “I always separated science and ethics,” and “with nanotechnology I just like never really thought about ethics with it I guess.” Building upon this, participants expressed a desire to be exposed to more SEI training earlier in their career. In particular, students proposed that SEI be incorporated into their training and education in the form of a course or mandatory equivalent. One student stated, “I think there needs to be some balance so not everything regarding safety and ethics is an afterthought, but more into the initial design.”

When asked how might participants use this knowledge in decision making, responses from majority of the group indicated a better understanding of the interrelation of science and ethics at the nanoscale. For example, one student stated the pilot module, “really made me start thinking about what could the ethical implications be for the research that I’m doing because I definitely had not thought of that before.” Major themes from this section included research integrity and research progress and limitations also emerged in this category.

Regarding information retained, participants defined an ethical leader as a person who, “thinks about SEI and actually pursues it,” and is “willing to ask hard

questions, think about the impact on the population, kids, and the future." A few participants also stated that ethical leaders should be willing to use departmental/program funds to educate students on SEI since, "scientists get the safety aspect more and big companies spend a lot of money making people safe." Building upon this, most participants emphasized that the role and responsibility of SEI begins with the individual first as seen through statements like, "We typically think a higher-level person plays a bigger role but the role we play is important." However, this was contradicted through statements that attributed more responsibility to their PI and other superiors due to their lack of knowledge about SEI. Several participants expressed their concern in comments like, "I wish we had power over that (SEI) but we're just students." Another student shared, "there has to be someone who starts the conversation," but did not attribute any self-responsibility for being that someone.

Despite high awareness and acknowledgment of the need for SEI, several participants showed detachment from SEI and were not able to immediately recognize downstream implications of their work due to the unforeseeable nature of their projects. For example, one student stated, "we don't really need to think about our semiconductor lasers and how they would affect the world because they simply aren't going to be in the foreseeable future."

These participants also voiced uncertainty on when to begin thinking about SEI and how to incorporate it into their current work (i.e. academic phases of their undergraduate research and development). Some students felt that their research was at an academic stage that did not necessarily require SEI stating, "my research is so academic there is no point in discussing SEI," and "it's (SEI) just really hard at this stage to consider."

There was a consensus among participants that the consequences of ignoring SEI in research could lead to negative impacts. Students stated global warming, bombs, and holes in the ozone layers as examples of negative consequences. One student even expressed that societal dependence could be detrimental by saying, "Everyone knows how bad some of these things are and it brings up the (SEI) question and we realize we've been doing this really horrible thing but no one wants to change because it's too ingrained into our society." There was also group agreement that the lack of practical alternatives was reason for scientists to continue pursuing research despite potential negative consequences. One student shared, "At this stage, we don't have any practical alternatives, so we are kind of like forced (to continue)." Another student continued that scientists have to "launch the product first, then we see the effects," before considering SEI.

It is important to note that a few participants misunderstood the value of SEI, expressing concern that the progress of nanotechnology would be inhibited by the inclusion of SEI. For example, participants feared projects wouldn't proceed preliminary research stages due to the lack of practical, foreseeable alternatives for nano scientific solutions that do not comply with SEI consideration. This was made apparent through statements like, "SEI takes away from research, SEI isn't your job. It's a different job," and "SEI is an afterthought, after decades, considering SEI beforehand leads to slower product launch." One student also expressed that, "If (SEI) legislation was enforced nothing would ever be safe enough," while another student shared, "There's always that question of at what point does our progress become limiting to the environment and at what point does our consideration of the environment become limiting to our progress." Based on these statements, a consensus of risk avoidance and self-preservation surfaced among participants

when asked the importance of considering the social and ethical implications of their work. For example, one student stated, "I wouldn't want to be a part of a project that was a disaster," while another student shared, "first thing I think about is self-preservation, what is affecting me directly or will affect my family." Only one student voiced tension between wanting to see his work in the market place while also being concerned with its future implications.

Like themes in the first category, roughly half of participants agreed that SEI should be introduced during the academic stage of research, preferably before the start of their REU internship. In fact, majority of participants viewed SEI as an integral part of a responsible research program/orientation. For example, one student expressed the module would have been, "good to use had we had this at the beginning of the summer to think about before starting the research." Subsequently, themes centered on having a required SEI educational component during undergraduate studies emerged. One student shared that SEI is, "something that is not really talked about, you *teach* this." Several participants suggested that having an SEI expert on staff could help introduce students and researchers to SEI in the preliminary phases of their work thus helping mitigate the level of negative consequences stemming from a lack of SEI education. For example, one student suggested the creation of "SEI departments in labs just to evaluate research projects," while another student suggested integrating philosophy into the lab by having a physics professor teach philosophy. Other responses included hiring consulting firms to deal with SEI in the workplace and establishing a role where someone who has a technical background and an ethics background could work with researchers enough to say, "hey, I just thought of something about your

research that could be really, really bad. Let's discuss ways in bringing in other people to possibly get around that before it becomes an actual problem."

Several participants also felt that SEI would not prevent researchers from selfishly pursuing work that could harm society and the environment. This stemmed from discussion about laws and regulation of SEI. Students felt that, "laws are always going to be reactive, so I guess you would hope to develop a culture that considers it (SEI) first." However, one participant objected to this perspective, stating "I guess I'm kind of opposite of that (because) I start off thinking off with the environment instead." This again spurred conversation over the appropriate time to introduce SEI training into a scientist's research and development. The common theme resulted in the need of early introduction of SEI training to increase scientists' level of awareness about unforeseeable implications. Several participants revisited the idea of having an SEI expert on site along with identifying ways to discern SEI leadership in the workplace. Common statements included, "it would be really interesting just to see who in the organization here that we worked under or interacted with is engaged with SEI," and "who can we talk to here about SEI?"

The neuroethics video by The University of Washington shown in the training module was received well. Participants communicated the importance of seeing nanoethics in action in other programs. For example, one student stated the video showed how, "as scientists, we tend to think of our own interests; We need to think about the problems society needs more help with," while another participant stated, "It's interesting to hear how others approach this subject to talk about ethical issues." This exhibits the effectiveness of using an ecological framework and a theoretical foundation to educate scientists about social and ethical implications.

Emerging themes from this section also included emphasis on individual responsibility, risk avoidance, ownership, and reinforcement of SEI inclusion.

In terms of improvements for the pilot training module, participants requested that the module contain questions, SEI examples, and case studies that are nano specific or could be transferred in a way that related to nanotechnology research and development. Participants overwhelmingly agreed that learning about SEI should happen in interactive group settings, such as in the classroom, to encourage discussion and retention of SEI information and how to think through concerns. Students expressed concern about individual SEI learning and risk avoidance with comments like, "as an individual it would be easy to avoid the thoughts or questions you don't want to think about," and, "it'd be easier to just not say anything and to just view it and be like, hmm okay." Participants acknowledged that an SEI course would lead to more insight on how peers are understanding and engaging with the information and reduce risk-avoidance. One student even stated that SEI lectures would be more engaging than the module presentation. Additional sources suggested for receiving and continuing SEI education included in-person conversations, meetings, socials, blogs, and newsletters. Easy access and availability of the training module and supplemental materials were also proposed for continuing SEI education. There was consensus among participants of the appropriateness of the length of the module based on the amount of information included. Only one participant requested that the module be slowed down to include interactive discussions due to the amount of information being relayed, which would also help with the amount of information retained.

Overall, participants stated the most important information gained from the training module was learning how to start thinking about and incorporating SEI into

the conversation. For example, one student shared, "I already knew stuff I was doing could have ethical implications. The module helped bring this to forefront of my mind." Participants also communicated feelings of confidence facilitating and contributing to SEI conversations after learning basic vocabulary and terminology to use. Common statements included, "Now I feel more confident using SEI in my work," "the module was really helpful in establishing basic vocabulary and the general ideas and structures," and "I don't know where to begin, but having this as a spring-board is useful." Participants also agreed that learning about SEI now would be helpful for them long-term, sharing that, "Being exposed to this now is helpful so that when we start those jobs we will have the insight to deal with this," and, "eventually we will be the ones with interns so SEI is something we need to pay attention to now."

The research team also made several observations throughout the focus group. For example, side conversations about the role of ethics within large corporations were brought up throughout the focus group. There was a consensus among participants that oil executives and corporations should be required to hire SEI directors and place an emphasis on SEI education in the workplace beyond academia. It appeared that students perceived that ethical issues in the lab were a result of loose social and ethical requirements within the industry. Corporate social responsibility (CSR) was noted as a first step of action for corporations, but participants largely believed that CSR was not an adequate solution for SEI implications. Participants were also concerned about the amount of selfish and financially driven research being conducted as a result of industry practices.

In conclusion, participants seemed to be relatively comfortable discussing SEI in a group setting among their peers. Each participant contributed to discussion

and often called on fellow students to respond to certain questions. This level of comfort could be a result of the participants' relationships with each other having spent the summer working on projects and engaging in social activities with each other.

Chapter 5: Conclusions

The studies conducted in this thesis sought to understand nanoscientists' perception of nanoethics and introduce an intervention messaging model that could help train nanoscientists on the social and ethical implications of their work. Our findings from the qualitative analysis conducted in study 1 revealed that nano-scientists' perception of nanoethics largely related to the micro-social level, and scientists were reluctant to incorporate any ethical considerations into their work beyond this level. This conclusion led us to develop the interactive pilot training module using an intervention messaging technique. The message effectiveness of the pilot model was tested in study 2 by use of a focus group. Our results from study 2 show that nano scientists and researchers have a significant interest in social and ethical implications, but had a very limited foundation of nanoethics and consideration and application of SEI in the context of nanotechnology. In fact, results from study 2 are grounded in the data, revealing that exposure to the training module resulted in participants feeling more confident about having conversations about SEI with their peers and colleagues. These results are congruent with research conducted by Gina Eosco that explored the societal and ethical views of REUs in 2014 (Eosco, G. 2014).

Conclusions based on this research indicates that future research should thereby be diverted to understanding the effectiveness of SEI exposure and training during the early stages of nanoscientists' education and research. Findings in study 2 support this conclusion, with focus group participants expressing a desire to learn about SEI in the beginning of their program and academic research. If the goal is to create an industry of scientists and researchers who think about downstream SEI,

then we must provide them with the proper training to do so. Due to the perceived complexity of thinking about and incorporating SEI at the nanoscale, scientists should be exposed to recurring SEI courses and materials to better equip them with the tools needed to think about SEI in the context of their work.

Integrating ongoing discussion and SEI training throughout scientists' careers could also help cultivate a culture of SEI thinking and build better SEI practices into the workplace long-term. Nanotechnology is a multidisciplinary field undergoing rapid development. As such, engaging with ethicists and philosophers as seen in the video created by the University of Washington, and providing opportunities for cross-collaboration on ethical studies, can further increase engagement and understanding of SEI among scientists. Furthermore, there lies a need for continuation of more in-depth research to understand the effectiveness of SEI intervention messaging strategies and techniques on behavior change within the nano industry. This research could help push nanoscientists' boundaries and comfort zones on ethical thinking and help encourage nanoscientists' to understand the value of considering unforeseeable implications. One additional recommendation for future research is to study the progress of REU SEI conversation and work integration beyond the program.

At present, the existence of ethical issues within nanotechnology will continue to be a prominent matter. However, research must help move scientists towards action to help recognize and mitigate social and ethical issues before and after they manifest. The method used in this paper employed an ecological framework to help nanoscientists understand and envision how ethical thinking is used in cross-sector examples. The younger generation of nano scientists are already engaged in learning about SEI, yet there still needs to be a focus on

nurturing this interest to help catalyze change in the nano sector. Much of the context of this thesis is also relevant in the health communications fields. For example, the Association of Teachers of Preventative Medicine and the Association of Academic Health Centers has conducted research to determine the most appropriate approach to provide a new framework that incorporates ethics into health professionals' curriculum (Allan, J 2005). As seen in the health communications field, there needs to be a transformation of content, methods and approaches to integrating SEI into education and training to facilitate change in ethical thinking and behavior in the nano industry. Development of inter-professional and collaborative training methods for the nano audience could prove useful in creating a work environment that encourages conversation and use of SEI in both the lab and classroom.

Appendix

APPENDIX A. OPEN ENDED QUESTIONS AND RESPONSES FROM STUDY 1

In your own words, what does the phrase "ethics of nanotechnology" mean to you?

The moral and societal implications of using nanotechnology

safety in nanotechnology to public

honest

It means be cognizant of the impact of your research on society. It also means doing research in a safe manner.

Using/studying nanotechnology in an ethical manner and in ways that are not detrimental to humans.

Understand harzards, do right things

Ensuring no harm to the environment or life occurs

Utilizing the products and processes enabled by nanotechnology to better society and individuals, not harm it or them

Doesn't harm people

Passion

Using nanotechnology in a manner that is beneficial to humans and does not exploit or endanger them.

“Do no harm” at the atomic size scale

Using nanotech in ethical way

delimas relating to the research and use of nanotechnology including unexpected consequences, potential negative uses, and public awareness issues.

as far as human still control the process

Complete safety disclosure

Considering the impact of nano products on the environment and on human/animal health.

honesty with your experimental results

Study of and development of phenomena and technology in the nanometer range, at which point certain physical and chemical phenomena are accentuated.

Dealing with surprising, new moral decisions that were moot before the emergence of the particular nanotechnology

The phrase represents the care researchers and industry must take to ensure that the use of nanotechnology does not negatively impact human health or the environment.

It means one do not just work to advance the technology, but really consider the impacts on whole society.

How nanotechnology impacts human and other life forms, including the environment as a whole.

not meant for making weapons or harming the environment

The principles that guide the use of nanotechnology away from ends that would negatively affect society.

It conforms to existing ethical protocols, with possibly required adherence to either medicine's "First, Do No Harm" credo or the Precautionary Principle when referring to long-term effects or continued presence within ecosystems and the like.

Ethics of nanotechnology means to me as a researcher to be aware of the current and future implications of my research on the health of people, animals, and natures, as well as its possible impact on day to the day life in todays' and tomorrows society.

developing technology without damaging the world

Moral guidelines directing behavior in the field

The manner a variety of nanotechnologies can be used; weighing the benefits versus detriments to individuals and societies.

Same ethics as science in general except we need to look into the health implications of releasing these materials into nature.

like the MD oath - do no harm to people or the environment

Being responsible and trustworthy regarding research in the nanotech field.

complete cost benefit analysis of unknown technology

propper use of nanotechnology with regards to the betterment of humanity

Managing the advances in nanotechnology while not losing sight of ethical and moral practices

Ethics of nanotechnology means that technology that employs devices/chemical structures on the nanometer scale are regulated to ensure people's safety and civil liberties

Applying nanotechnology that will not individually target or negatively impact the public.

developing and use nanothecnology placing human needs and safety first

It means using ethics within the research and exploration of all things related to and coming from nanotechnology.

study of nanotechnology should follow certain ethical principles and should make discoveries that would be beneficial to the society

A reasonable effort to ensure that nanotechologies do not expose us to dangers much larger than those in our current environment

Understanding the societal environmental impact of nanotechnology and using nanotechnology in a way that does not harm the society or environment.

In my opinion, this refers to the responsible use, handling and packaging of nanomaterials and nanodevices.

I tend to think of safety issues associated with nanotechnology, as I don't really think there are huge moral/ethical issues specific to nanotechnology.

rigor and standards in scientific research

Consideration of the impacts of nanotechnology employment upon human health, equality, liberty, an on ecosystem health.

To the best of your understanding, your statements about the use/performance/cost of nanotechnology are true.

safe for human use. properly educating the public of the benefits and risks

Scientific ethics in the study of nanoparticles and nanotechnology; simply the ethics of research in regard to nanotech

Moral concerns related to nanotechnology

For me it covers standard academic research ethics in addition to the effects of nanotechnology on the world

what is right and wrong about nanotechnology

I don't see a difference in ethics of nanotechnology and a more general ethics of science. The only thing that changes is the size scale and we must recognize that we cannot make the same assumptions for materials at the macro and nano scales. Ethics ofscience or technology means we have to be honest and care about how we take our data and honest about reporting our data. We do not delete data points simply because we cannot explain them. We are open and transparent in our pursuit of science.

ensuring that nanotechnology is only utilized in an application when the relevent risks have been appropriately evaluated

primarily, not exposing innocent people to hazardous effects of nanotechnological research and materials

ethical and unharmful use of nanotech, clear and correct education of nanotech to the general public

Nanotechnology is a field and especially the public is not aware about this field. Therefore, it is the ethical responsibility of the exrperts in the field to educate the public about pros and cons of the field.

this describes the ethical implications of the development, manufacture, implementation, and use of nanometer sized tools, whether particulate or nanomachines.

Building things from nano-sized parts to exercise control over basic necessities of life such as food sources, medicine.

Protection of environment including flora and fauna

Ethics of nanotechnology calls to mind an awareness of the effects that nanotechnology research and development may have upon the well-being of members of society.

Practices for people involved in research and industries related to nanotechnology that consider ethics and morality in larger social frameworks, concerning the consequences of what people in this community do.

Acknowledging the risks of nanotechnology; understanding impact on environment; conducting conscientious research so as not to mislead the public

Ethics of nanotechnology is the obligation of those who understand nanotechnology to properly advise the rest of the world on the dangers and potential opportunities associated with nanotechnology.

exploring the safety and complex ethical implications (even tradeoffs) of various nanoscale technologies

use innovative technology for good purposes.

It means ethics associated with any application of nanotechnology

decisions for upholding the safe and proper use of nanotechnology

protection of individual information related to nanotechnology.

Moral questions about the development, use and sale of engineered materials that are comprised of materials on a nanometer length scale

Honest analysis and reporting of original nanotechnology data obtained.

The question of how nanotechnology should be applied to mammals, and how the potential health threads of nanotechnology are handled

The use of nanoscale objects-based technology for physic, mechanical, electronic, optics applications

Socially responsible implementation and dissemination of nanomaterials.

You shouldn't use the technique to harm people.

Ethics relating to the use of nano materials, nano particles, and other nanoscale elements. In other words, ethics of however one defines what nanotechnology is specifically

whether or not some use of nanotechnology is advancing ethical goals

it refers to an academic exercise of ethics being created before technology

Thinking 'big picture' about what you are doing in the clean room and how it may effect people down the road.

Using nanotechnology in a manner that does not harm living things or the planet

The question of should we pursue this field without knowing all the consequences of it.

Ethics of research involved in the nanotechnology field.

As with all sciences and engineering, there needs to be validation of how the technology will impact people and the surrounding environment and check points in place to ensure safety and well-being beyond what the science could achieve. If potentially detimental to society, the technology should stop or be re-addressed to avoid negative impact to humanity.

Doing ones best to understand and plan for possible negative and positive effects of research using nanotechnology.

Attitude

I found this difficult to answer: What are our responsibilities to fully understand the impact of nanotechnology on the body and environment

Using nanotechnology to better humanity

Thinking about the ramification of the long-term effects of ones nano research

The moral responsibilities associated with engineering technology at a nanoscale.

Provide better living and do no harm for human beings

Making sure that what you make is not detrimental to the world or society and that it advances science.

Responsibilities regarding applications of nanotechnology in life

Bad impact when we change the world using nanotechnology

here are sanctioned uses of nanotechnology and other areas that might not qualify under that banner

don't be evil with nanotechnology

Guidelines to follow when doing research in nano-sciences

Nanotechnology impacts that could lead to negative consequences of biology or environment

Complete transparency of intended use

Considering the technological and safety implications of the new properties resulting from nanoscale objects

Studying and guiding the "appropriate use" of nanotechnology in human (e.g., healthcare, military) and environmental applications.

Nanotechnology should be used properly to enhance the quality of our lives

To me it means: How is nanotechnology used? Is it used for ethical purposes?

No idea

Dealing with ethical issues unique to nanotechnology which have not previously been explored.

Everything from the accuracy of reported science to implications of research on the genral population

whether or nor conflicts of interest are identified

The moral guiding principles relating to the decision whether or not to engage in research, develop products, or distribute items/solutions containing nanoscale features whose health and safety properties are not fully understoof.

all the moral and ethical advantages, conflicts and difficulties related to the use of nanotech thta can affect in any possible way directly or indirectly any living creature

Moral decisions and precautions related to the societal impacts of nanotechnology.

it mean the a responsible way to make nanotechnology science (research)

Not wasting a lot of raw materials to fabricate nano materials

nothing

Not anti-social, beneficial to human society

The topic about if nanotechnology will harm the human society

Researching nanotechnology and integrating it into industrial and commercial products in a way that doesn't pose a threat to the health or well-being of researchers or consumers.

not so much

safe use by researchers and ethical applications

evaluation of all (i.e. not merely scientific) consequences of research in and application of nanotechnology

Doing the right thing to enhance science , by solid work but not inflated-hot-topics

doing right thing

The sever side-effects of nanotechnology and its related products on environment and human health in future (as an example)

Similar to all other fields, it means that the use of pieces of nanotechnology do not harm others or the environment. It also means that research conducted is performed in good faith for scientific advancement.

You should be able to explain your work to your grandmother.

good use of nanotechnology

the impact of nanotechnology on society

presenting the true and genuine potentials of manipulating energy and matter in nanoscales, rather than spreading the buzz word.

The proper use of nanomaterials and the control over their public health hazards.

Due diligence in foresight about potential dangers of the work.

To me it means keeping the community informed about the benefits and underlying effects.

using nanotechnology in a way that society considers appropriate

Possible implications on society, environment or economy that may arise from the use of nanotechnology or related products falls under its ethics.

Ethics of developing and implementing technology at nano length scales.

Realizing that we're breaking ground and unleashing millions of possible new ideas while having the decency to make sure they're not used maliciously.

Ensuring nanotechnology is used safely and appropriately for both researchers and end users

the moral choices associated with the development, implementation, and commercialization of nanotechnology

following principle while doing research

weapon use, heath issue

awareness of nanotechnology use as it pertains to humans, animals, and environment

Following appropriate EH&S procedures

It means the specific ethical issues that need to be considered in performing research in the field of nanotechnology

Ethics in research and ethics with regard to any detrimental health effects associated with the use of nanotechnology

to make sure that the technologies are safe and do not threaten to harm peopl or animals

Understanding the implications of one's research and taking into account societal harm.

Using technological advancements in nanotechnology for improving human life and not for harmful purposes

It means some bureaucrats and admins have nothing important to think about

Protecting human/animal health and the environment during the research, manufacturing, and use of products enabled by nanotechnology

The morality of nanotechnology

it doesn't relate to any ethical issues to me

Scientific research for the betterment of humanity, not for harm or weaponry

Do not fake your data.

being ethical

This is meaningless phrase to me, as it is equivalent to the ethics of any scientific or engineering field

It means the set of issues that accompany some research on nanotechnology, in which there are ethical concerns regarding the practices and/or consequences of the research.

The responsibilities and moral issues surrounding the use of nano-scale technologies, such as nanoparticles.

The responsibility to ensure that nanotechnology meets the standards of toxicology as required for other chemical exposures

Nanotechnology should only be used where it will not cause harm to human beings and the environment.

conscience

benefit and risk brought by nanotechnology to human and society

---

In your opinion, what is the most pressing ethical issue in nanotechnology today?

Ensuring that there are no toxic side effects with nanotechnology used for medicine

potential future hazards that we have yet to understand. Similar to the hazards realized with asbestos after it's use.

bias on the finding

I think there is much need for an understanding of the imapct of nanoparticles in the envrionment and interaction of these particles with plants and animalz, including humans. What is the fate of these particles.

How they can affect human health or be used to harm others.

Do know every harzards

Accurately determing the effects of nano-sized materials on the human body
Long term and short term health effects of both final as well as waste products

Implantables

to develop new technology

The potential that it could decrease the importance of doctors.

weapons & surveillance

Using it in a way which may harm human instead of helping

unexpected consequences, it is often assumed that because the bulk properties of a product are not harmful, the nonascale product will not be harmful either. This is not necessarily true and the effects of chemical need to be studied before used with the ublic.

robitics

Safety

Establishing safe production and use guidelines.

fabricating data and making untrue claims

The design of devices that directly alter or enhance human ability on a molecular/cellular scale.
Informing the public, so that they can meaningfully be part of ethical decisions

I am concerned about the rapid adoption of nanotechnology in consumer products without sufficient research or thought to impact--for example, the inclusion of silver nanoparticles in non-medical products could cause antibiotic resistance.

The possibility to generate hazardous particles for environment and human health

Because this technology is so small, it has the potential to contaminate many different systems.

pollution

The use of animals towards its development

Nano-toxicology studies, particularly dynamics of common nanoparticles in biological cycles and studies of how nano-structures bio-accummulate and their effective life span in the environment.

Unexplored and unknown effects of nanoscale materials on health, use of DNA to create "artificial lifeforms"

environmental impact of nanoparticles

Stealing ideas

Cloning.

The lifecycle of the materials and how they can enter poducts we directly consume.

same as in al technology - we need to consider the consequences of the products we develop

Having enough significant data to confirm findings on such small scales and providing all data, not omitting unexpected findings.

try to commericialize a technology without thorough study of potential hazardous effects

the use of propper precautions to prevent accidents

Possibility of (practically) undetectable surveillance

In my opinion, the most pressing ethical issue with nanotechnology today is enforcing new regulations that require structures with new properties endowed by their specific size regime to be tested for toxicity and other safe handling and use.

Use of nanomedicine by health insurance companies.

safety

I think the most important issue is thinking about the longterm consequences worldwide of everything moving to the nanoscale.

new materials and applications that researchers invent mey put a threat to environment and to people's health

Potential toxicity effects?

Understanding and regulating the Impact of transgenic plants and animals, personalized genetic analysis, and any nanomaterials that will be in consumer products or dispersed into the environment..

Long term effects of nanotechnology as it pertains to human health and the environment.

Exposing researchers to poorly understood health hazards

reproducibility of results.

I am not sure.

Honesty in the reporting of characteristics/physical properties and the ability to scale/manufacture those up to "real" applications

biowarfare and undetectable weapons

Reproduceability of results, papers that have irreproducible data

Environmental impact

I think publication ethics is an important issue as a result of the large quantity of articles produced, vigilance is certainly required to maintain quality

companies who may be in the business and have nano waste but there are no policies yet for this

The same that it is for science. In the "publish or perish" environment, some people are tempted to cut corners or massage or reuse data in order to get more papers.

ensuring that we aren't using products that will turn into the next asbestos.

developing a general protocol for working safely with materials and structures that have undetermined (possible hazardous) characteristics

misleading media

Nanotechnology is relatively a new field and there is not much histrory behind this and therefore, even scientists and engineers in this field are learning about advances in this field and therefore, the pressing issue is to find the consequeses of thes advancements at the same time as its benefits to understand how these advances have negative effects either on the environment or humans.

Uncertain.

A means to invade privacy and/or administer control over one's life.

Understanding the differences between bulk and nano scale properties of materials

Potential negative effects upon the earth and within society, generally health-related.

Privacy issues

Improperly labeling a technology as nanotechnology for funding or publicity

Not sure

Nanotoxicity (human and environmental hazards)

uncertain rules and agreement for the applications being pursued in bio research.

Ensuring that usaged and waste streams do not damage the environment.

misuse of the technology

DNA analisys

The unforeseen health and environmental impacts of the wide scale use of nanotechnology.

Misrepresentation of data and plagiarism of data.

The still unanswered question whether nanoparticles do or do not cause diseases in mammals, and under what conditions

no clue

The unknown health and environmental responses to nanomaterials.

We are not certain on properties of some materials.

Understanding the effects and interaction of nano particles on cells and small-scale organisms in total

avoiding asbestos-like toxicity

the hype exceeding the promise of nanotechnology and thus poisoning the field for future generations

I am not aware of a pressing ethical issue.

The effects of nanotechnology are not known.

Will the use of nanoparticles in consumer items result in unforseen human health and environmental consequences.

The same issues that are related to the entire scientific field. I can't think of anything specific to nanotechnology.

Environmental Health and Safety risks associated with items that cannot be physically seen but still contain or are made from hazardous materials.

Medical ethics is a major issue associated with nanotechnology.

Unknown health hazards

N/A

What is the environmental impact of nanoparticles once excreted from the body

Nanotechnology being explored as a weapon

I honestly do not think there are any ethical issues in nano today

Design of functional enhancements using nanomachinery.

lack of regulations

The hazards associated with nanomaterials being released as polutents

access to fabs

Human cloning

health issues relating to nanoparticulate usage and exposure

define the appropriate research areas

Long-term effects of nano-materials in health and environment

I'm not really aware of ethical issues regarding nanotechnology. I don't consider genetic manipulation to be nanotechnology.

Luminescent nanocrystals as bio-markers

Proper toxicological characterization of nanoscale materials, as their properties can be substantially different than their bulk versions. Challenges of disposing of materials when they have unknown or novel function.

Misuse of nanotechnolgy in military applications

Biological applications such as cloning animals and "growing" meat. Also surveillance applications that could intrude on privacy.

None

Publishing results without rigorous experiments and the quality of the work.

Accuracy of scientific claims being made

secret financial incentives or rewards

Long-term health effects, such as bioaccumulation, risk of cancers, and increased chemical activity solely due to the small size of nanoscale features.

Use of nano-tech for manipulation of genetic material

Biological safety of humans when implementing nanotechnology.

Developing nano material based alternate energy sources that have been developed with intensive energy consumption

Researchers pursuing it just because it is hyped up

Following the need of technology progress without damaging the benefit of whole human society

Not sure

Biomedical applications such as the recognition of genetic risk factors for disease could be misused by medical insurance companies.

People are not aware of how small nm actually is. They may handle the products wrongly

weapons?

The most pressing issues in nanotechnology are whether and how it addresses the most pressing non-nanotech issues: global suffering due to poverty, disease, and conflict (roughly in that order).

too much emphasis on the 'wow factor' , too little long term investment , meaning half cooked result and shaky data is everywhere.

fabrication and stability

It s a new terminology and a lot of researchers and companies just use it to sell their products, without any real improvement based on the nanoscale characteristics of their products

Perhaps the presentation and review of research. Too often, low impact or questionable results are published, even in higher quality journals. This is a lapse on both the reviewers and on the people conducting the science.

Anything that has to do with animals

competitive atmosphere

potential dangers of nanotechnology on society

Not exaggerating the capabilities and potentials

Nanotoxicity

Regard for how industrial operators will interact with various technologies at each stage of the commercializations path.

Awareness among public

drug delivery

To use nanotechnology for weapons development is a very important ethical issue.

Consumerism and over-commercialization

Because it's working on the nanoscale, we don't always know How the materials affect humans, e.g. Nanotubes of a certain length are carcinogenic. These things need to be investigated.

Lack of proper training of undergraduate-level researchers on inhalation risks of nanoparticles

the uncertainty of the long-term health and environmental impacts of nanotechnology products, esp. with regards to widespread commercialization

genetic modification

heath issue

use as weapon

nanoparticle toxicity

The biggest issue seems to be taking into consideration of the various adverse effects a new technology can have on society and the environment before mass production/utilization

Managing any adverse health effects associated with the use of nanotechnologies, whether through the use in vivo or through contact.

how it would be used for weapons

Outreach

I really have no idea

That some people insist on eating and breathing things they should not
Not disclosing/communicating the direct or side effects of the nanotechnology based research/products on the human health and environment

If you build a self-reproducing machine it could destroy the world (grey goo)

none

profit at all costs

plagiarism

being ethical

There is none

Public safety and toxicity of nanoparticles/nanostructures, especially if/when they become airborne.

Whether the nanoparticles cause environmental harm or disease.

Protection of workers in occupational environments during nanotechnology manufacture

Use in human medication.

falsehood

the emerging of Nanotechnology can lead to revolution in industrial and civilization whereas the long term risk is unpredictable.

Think about your most recent experience SEEKING information about ethical issues related to nanotechnology. Where did you find the information (e.g., on a particular website, via a colleague, etc.)? If you have not sought information, enter "na."

Journal articles

website

I have used the NNIN website, the CNS website, NISE Net website, government publications
NA
NA
MSDS
Colleague
Google
Via a colleague
A training program at my lab
Scientists blogs
Google first
nano ethics seminar
NA
NA
Nature journal
NA
colleague
NA
To be honest, I've sought information through lay news reports (NYTimes, WSJ, The Atlantic) more than scientific sources.
Colleague
NA
NA
NA
journal articles and journals related specifically to nano-toxicity studies
NA
nanotechnology course
NA
Presentation
NA
NA
I usually go to web of science but a lot of conferences are now having sections focusing on this topic.
NA
NA
NA
NA

University websites for ethics programs and nanotechnology programs
NA
N/A
google, seminar, colleagues
NA
NA
Talking to well-informed colleagues
NA
NIOSH Document on safe handling of nanomaterials
NA
colleage
NA
NA
NA
Various websites hosted by nnin or nano days
via a colleague
none
NA
NA
I think nanoethics applies when you are engineering a product that will make it into the real work. Basic research does not always have ethical implications.
nanotech textbooks and via a web search
website
NA
NA
A variety of websites.
discussions with other scientists
NA
Via senior colleagues and university professors
A course in materials science; discussions with colleagues
Usually look at the Internet, often Wikipedia or more specialized websites with core information about the particular topic
technical paper/presentation, colleague
on regular science online report.
Colleague
Via a colleague

NA.
MSDS and other similar references
NA
Chemical & Enginerring News and other science journals
NA
NA
NA

When a concern about nanotechnology is brought up it depends on the nature of the issue. E.g. safety of chemicals used and disposed of when working with nanotechnology vs how the nanotechnology may affect humans. Most research is conducted via searching n the internet since there are no other handy/easily accessible/thorough resources

I read scientific articles on the environmental consequences of nanoparticles and the news reports following theses articles several years ago.
NA
articles in technology magazines
NA
a colleague and website
NA
NA

I was seeking information so I went to our nanotechnology lab and read up on it. There are also posters all over out lab.
NA
NA
NA
NA
News
http://www.ethicsweb.ca/nanotechnology/
research articles
google
EPA website and school website. Safety training
NA
NA
ACS C&EN, journal articles

Colleague who taught a college class in ethics of nanotechnology to non-science majors.
NA

website via google

Exposed to such ideas reading biographies of scientist or reading their books/articles.

Both mainstream news sources and scientific journals (news source to hear the issue, then scientific journals to see what they are actually reporting about and how much they generally don't report correctly).

NA

NA

Published online, and in a journal

NA

NA

Faculty presentations

NA

Seminar,

NA

msds printouts, occasional ieee publications

NA

a researcher's personal website

NA

NA

via a colleague

NA

I took a short course on ethics as a part of a nanofabrication training course.

NA

websites, lectures, seminars..

NA

NA

NA

NA

NA

google

EPA website.

Lab website

NA

online articles, journal articles

youtube

website

conference goers
Literature search
A seminar on research ethics
seminar at school
NA
NA
Via a Colleague
NA
NA
IEEE magazines, colleagues, various websites related to scientific/technological advancement
On a website
NA
conferences
NA
NA
NA
conference, colleagues
University research ethical session
Looking for goverment regulations about spray coating of nanoparticle contained solution for building envelope

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MSDS
Colleague
Google
Via a colleague
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Google first
nano ethics seminar
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NA
Nature journal
NA
colleague
NA
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Colleague
NA
NA
NA
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NA
nanotechnology course
NA
Presentation
NA
NA
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NA
NA
NA
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N/A
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Talking to well-informed colleagues
NA
NIOSH Document on safe handling of nanomaterials

NA
colleage
NA
NA
NA
Various websites hosted by nnin or nano days
via a colleague
none
NA
NA
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NA
A variety of websites.
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NA
Via senior colleagues and university professors
A course in materials science; discussions with colleagues
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on regular science online report.
Colleague
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NA
NA

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NA

NA

NA

NA

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NA
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NA
NA
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NA
Seminar,
NA
msds printouts, occasional ieee publications
NA
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NA
NA
via a colleague
NA
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NA
websites, lectures, seminars..
NA
NA
NA
NA
NA
google
EPA website.
Lab website
NA
online articles, journal articles
youtube
website
conference goers
Literature search
A seminar on research ethics
seminar at school
NA
NA
Via a Colleague

NA
NA
IEEE magazines, colleagues, various websites related to scientific/technological advancement
On a website
NA
conferences
NA
NA
NA
conference, colleagues
University research ethical session
Looking for goverment regulations about spray coating of nanoparticle contained solution for building envelope

---

Think about your most recent experience SEEKING information about ethical issues related to nanotechnology. What kind of information did you find? (If you have not sought information, enter "na.")

I found all kinds of information about....
an op ed
prevention
nanoscientists ethical practices in the lab
NA
Editorial columns in magazines such as wired
safety information
There are some interesting articles and lessons to be used. I have not found a good source for a one-stop on environmental studies. I think this will require a citation search but I wish there was a more consolidated source for some enviro studies and teir results.
NA
NA
Not much
Paper and opinion piece
Health issues
NA
NA
Case Studies

NA

both laboratory practices and general societal impact concerns.

NA

NA

Overview describing the types of issues that will soon arise from nano products.

NA

Little more than a unfiltered opinion

NA

Largely, questions are posed, but I don't see a lot of discussion or definitive results.

N.a.

NA

NA

NA

Standard uncoated SW-CNTs bioaccummulate and potentially do harm in living organisms, while functionalized ones are passed through organisms with minimum interaction

NA

toxicity of CNTs

NA

Authorship guidelines

NA

NA

I found out that TiO2 nanoparticles are used as coloring agent in white food products.

NA

NA

NA

NA

Types of ethical dilemmas and potential abuses of nanotechnology

NA

N/A

very little / very poor informations

NA

NA

Opinons on who bears the responsiblity to ensure nanotech is not harmful

NA
recommended safe handling practices
NA
NA
NA
NA
NA
Activities to help educate and articles on nano particle studies
safety information for chemicals involved in fabrication
none
NA
NA
NA
safety information about exposure to CNT's, graphene, solvents used in nanofabrication
toxicity
NA
NA
The pros and cons of nanotechnology.
Impact of nanoparticles on health
NA
Case studies
Information lacks clarity
I usually read the fundamentals of the process/issue from as unbiased a source as possible and form my own opinion
data
makeup fake research result and put it into peer reviewed paper
General health implications of nanoparticles
Info on misuse of nanotechnology
NA.
Methods of containment and mitigation of release into the environment
NA
updates on the current knowledge of nanoparticle toxicity, despcriptions of the effects of different types of particles
NA
NA
NA

This question is not clear. Kind of information could mean many things. Useful information. Inadequate information. Convincing information. All accurately describe some of my past experiences
As described above, from scientific literature and news reports of this work.
NA
I learned about carbon nanotubes and the environmental hazards associated with working with them in open air.
NA
NA
NA
NA
I found that we all need to be conscious of our research and how it will affect the world around us.
NA
NA
NA
NA
Lack of awareness
NA.
exposure of phase contrast fluids, nanofilled dispersions
The Ethics of Nanotechnology
Mostly on regulations within the lab and transport of nano-materials
NA
NA
New mechanisms of toxicology from CNTs
I found due concern for nanoethics but not a lot of consensus
NA
I found a website discussing some of the issues which I previously mentioned and possible solutions, from reasonable solutions to drastic ones such as banning nanotechnology altogether
On concerns of a physicist about the well-being of fellow human beings and the responsibilities of a scientist.
I found articles.
NA
NA
Published MSDS on metallic nanoparticles

NA
NA
I realized most of the nano fabrication techniques are very energy intensive for what they promise
NA
Operation safety, research motive.
NA
consequences of bioterror technologies
NA
descriptions of near-term applications of quantum computing
NA
NA
NA
NA
We discussed some of the technology available and whether we thought it was ethical.
NA
potential dangers of nanotechnology on society
NA
NA
NA
NA
NA
Ethical issues dealing with privacy, moral and societal implications, defense, environment.
Mostly regulations, legal information.
Consequences of material handling.
NA
results and discussion about potential health impacts of nanotechnology
alarming
its potential threat to health
issues relating to health
peer-reviewed papers
the amount of new nano-particular that are being used in cosmetics and other consumer products that have not been tested or considered for adverse side effects in untraditional areas
information that was interesting but not necessarily related to my work

NA
NA
Information regarding animal studies and nanotechnology. Particularly long-term decomposition and bioparticipation.
NA
NA
Societal impact of new technologies, ethics of using live animals/insects in research, ethics of bio-machine interfaces
Health related studies of carbon nanotubes
NA
lots of conflicting viewpoints
NA
NA
NA
NA
Authorship and manipulate
NA

Think about your most recent experience SHARING information about ethical issues related to nanotechnology. Where did you share the information (e.g., blog, email, in person, etc.)? (If you have not shared information, enter "na.")

The last time I shared information about ethics, I believe I was...
social networking sites
NA
Email
In person
person
public lecture
I shared in person with a group of undergraduates.
NA
Lab
Email
In person
Email
NA
NA

In person
NA
in person
in person
NA
NA
NA
NA
in person
Sometimes, ethics of research come up in conversations with my partner.
Personal discussion
NA
NA
NA
comments on a blog
NA
in person
NA
Email
In person
NA
in person with another grad student in our office area
NA
NA
NA
NA
In person.
N/A
colleagues
NA
colleague
In person
NA
I gave a training seminar on safe handling practices of nanomaterials to a group of summer interns.
NA

NA
In person.
only in personal communications
person
In person during a class
in person
in person
NA
Classroom discussions about scientific ethics
in person
in person
in person
NA
NA
In person
in person
In person
NA
In person discussion with colleague
In person
NA
social network software such as facebook, weibo, and wechat.
Friend, in person.
In person
NA.
in person
discussions in person
NA
NA
NA
In person
In person with the members of my research group
NA
In person
NA
person and email
NA

NA
I have discussed these issues with fellow lab mates in our nano lab.
NA
IN PERSON
NA
NA
in person
National meeting
NA
NA
NA
NA
Email
in person to family members
NA
At school with other researchers
NA
NA
NA
In person
person
NA
in person
person
BBS
NA
in person
NA
in person
NA
NA
in person
NA
NA
NA
NA
personal discussion

NA
NA
NA
NA
Class presentation.
Email
NA
NA
NA.
NA
in person
Journal article
Conversation
NA
NA
NA
in person
NA
in person
In person with colleagues
in person
NA
In person
in person
in person

Think about your most recent experience SHARING information about ethical issues related to nanotechnology. What kind of information did you share? (If you have not shared information, enter "na.")

Would enter something here that reflects my opinion of the interaction of what I wrote above..
lab regulations
NA
perceptions of scientists on nanoethics

Health safety information
concerns and possibilities. Understanding of how things work.
possible risks and safety
We did a interactive role playing activity with 100 students on how current and futre nanotechnologies could impact people around the world -- activity develoed by CNS for Nise Net.
NA
Safety related
Health-related
Safety of nanoparticles in human health
Health issues
NA
NA
Case Studies
NA
societal impact concerns and ways to help avoid problems.
explain whAt is nanotechnology and the impact it can gave on the future
NA
NA
NA
NA
Public Safety and impacts of germ line manipulation
Typically, it's issues of water quality (my partner's field). We've talked about the effects of airborne nanowires as well.
The effect of nanoparticles on human body.
NA
NA
NA
Specific nanoparticle related information relevant to the study in question
NA
possible implications of "creating artficial life"
NA
Papers
Summary of articles read. No personal opinions shared.
NA
food information
NA

NA
NA
NA
I shared information about a study done on assessing the toxicity of CdSe quantum dots.
N/A
NA
NA
safety issue about handling nanomaterials
Information about the danger (biotoxicity) of nanoparticles
NA
I shared our agency's rules and regulations on safe handling and disposal or nanomaterials.
NA
NA
I explained health risks related to nano particles.
only high level discussions
dangers of nanoparticles
Discussion of paper on nano particle s impact on plant growth
safety information, environmental concerns
that most medical work we and others do is safe and there are very few negative impacts
NA
case studies.
the importance of researching adverse side effects
safety issues pertaining to the use of CNT's, graphene, and associated solvents in the lab
regulation in biomedical applications
NA
NA
About drug delivery devices
potential hazzards of nanoparticles
The potential risks involved in nanotechnology research and development
NA
Disposal of nano materials waste
The hazards of nanotechnology (nanoparticles mostly) and how to decrease those hazards
NA

paper contains fake nano results got exposed to research public.
Health implications on nanoparticles
About misuse of nanotechnology
NA.
The ethical issues related to treating a disease with unforeseeable side effects
quesions about potential carbon nanotube toxicity
NA
NA
NA
Again, not clear. The information shared was some of my own basic searching results which resulted in very sparse information and served as more a discussion point than anything else.
The fact that the research may have unforseen consequences and if they are uncomfortable with this, they should discuss it further with me.
NA
During a laboratory design build out, discussion on safety related to nanotechnology
NA
NA
NA
NA
we discussed the potential long-term affects of our research.
NA
ANALYTICAL TEST AND MONITOR
NA
NA
some published fake data
Nanotechnology is used today in radiography
NA
NA
NA
NA
More interesting toxicology pathways
Concerns of some scientists over unknown properties of new nanomaterials/catalysts
NA
I don't remember exactly, but we did discuss some of the ethical implications of nanotechnology
NA

NA
NA
Increased chemical activity of sub-50nm metallic nanoparticles, which are normally inert (gold, etc.)
role of FDA
NA
Top-down Vs Bottom-up approaches for nano fabrication
my opinion of the usefulness of nanotechnology
Research motive
NA
NA
NA
comparison of (distant) applications for different potential research agendas, in terms of ethical implications
NA
NA
NA
NA
NA
NA
NA
environmental effects. potential and possibilities
NA
NA
NA
NA
Regulations, FIRPA, posed questions regarding over commercializations of nano-silver
Mat handl.
NA
NA
NA.
NA
some concerns i have based on news
cell viability assays, in vivo inflammation studies
Probably about how buckyballs have been shown to accumulate in the brains of fish
NA
NA

NA
The nature of in vitro drug testing models vs in vivo ones
NA
The fact that idiots should not eat nano particles
Information and discussion about new research which rises ethics questions
health related information with my family
NA
personal vs legal issues
research results
health risk of the inhalation of nanomaterials in lab

Do you have any other general comments that you'd like to share about the ethical dimensions of nanotechnology?

The expression has different connotations in different fields. Must distinguish between nanobiology and nanophysics.

I think of nanotechnology as busword that can encompass many things. You should be more specific

You asked the same question multiple ways many times=annoying waste of my time. Also failed to list news and journal websites as sources of newe

Many applications of nanotechnology have no ethical dimensions. Inorganic semiconductors is the biggest industry of nanotechnology, it has none.

all people should have a strong ethical code about really everything they do or are involved in - nano al well if applicable

there is not enough discussion/awareness about nanoethic in the scientific community. A lot more effort should be done by institution and researcher

I get information about science online from news websites.

I don't necessarily think the ethical dimensions of nanotechnology are different from any ethical considerations in other scientific disciplines.

Other than dangers of nanomaterials and the ethical concerns in research what are nanoethical concers?

I think there is great potential in nanotechnology as a positive force in animal welfare issues.

Nanoethics is an odd, vague term. Personally, I view nanostructures as another chemical. Before it is used or put into production, its health and environmental effects should be studied and known. Nanotechnology has the same "ethics" of any chemical - don't see why there should be separate term.

Whenever there are unforeseeable affects of any technology, it is important to do further study of the health, environmental, and societal impacts of that technology. More stringent standards and greater funding in this area is needed to make any impact o determining such effects.

This survey is based on the premise that nanotechnology is clearly defined. It is not and depends on who is defining it. Media and marketing (buzzwords) for example will identify virtually anything that is small scale or worked on in labs as nanotechnolog. Technologists/engineers define nanotechnology based on the physical size scale of what they are working on. For example, for me a nanotechnologist cannot physically handle the devices they work on because they are way too small. Gold nano particles withprotein coating would fall into this category. A micro technologist on the other hand utilizes nano fabrication principles only at certain points (e.g. thin film depositions which are typically measured in nanometers) but the final device can be measured n the micro scale (e.g microns to millimeters even).

No

No

NA

NA

NA

I do not know of many truly pressing ethical issues regarding this field. If this is about that "grey goup' book, this was a waste of my time.

NA

NA

It is good to see proactive discussions of ethics within the scientific community before major issues come up

not at this time

There could be seminars or courses on this topic.

NO

proper use of nanotechnology will solve many of earth's problems

NA

I have not found reasons to be especially concerned about health and safety risks of nanotechnology today, but I get the feeling that that's still what most people think of when they hear "nanoethics."

NA

NA

Funding agencies are the most important organizations that can control these ethical matters related to nanotechnology, in my opinion.

This survey prompted me to search out the "ethics of nanotechnology" midway through. It was an issue I had never considered before, however, the information I found was rather though provoking and change my definition to the first questions asked. I thik the most pressing issue is perhaps the use of nanotechnology in defense and surveillance unbeknownst to the people.

I think the concept itself is not widespread, yet. It is quite an unfamiliar term.

more educational activities should be carried out about ethical dimensions of nanotechnology

no

no

we must spread awareness in the level which excercise power

NA

NA

Enforcing the consideration of ethics in nanotechnology will be quite difficult

no

no

I've never even thought about the ethical aspect of nanotechnology before...

This is the most worthless, redundant survey I have every encountered. The authors should know better than to reproduce with their parents.

I'm glad someone is doing this survey and hope that this furthers the effort on the ethics of nanotechnology

NA

nope

n/a

APPENDIX B. PILOT TRAINING MODULE

Slide 1.

Microelectronics Research Center
THE UNIVERSITY OF TEXAS AT AUSTIN

The Ethics of Nanotechnology

National Nanotechnology Coordinated Infrastructure

The University of Texas at Austin
Communication Studies
Moody College of Communication

Slide 2.

Purpose

The purpose of this module is to introduce you to the issue of **ethics** as it relates to the **work** that you do.

Slide 3.

Learning Objectives

In this module we will cover:

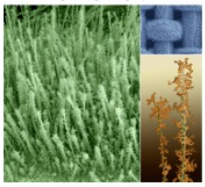
1. What is **nanoethics**?
2. Why does it **matter**?
3. How might you think about ethics in the context of your **own work**?

Slide 4.

What is Nanoethics?

Consideration of the **social** and **ethical** issues and concerns related to nanotechnology

Nanotechnology in the environment



http://web.stanford.edu/group/zheng/pages/research-gallery

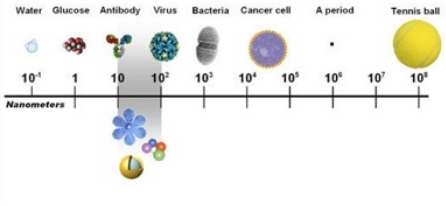
Nanotechnology biological application

http://www.diabeticlifestyle.com/blood-glucose/insulin-pump-continuous-glucose-monitors-control-blood-glucose-levels

Slide 5.

Nanoethics

Ethics has uses in other fields but here we take ownership of it as an important consideration of science at the nanoscale.

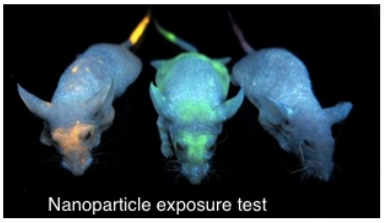


http://nano.cancer.gov/action/news/featurestories/monthly_feature_2005_aug.asp

Slide 6.

Ethical Concerns

The advancement of nanotechnology has raised concerns about the societal and ethical implications of nanotechnology on humans, society, and the environment.



http://www.cbc.ca/news/technology/nanoparticle-exposure-test-developed-by-canadian-scientists-1.2649608

Slide 7.

Nanoethics: It's the law

The 21st Century Nanotechnology Research and Development Act, a 2003 U.S. law, emphasizes the need to understand our science from social and ethical perspectives.

Calendar No. 772

107TH CONGRESS
2D SESSION

S. 2945

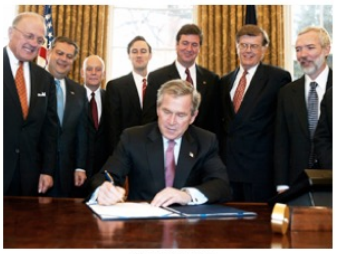
[Report No. 107–350]

To authorize appropriations for nanoscience, nanoengineering, and nanotechnology research, and for other purposes.

https://www.govtrack.us/congress/bills/107/s2945

Slide 8.

Nanoethics Research Requirement



library.cqpress.com

Research that is funded through the National Nanotechnology Program must consider ethical and societal impacts. The information presented today is to help us meet this requirement.

Slide 9.

Being aware of the *down-stream,* or future **implications** of our work makes us **ethical leaders**.

http://calibermag.org/articles/stanford-university-publishes-unethical-report/

Slide 10.

What is an Ethical Leader?

An Ethical Leader:

- Discusses business and research ethics or **values** with employees.
- Sets an example of how to do things ethically.
- Defines success not just by results but also how they are obtained.
- When making decisions, asks **"what is the right thing to do?"**

Excerpted from Brown, M. E., Treviño, L. K., & Harrison, D. (2005). Ethical leadership: A social learning perspective for construct development and testing. Organizational Behavior and Human Decision Processes, 97, 117–134.

Slide 11.

Ethical Leaders

Regardless of whether you are an independent researcher or a manager of a large group of employees, you can lead.

http://www.forbes.com/sites/ryanwestwood/2015/02/05/humility-the-secret-to-confident-leadership/#1a8de7aa5237

Slide 12.

Discussion Question

What is nanoethics?

[Pause for discussion]

Slide 13.

Discussion Question

What is nanoethics?

Short answer: The consideration of social and ethical issues that may result from nanotechnology research and development

Slide 14.

Ethical Leaders

- Being an ethical leader is important in order to preserve the integrity and *discovery* of nanotechnology, as well as protect society and the environment from *potential* negative impacts.

Slide 15.

Potential Negative Impacts

- Severe environmental damage due to insoluble nanoparticles.
- Lung inflammation, liver and heart problems from inhaled toxic air.
- Severe brain damage to fish exposed to contaminated water.

http://ethics.calpoly.edu/nanoethics/bad.html

Slide 16

Ethical Decision Making

Ex: Flint Michigan water crisis

http://hereandnow.wbur.org/2016/01/15/flint-water-crisis-disaster

http://www.independent.co.uk/news/world/americas/flint-prisoners-including-pregnant-women-were-forced-to-drink-poisoned-water-a6854326.html

Slide 17.

Why else does nanoethics matter?

Ignoring the possibility of social and ethical implications is risky and can jeopardize our future work.

Slide 18.

Potential Risks

- Concern that scientists are not considering human impacts can lead to decreased funding and increased regulation.
- The discovery of negative human impacts – particularly if perceived as the result of the negligent pursuit of progress – can bring the science to a halt.

Slide 19.

When to consider ethical implications?

The societal and ethical implications of our work should be considered in every stage of our research.

Slide 20.

Discussion Question

- Have you known any ethical leaders?
- What qualities did that person have?
- How did he/she lead?

[Pause for discussion]

Slide 21.

What does it mean to consider the **societal** and **ethical implications**?

Dr. Leela Prasad, Faculty Director of the Duke Center for Civic Engagement, introduced a concept she calls "Ethical Doubt."

http://kenan.ethics.duke.edu/multimedia-publications/good-question/leela-prasad/

Slide 22.

Ethical Doubt

According to Prasad:

Knowledge comes from "experimentation and reflection, marked by things like missteps, doubt, and correction."

What results is "a sense of fulfillment."

In this way, doubt enables reflection and an awareness of alternative possibilities and explanations.

Slide 23.

Research & Ethics

Explore your ethical doubt as we consider the societal and ethical promise and risk of the work we all do.

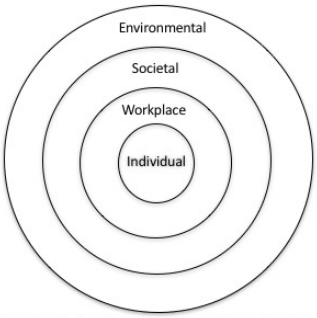
Slide 24.

What does it mean to consider the societal and ethical implications?

As nanotechnology presents new opportunities for our future, we must also consider the potential risks and hazards that comes along with it.

Slide 25.

Nanoethics – at four levels

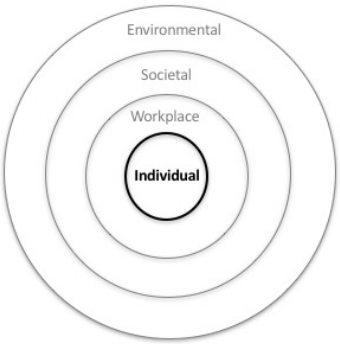


Four levels of ethical consideration in the context of science conducted at the nanoscale

Slide 26.

Ethical Responsibilities: **Individual Level**

At the *individual* or personal level, we each are responsible for adhering to high standards of **honesty** and **integrity** in our profession and scholarship.



Slide 27.

Individual Level: Honesty and Integrity

Ex: Chemical Spill

All chemical exposures or suspected chemical exposures must be reported immediately to the Facility Office.

Slide 28.

Individual Level

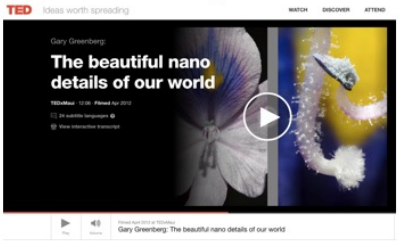
http://www.smtnet.com/media/images/Cleanroom%20Bunny%20Suit.JPG

Furthermore, we are expected to meet **training requirements** related to the **responsible** conduct of research as required by sponsors and host institutions.

- Personnel Protective Equipment
- Chemical Handling & Storage
- Chemical Waste Disposal

Slide 29.

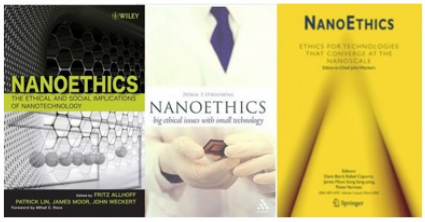
Individual Responsibilities



We are also responsible for being familiar with the emerging research on the ethics and societal impacts of the work we do. This research can be accessed via the web in journals such as Nanoethics or in TED Talks like the one above.

Slide 30.

Staying informed about ethics



This research can help us stay informed about ethical issues and explore our personal ethics and ethical doubt.

Slide 31.

Ethical Responsibilities: **Workplace**

In the *workplace*, we are responsible for ensuring a **safe** working environment for those who come into contact with our research.

Slide 32.

Workplace Level

We are responsible for making sure the work environment is **compliant** with Federal and State **regulations**, University **policies** and **procedures** associated with the research, and matters related to chemical/biological safety, security, and disposal.

Slide 33.

Workplace Responsibilities

For example, we should supply safety equipment such as eyewash fountains, first aid kits, safety showers, multi-purpose fire extinguishers and spill kits.

Slide 34.

Workplace Leader

Within the workplace, we also can be an ethical role model by raising questions about issues of ethics and societal impacts in meaningful ways.

Questions to ask:

1. How might this development effect the environment?
2. Will this finding create potential safety concerns?

Slide 35.

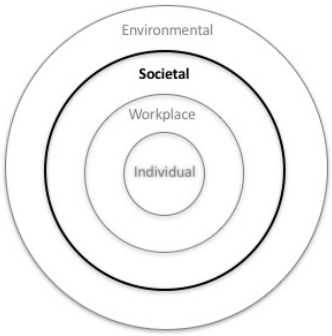
Ethics-Focused Workplace

Your workplace might not have all the answers to questions asked, but simply asking ethical questions helps build a more ethics-focused work environment.

Slide 36.

Ethical Responsibilities: **Societal Level**

At the *societal* level, we are responsible for understanding the social world that hosts and sustains our work.



Slide 37.

Societal Level

Microbeads are found in products such facial scrubs, shampoo, and even toothpaste.

Slide 38.

Ethics in Action

- Next, we will watch a video that focuses on how neuroscientists and ethicists are having meaningful conversations about emerging technologies and their potential impact.

Slide 39.

Slide 40.

Ethics in Action

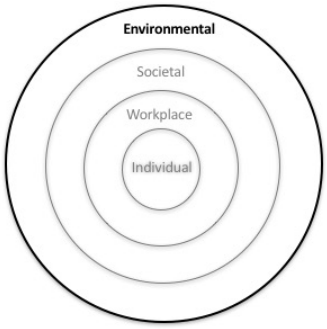
- This video suggests that through active exploration of ethical doubt, we can become aware of the potential social and ethical impacts of our work.

Slide 41.

Ethical Responsibilities: **Environmental Level**

At the *environmental* level, we are responsible for understanding the environmental world that hosts and sustains the work we do.

This includes thinking about flora, fauna, air and water.



Slide 42.

Environmental Responsibilities

Ex: In Waco, TX, an ammonium nitrate explosion occurred at the West Fertilizer Company storage facility and had tremendous long-term impact on the community and the environment.

Slide 43.

Discussion Question

What are the four levels of ethical consideration?

[Pause for discussion]

Slide 44.

Discussion Question

What are the four levels of ethical consideration?

- Individual
- Workplace
- Societal
- Environmental

Slide 45.

Nanoethics – at four levels

Consideration of these four levels of nanoethics will help us begin integrating ethics meaningfully into our research.

We will now discuss ways we can develop conversations about the social and ethical implications (SEI) of our work.

Slide 46.

Ways to stay informed about SEI

- Search Google and Google Scholar using terms such as nano ethics, nanoethics, ethics of nanotechnology, or ethics of technology.
- Stay up to date with the evolving National Nanotechnology Coordinated Infrastructure website (or the old NNIN Website).
- Attend conferences/forums that discuss SEI. E.g., Arizona State University hosts an annual conference on "Emerging Technologies: Law, Policy, and Ethics."

Slide 47.

Integrating SEI into Nanotechnology

- Partner with ethicists and philosophers to have them speak in your workplace or lead workshops.
- Locate or develop case studies or workshop simulations that can stimulate critical discussion of SEI.
- Research potential ethical or social issues that may stem from your work and work as a group to conceptualize ways to reduce those issues and impacts.
- Be proactive in including an SEI component of some kind within each research plan or proposal.
- Establish an SEI research code for your laboratory.

Slide 48.

Ultimately, this module serves as a starting point for discussing societal and ethical implications, just as researchers have begun doing in neuroscience and other fields.

Slide 49.

As you think about what we've discussed today, particularly about the social and ethical implications of the work that you do, we hope you will remember the words of Dr. Prasad:

"This process of 'knowing' is usually one of experimentation and reflection, marked by things like missteps, doubt, correction, and a sense of fulfillment."

Slide 50.

For additional information or questions about this module contact:

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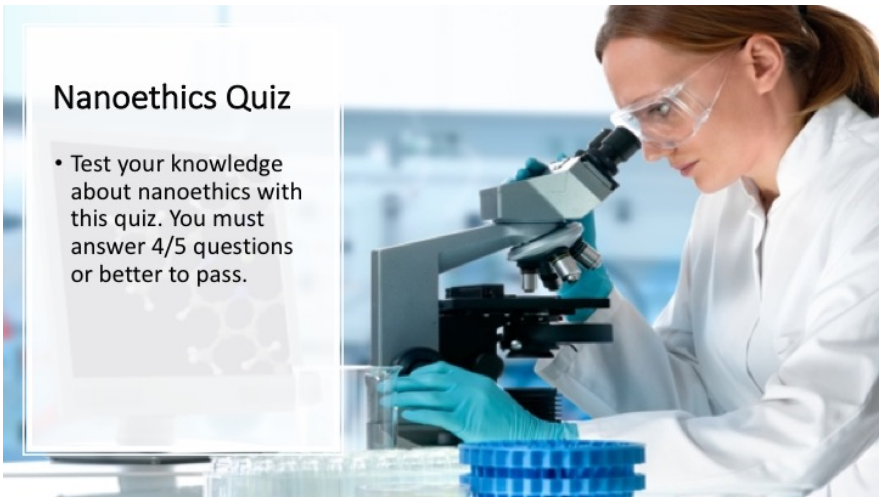
Technical Support:
Moody College of Communication

Development and production of this training module was supported with funds from the National Nanotechnology Coordinated Infrastructure

Slide 52.


Nanoethics Quiz
• Test your knowledge about nanoethics with this quiz. You must answer 4/5 questions or better to pass.

APPENDIX C. REU PRE-FOCUS GROUP EMAIL RESPONSES

1. I have received ethics lectures in general from both chemical the engineering and chemistry departments at LSU. One focused on ethics and safety in chemical plants while the other talked mostly about ethics and publishing in scientific journals. I have not received any information on ethics specific to nano research.

2. The question of ethics has plagued the current presidential race in the media. With regards to science, it seems that the media tends to question the ethics of nuclear power, oil, fracking, gas, etc.

1.) In terms of ethics in general, I've taken multiple Buddhism/religion/philosophy classes that have discussed the topic fairly heavily. I've also received lots of information on ethics in the sciences during my time as an undergraduate. I've taken a biomolecular engineering class and a neuro-engineering class, both of which have a heavy emphasis on genetic manipulation and experiments with animals. In both classes, we've had multiple discussions on safe testing procedures on animals, minimizing pain/suffering in experiments, and the always present "just because we can, should we?" question that is prevalent in most research. As for ethics in the context of nano research, not much has been brought to my attention. I have thought about the environmental impacts, such as the ultimate fate/transport of nanomaterials as well as their nanotoxicology, but I have never actually done any extensive reading/research about it.

2.) I'm not sure if this is specifically referencing ethics in science. In the case that it is, I think most of what I've seen is about climate change, abortions, stem cells, and GMOs. Honestly, the issues of ethics in sciences in the media is often debated by laypeople that really just don't realize that the issues are often multifaceted and can have multiple interpretations/ethical implications.

---

1. When it comes to ethics teaching in undergrad, I think plagiarism is the primary focus. In English classes, I have heard countless times about how to avoid plagiarism and the consequences of using someone else's work. For my Organic Chemistry Lab, there was a big focus on ethics. This was because we had to write formal reports and cite references, and we had more interaction with literature. In my chemical engineering seminar, we had a couple classes on ethics-- outside of plagiarism-- and an assignment that focused on an ethical dilemma. Overall, I feel that I have a good understanding of ethics in science and engineering. I have not heard a lot about ethics in nano-research specifically.

2. A lot of news comes from people who make unethical decisions and mess up, whether it is politicians, CEOs, or scientists. Issues like spaceships blowing up and the Flint water crisis bring to light the fact that making ethical decisions is a complicated issue that scientists and engineers face. However, I am not really informed on ethical issues specific to nano-research.

---

1. I took a philosophy 101 course many years ago. I have also received a little ethical insight concerning nanomaterials in a few of my classes. I will be taking a course on science and philosophy next semester, and hopefully, that will be part of the course.

2. Nothing in the media has brought science and ethics to my attention outside of a few TED talks.

---

1. I have received very little information on ethics in my time at the University of Pittsburgh. I have attended one seminar on ethics in engineering. I am however only a freshman.

2. The recent shootings and even the presidential election caused the media to bring ethics to the forefront of our society.

I had one course that briefly touched on ethics. We discussed how mechanical failure could be the engineers fault due to negligence.

The media has made me think that the general public doesn't understand the complex engineered systems around them and that there are some issues that can be overlooked. Engineers are very thorough, but one fatality out of a million is enough for the public to freak out even though it could be a result of user error (Tesla's auto pilot)

Yes I took an ethics class about the modern social structure of Germany after WW2. But I have not had any ethical training during my science or physics classes.

In media I see the topic of LGB rights, westbourough baptist church, and illegal immigrants all as topics of ethics. I rarely see media coverage of science ethic questions.

At my school we talk about ethics pretty frequently but this is my first experience doing nanotech. Moderator's presentation was the only thing on ethics.

Mainly news stories about disasters and stuff, the tsunami in Japan and stuff.

APPENDIX D. REU FOCUS GROUP TRANSCRIPT

Jacy: All right so we're going to go ahead and begin the session, all right yeah as long as everyone has a nametag that's cool. My name is and I will be the Jacy of this focus group session I am a graduate assistant to LeeAnn Kahlor we're both looking into the social well basically the societal and ethical implications of nanotechnology. Also working with me is Moderator who you all know, she'll be taking notes throughout the session she's not necessarily here as an REU she's here as a worker. First of all I would like to thank you for taking the time out of your schedule. I know this is the last week so things are kind of busy wrapping things up on your end. So I really appreciate you taking the time to be here with us. So, the topic for today we designed a module that is supposed to explain the societal and ethical implications of nanotechnology to you. After the module is over we will discuss different questions and your thoughts on the content. I hope everyone will participate and all your thoughts are welcome even if they're different from one another or their negative. This is a safe place and I want you all to feel comfortable sharing your thoughts your comments, your feedback on what you'll see today. Also we ask that you listen respectfully form one another. If someone does have a different opinion lets not jump on them about that lets just kind of move forward. That we can have a productive session. Also I know you probably noticed the recorder, I am recording this session so we won't miss out on any of your comments. We really need the feedback going forward with this program. If that's concerning to you let me know, but if not we're definitely going to record the entire session. This is also going to be helpful for Moderator as she won't be able to write down everything little thing that you say so she can go back and transcribe. Please speak clearly so that the recorder can pick up what you're saying, so just keep that in mind. Additionally everything that is said in this room will be completely confidential. It won't have an impact on any of the work that you're doing right now. All of this is going to be gathered by the SEI team and it's going to be directly used to further train on societal and ethical implications. So it has no direct risk on you and what you're doing. So I think with that it's pretty much time to begin we'll go around the room and I would like for everyone to kind of say your name, what university your from and maybe like your favorite thing about Austin so far. So who wants to start, I'll start on the right.

(Students introduce themselves, their college and state favorite thing about Austin).

begin the module. It's roughly 15 minutes I do ask that everyone silence your phone or put it on do not disturb. Just try to like focus on what you're hearing and seeing on the screen.

Moderator: Lets pass these out first.

Jacy: Oh excuse me I missed a very important part. Before we begin that I need you all to sign a consent form please take a minute or two to read it and sign it. It kind of explains everything that's going on today.

Moderator: We have copies too if anyone want a copy of it.

Jacy: I can collect those if you're done.

Student 8: Man that's a great signature. How beautiful is that.

Student 2: Not very.

Jacy: So Moderator is going to now play the module.

(Module is played for the group)
(Student 4 leaves room after module is done)

Jacy: Alright cool, I guess maybe he went to the bathroom so we'll actually have to wait till he comes back. Since we finished watching the module we're going to move into the discussion portion and basically I'll ask you a question and everyone will have a chance to respond or say your comments or thoughts on it.

Jacy: I guess we can go ahead and start and he can just jump in whenever he comes back. The first question would be, what were your initial thoughts on the module. *What first came to mind, what did you think about through this process of watching it?*
(7 second pause)

Student 3: It brings up some good topics and it's definitely a good idea to think about these things. The social and ethical implications of essentially anything that you're doing and it should definitely apply to sciences and research. Making a certain product that is going to influence people in a certain way. I mean it's definitely important however I'm not too knowledgeable about it.

Student 7: It really made me start thinking about what could the ethical implications be for the research that I'm doing cause I definitely had not thought of that before. I'm not really sure what those implications would be.

Student 2: I guess that's kind of the point right to just kind of get you started thinking about it.

Student 3: Perhaps that's not immediately obvious. What are going to be the effects?

Student 2: Yeah.

Student 3: But perhaps there could be some big effects that something that you make.

Student 7: Like a deeper knowledge.
(Student 4 re-enters the room).

Jacy: So um, I just asked the first question. Which was what were your initial thoughts after viewing the module so everyone is just kind of giving their initial thoughts.

Student 4: I think it's important. It's not covered enough. I know professors I work with think about it but it is not their primary focus so there is only so much that really can be known until this becomes more in the spotlight.

Student 3: It's also something that is not really talked about like you teach this. This is not taught at all.

Student 4: It's mentioned in a few of my classes that I've taken.

Student 3: Really?

Student 4: But it's not the focus it's like there's this thing that I think about so I'm going to tell you guys about it and then it's kind of up to us to research it further.

Student 7: I've had a one hour session that we did that was just like general ethics.

Student 4: Yeah.

Student 3: I've had zero whatsoever. However occasionally, I think it's brought up like, a researcher person neglected a certain thing like the plant in Waco. It's like yeah we were dumping lots of chemical materials in in the lakes water and we knew we didn't screen for it. You hear about these things bad things that happen but they don't teach you about them. They just say don't do that cause it's bad.

Student 4: Yeah

Jacy: Right

Student 2: Well I guess I'm taking a process safety class where we discuss not necessarily safety with nanomaterial's, but in terms of general industrial procedures and policies. A lot about what is considered ethical and what is considered

productive and how the two don't always coincide with each other. There was a lot of discussion about how like work place policies are now very very strict in terms of safety so big big companies like Exon Mobile, Shell they like emphasize safety over like over everything else now. Even though they have a lot of focus on production workplace safety is like a huge issue for them now. But for now too just because its new there's not as much information about it. In terms of like genetic engineering there's like a lot more awareness. It's more really obvious what the ethical questions are.

Student 3: Is it? Is it obvious?

Student 2: Personally I think it is. In terms of how much control we have over an actual life.

Student 3: Do you believe we should be genetically modifying babies?

Student 2: I mean
(laughter from group)

Student 3: I mean that's pretty soon. In a year that's going to come out.

Student 2: I mean

Jacy: So, in terms of nanoethics do you think it would be helpful even as an intern coming here, do you think it would have been helpful if you would have had a class or training that specifically spoke to considering societal and ethical implications of the work that you're currently doing.

Student 1: One kind of thing that I started thinking about was as researchers what can we do, we're doing our research developing new things or whatever it's only isolated to that one, do before there are huge implications? We kind of have to discover something before we can have like huge implications. I understand like the societal implications of a chemical plant blowing up. That's a huge industrial facility, but there's nothing like that that we're working with currently. Like we don't know where it could head.

Student 8: We received some instruction about some of the stuff like this. Some of the stuff that was in the module was talking about workplace safety. The ethical considerations of how you do work your and how it might affect the people around you and so we did have reasonable amounts of safety instruction.

Student 1: Yeah.

Student 8: Between the various tool trainings like the hellish morning in the conference room. And so I guess that sort of addressed at least to some extent the work place safety side of thing where as I suppose this is my first nanotech anything and so maybe what's been missing from my thing more is down the line once something gets out but then I think about it and my research is very far away from releasing anything publically for consumers.

Student 3: It's like 15-20 years from being practical. I doubt that like I don't even know all applications like all the applications it could be used for are so vague being able o think about like there would be thousands of different ethical like implications with my work. I think it it's just really hard at this stage to consider.

Student 2: I mean like even in the fabrication process your materials you devices you can like consider these things.

Student 7: That's true yeah.

Student 2: Like part of our process is we etch away metals in order to make these, but what happens to these metals after we handle them. What do we do with the etching? What do we do with the metals? Where do these end? How do you treat that. Those are all definitely part of the process that we should definitely consider. If these are meant for industrial scale, you know were working with small volumes and small concentrations now they may not always be that way.

Student 7: Yeah well like in the clean room there's very strict disposal.

Student 2: I mean yeah but in terms of industrial scale

Student 7: Yeah yeah.

Student 7: How are the processes inherently safe for design, is there a way we can just like completely avoid whatever hazardous process. For me making grapheme we like etch away the copper, but is there like a way to not etch away the copper can we just like peal it off. That would be like quote unquote inherently safer design.

Student 7: But they don't do like large scale, do they do large scale industrial size grapheme?

Student 2: They're trying to.

Student 7: Eventually they will yeah.

Jacy: But that's not to say that you shouldn't consider you know

Student 7: Yeah I know.

Jacy: The impacts of that long term. Okay did you have something (referring to Student 5)

Student 5: Yeah I'd like to see more information about maybe some positive impacts of it of like ethics and nanotechnology. We talk a lot about plants blowing up you know poison water supplies but what have been maybe some more positive impacts of hey we actually talked about this, this is something good that came out of it. Show us maybe more of that like down the road I guess. I'd like to see more of that.

Student 8: It's probably hard to find documentation about that. (agreement from group)

Student 4: Well it's like people not dying. Or getting sick.
(loud laughter from the group and agreement)

Student 7: People like stopping it before it happens.

Student 4: Yeah

Student 7: I mean that never really gets focused on. People thinking ahead.

Student 5: That's what should be focused on.

Jacy: Okay.

Student 4: It's not a news story.

Student 5: But I think that's what we're going towards.

Student 3: There's a reason our phones are so cool. There's a reason why we have 50 inch plasmas, 4k screens with the curved screens. All that crazy stuff. I don't know. If that's not cool I don't know what is.
(laughter)

Student 3: Hybrid cars, all this technology. That they eventually go down and how we become more technologically advanced.

Jacy: Um so did anyone learn anything new? And if so do you mind sharing what that was. Or is just from watching the video.

Student 6: I guess just in general when it comes to ethics and science I always think about ethics and biology and genetically modified things. I've had the discussion before in classes like how far do you go before you're like playing god. With nanotechnology I just like never really thought about ethics with it I guess. It's harder to see what the applications are and how they could be harmful so I think the module in general just like got me thinking about that more.

Student 1: I always separated safety and ethics. Ethics at the personal level, ethics at the work place level. I guess that does kind of safety.

Jacy: Okay so could you envision using the knowledge that you gained whether it's new or a repetition of what you've known previously from the module into your everyday decision-making?

Student 1: Like in the lab?

Jacy: In the lab, at home, wherever you're making decisions could you envision using the knowledge about ethics and society and those implications whenever you're making decisions.

Student 5: I think it's a lot to ask to try and say oh in the lab let me think about the ethical implications but I think maybe before starting a project take a few hours or some amount of time to kind of go through the process. I feel like once you're in the lab it's what's going to happen when my copper etches away I'm not really interested in that I'm interested in the research that I'm doing. It's important to think about it before hand.

Student 7: What does happen to the copper that gets etched away?

Student 3: Good question.
(laughter)

Student 5: It gets put in a waste bin and then they carry it away.

Student 1: I think as scientist we should always investigate everything. Don't let oh we might make some waste here, might be dangerous down the road, like I think we should still do the project and learn what we can from it. Not just not do it cause down the road there could be issues. Like oh now we have issues with carbon dioxide in the atmosphere.

Student 7: It's like a risk and reward.

Student 1: They didn't think about that.

Student 2: To kind of counter that (counter acting Student 1's previous statement) there was a group in my lab doing something with oil and they were trying to convert it to something else and they accidentally produced mustard gas in our lab. (laughter)

Student 1: Um yeah.

Student 3: Produced what?

Student 2: Mustard gas
(laughter)

Student 2: Like very small concentration of it but you should definitely consider everything you're doing in the lab before actually doing them. Cause you might accidentally kill someone.

Student 3: At what point do you stop, at what point are you working on a project and you're like wow this is a lot of copper dust or whatever and it may or may not kill all the birds in the area.
(laughter)

Student 3: Or something like that, something really intense. But at the same time it's like well it's very very interesting and we're getting such great results and all this stuff. At what point do you, like before you're about to publish results or something like that do you finally then look at even though our results are great we're also doing really bad things. Do you stop?

Student 2: I feel like that's the most pervasive question in terms of progress and environment. There's always that question of at what point does our progress become limiting to the environment and at what point does our consideration of the environment become limiting to our progress. There's no fine defined line. It's more kind of a gray scale area. It depends on how far you're willing to go in either way.

Student 4: I think electric car batteries are a perfect example of this. They're like okay we'll produce this thing that's great for the environment, but when it come to disposal everyone for a long time was just shrugs just like I don't know.

Student 3: Just like we got to mine lithium and it just so happens that we do that in 3rd world countries and destroy these communities.

Student 4: All of these provide other engineering problems. So we might start with big problem and the ethical considerations come as after thought and then we engineer ways to make these better after decades. When maybe, I don't know where the balance would be, but if some of these things would have been considered before hand it would be like slower to market or slower to the product being available for everyone though. I don't know when a company needs to say okay now's the time it's same enough like I think if any sort of legislation starts to be enforced then nothing would ever be safe enough or nothing would ever be ready. I think there needs to be some balance so not everything regarding safety and ethics is an after thought, but more into the initial design.

Student 3: It seems like how this works right now is that you kind of just put your thing out there first and then you see how if effects everybody.

Student 4: Yeah

Student 3: Like with leaded gasoline you know they originally had gasoline with lead in it you know it actually makes your cars faster and more fuel efficient. And you know there are tons of reasons to lead the gasoline, but however it also releases toxic lead into the atmosphere, which destroys the ozone layers and all these other bad things and eventually have it now unleaded which is a requirement. But that's kind of later down the line. Once they figured out that is was destroying ice caps and stuff like that

Student 2: I mean I don't see a reason why we shouldn't try and investigate that in the first place. I mean that's kind of the reason organizations like the EPA were created right.

Student 3: Mhm

Student 2: Both to enforce environmental policy and also to enforce some basic level of environmental protection.

Student 1: I think the solution is not less engineering like we shouldn't like unleaded gas we're creating all these toxic fumes, don't just throw that away, try figure out a way to unlead the gasoline. (42:11)

Student 2: I agree with that (Student 1's point) engineering shouldn't stop.

Student 8: I liked integrating philosophers into the process. I don't spend all my time with scientists so I've seen benefits of having friends with different viewpoints.

Student 8: Ethics not a part of formula cause it's easy to omit.

Student 7: Could create SEI departments in labs just to evaluate research projects.

Student 2: But researchers understand most (in relations to their projects)

Student 7: They need to work together.

Student 8: Fundamental tension, SEI takes away from research, SEI isn't your job. It's a different job.
Student 4: Having SEI (expert/employee) being highly trained on science aspect. Taking philosophy class taught by physics professor. Holes if not form science background. I don't know how to begin the process.

M: I mean, I thought the video was good in terms of providing concrete examples, where the two fields clearly intersect. Although the module was really helpful in establishing basic vocabulary and the general ideas and structures.

Jacy: Student 6?

Student 6: Yeah, I would say that the module is helpful and its like seeing it now, if maybe I was doing something in my research that wasn't quite right I would feel confident in saying like look at the SEI of it since I know that term now. The examples were definitely good and helping make the ideas more concrete.

Student 4: I agree with what they said.

Jacy: So how would you define an ethical leader?

Student 2: Can we watch the module again? (laughter from group)

Student 8: Did a good job of explaining that (module). Reinforced value and SEI considerations.

Student 3: They are willing to ask hard questions, think about impact on population, kids, the future.

Student 4: At ASU inorganic chem, talking with mentor, his responses mention looking into the safety of it. Protecting the students. "Lets make sure we don't kill everyone,"

If something goes wrong what can we do? No environmental concerns yet, only personal safety.

Student 1: Ethical leader would be willing to give up some money.

Student 5: Willing to think about SEI and actually pursue it. Link ethics and safety, but there's more to it. Scientists get the safety aspect more. Big companies spend a lot of money making people safe.

Student 2: Economic aspect. Exon does spend a lot of money on safety.

Student 4: While they (Exon) make materials bad for the environment.

Student 3: Apple phones made with child labor.

Student 8: Global paradigm. We make these choices as a society driven by money. **I** wish we had power over that but we're just students.

Jacy: Yeah. Okay. This question might sound redundant now but I will still ask it. Why is it important to you, individually, consider the societal and ethical implications of your work?

Student 7: I don't, I wouldn't want to be a part of a project that like ended up being like a giant disaster that no one on my team ended up foreseeing happening like because we didn't think enough about the ethical implications.

M: I think that at least for me, i'm concerned with the future application with what we're doing. I can offer like a fundamental understanding but I would want to see it in the market and starting to think about things now would help curve some issues farther down the line that would just put you at a standstill.

(papers shuffling)

Student 5: I think i=for me its more, when I think about ethics, first thing I think about self-reservation, what is effecting me directly or will effect my family and the environment around directly. Branching out.. You know I do care about the fish and plants and everything- but what's going to hit the hardest and make me take time to think about is that.

Student 2: I guess kind of opposite of that I start off thinking off with the environment instead.
(laughter)

Student 2: I guess I kind of assume that self-preservation and human safety is implied regardless because we are humans and that's going to be one of the more important things. But I think that in terms of environment it's definitely gotten better recently but there's still more that can be done.

Yeah I think that there has been some technologies that when they were put out ppl didn't really think about the environment but now it's so ingrained in our ways. Its really hard, like now we know that its really bad for the environment but we cant like stop using them because they are so important to our society now so its impossible to stop and we're trying to develop technologies to help them but we're still far down the road from being practical.

Like plastic!

(group agreement) Yeah!

Student 2: San Francisco has that ban on Styrofoam though! That's a step in the right direction.

I've never even heard of a ban on Styrofoam.

Student 2: It was like passed literally a couple of weeks ago.

Jacy: well there's a ban on plastic bags in Austin, yeah so.

Student 7: The university of Pittsburgh stopped giving them out too so the stores there.

Wait a minute, so you have to buy them? Like I have plastic bags in my backpack.

Jacy: Well you have to use reusable bags here.

Yeah like if you go to HEB you have to buy one,

Jacy: yeah, they will sell you like a plastic bag but it's a reusable one.

Student 8: Well UT gave me one that was crappy grocery bag, not that I use it now though.

(Group agrees with yeahs)

Jacy: In your opinion what role does ethics have within your research? What do you think the role of ethics is?

Student 3: my research? (laughter from the group)

Student 7: My research specifically? I don't know, we don't do that. The waste is a concern but I don't know about the applications.

Student 7: I don't even, thinking about my research step by step, I mean there could be some unethical implications in the growing process but I don't know about growing for my, like we don't do that, like as far as building like the waste I guess that, old devices, but as far as the finished product its so far away, and I'm not even like knowledgeable enough on like what the applications for this could be like 50 years into the future. It's hard for me to say.

Student 2: I mean like most of us are working with nanomaterials. I guess the most obvious question is, what will happen if these nanomaterials get into the environment? How will the effect the animals, are they toxic? Are they going to get back to us down the food chain? Just like whatever. That's usually the first thing that pops into my head.

Student 2: Where do these all go?

(group agreement over question)

Student 4: I know most of us, with technologies being developed, are going to be used in some way for renewable energy. So for the overarching goal we all have is ethically good but I think that we can break it down into things like you were saying.

What are the risks?

Yeah like what are the risks of creating these technologies.

Student 7: Yeah it's like a risk reward. You have to weigh all the risks vs. the reward.

Student 4: Or! In for military application, they have like uhm, aerosals that get sprayed over the battlefield so that they can tell if chemical weapons have been used. Like where do those go?

Jacy: right, right.

Student 4: Like they aren't going to stay over the battlefield. Eventually they are going to get knocked around so what happens to that?

Jacy: right, so thinking about those things is important but understanding where ethics lies within those questions so would you say the role of ethics is a smaller one, larger one? Is it more individual role, or societal, global? What do you think?

Student 7: Well, so for my research, it is pretty at an academic stage. My research relates to plans that my mentor has for doing some fabrication uhm, but we are talking about a handful of devices as opposed to like anything that would have a large impact of society in terms of it getting out there. Like the products of our research, we are at the stage where we don't really need to think about our semiconductor lasers and how they would affect the world because they simply aren't going to in the foreseeable future. Uhm now what we do have to consider is proper disposal of the materials that we use for our research. Almost everything I've worked with this summer has arsenic in it and its not like if you touch it it'll kill you, its chemically bound arsenic in like a lattice, but its arsenic and so there are special disposal procedures and I've been taught those. And I trust that the facility takes care of that but I, maybe if I were being a more thorough sei person I would go and question whoever that is that does the disposal. But that's sort of where my research sits, its at very academic level, and facility level.

Student 2: What was your question before? The one that was like what is the societal role or the individual role?

Jacy: Yeah I say like uhm, I'm trying to understand what do you think is the role of ethics so like do you think its just an individual role, or is it organizational.. You're saying right now research is academic role or the facility plays a role into it.

Yeah, cause like nothing we do goes out of the facility in the foreseeable future.

Student 2: I mean I guess my opinion on that is it always kind of begins with the individual then like grows to something more. I mean there has to be someone who has started the conversation like what are the environmental and safety and that grows into a bigger conversation with multiple people and then so on and so forth until it becomes more of a

Student 4: Until the scientific community is on board

Student 2: Yeah and that's the part where its like.. I mean guess like you SHOULD question it. Maybe you should go ask the guy who disposes.

(group laughter)

Student 1: I think, you have to think about, for any given piece of research plan when those conversations become relevant. I've also done like physics research one summer, theoretical quantum physics. Like that is so academical like there is no point in discussing SEI because it was so out there ya know. And that's like an extreme example because its so up in the clouds. But I guess you need to make a judgment about when it's appropriate to start talking about those kinds of things.

(quiet for a few seconds)

Jacy: so uhm, what are some consequences of ignoring societal and ethical implications in research?

Jacy: Adds* whether foreseeable or not

Group blurts out lists of things: ice caps melting, BOMBS, bad things, hole in the ozone layer, everything,

Student 2: Ozone layer
Student 5: dependence, ppl get used to things and it brings up the question and someone is like oh wait, we realize we've been doing this really horrible thing and no one wants to change because its too ingrained into our society.

Jacy: so you would say like plastic bottles would be an example of that?

Student 5: I was thinking more along the lines of cigarettes.

Student 4: FOSSIL FUELS!!

Student 5: Everyone knows how bad some of these things are but they don't care because there's been this dependence on them and its just ingrained into our culture.

(group talking over one another) 29:52

Student 7: At this stage, we don't have any practical alternatives so it's like uhhh. We are kind of like forced.

Student 2: Well maybe someone should find one. Consider it and try too.

Student 7: I'm sure people have tried to.

Student 2: Well I found it already so we can just stop all research! (Joking manner) (Group laughter)

Student 2: Stop all research.

Student 5: That would be a role for someone who has a technical background and also an ethics background and I think there's a place for a field like that. Where you have someone who works with the researchers enough to say hey, I just thought of something about your research that could be really, really bad. Let's discuss ways in bringing other people to possibly get around that before it becomes an actual problem.

Student 2: I mean, I'm not sure about that in terms of research but in industry now there are entire consulting firms that consult entirely on safety.

Student 7: Yeah I would assume like large companies have entire branches.

Student 5: I think its more a political act than a social one (referring to big industry motives for consulting)

Student 7: Yeah I think it'd be more interesting to see something happen at a lower level. (28:32)

Student 3: Even though, these perhaps, oil companies have giant consulting firms about safety, they're still willing to go fracking in places where, you know, they may disturb all the ground water and pump it full of deadly chemicals.

Student 7: Well see I'm from Pennsylvania where fracking is a major thing there.

Student 3: yeah that's a great example because fracking is very efficient and you can all of a sudden use it on these dried up Student 3 that would no longer have anything at all and you get tons more gas out of them. That's the reason why gas prices are so cheap right now.

Student 8: it's funny that we spend a lot of time talking about gray areas and when should we start thinking about "oh this is bad" but there's like a lot of examples where things are obviously terrible. Like fracking and-

Student 3 interrupts (beneficial on one hand! But obviously terrible).

Student 8: that's why they become things and they are pulling up mountains in West Virginia and fracking in upstate New York and stuff. Those things should also be talked about like when a company a just decides that something is just unambiguously awful from an environmental or safety standpoint.

Student 7: I actually watched a movie the other day called the 33 and it was about a gold mind in Chile. The company knew that there were problems with the gold mine but they kept working in it anyway and 33 miners ended up getting trapped for 69 days. Like 1700 meters underground so. That's like one case where the company should've have been like alright we got to call it quits on this and just get everything fixed before we keep sending people underground.

Student 2: I guess part of the problem with things like fracking is whatever; some of them don't have a set precedent for them so companies kind of of just like think they can do since there is no law preventing us. And you know it might be that but you know no one knows *yet,* so then they do it and the public figures out and it's like we did it, do we want to stop or..

Student 7: yeah that's not cool

(group members are in agreement)

Student 2: I definitely agree that it's not cool but that's what happens. In the same vein, how do you establish a law that can prevent people from doing that?

Student 1: I think laws are always going to be reactive in that sense, and I guess you would hope to develop a culture that considers it first.

Jacy: right, right..

Student 1: OR.. like in these cases where its obvious and you don't even have to reflect on it like is ____ removal bad? You just need somebody there who actually gives a shit.

Student 4: but I don't think oil companies are going to or natural gas companies are going to be the leading force in that ever.

Student 3: probably not

(group laughs and agrees)

Student 7: other companies are really detrimental. We're focusing so much on like—

NESTLE

Student 2: Nestle!! Oh my gosh they're horrible.

(GROUP GROANS)

Student 3: Monsanto!!

Jacy: well, so talk to me more about the negative consequences, or just the consequences of Nestle and Monsanto.

Student 2: Nestle has done so ughhh sooo many terrible things both environmentally and just like socially. They like advertise this kind of like milk product to countries in Africa. And its like oh this is so you don't have to produce breast milk anymore or whatever so you can save your energy for yourself (referring to Nestle advertising). A formula! Turns out, first of all, that it was leaded and then it became so popular a lot of mothers just stopped producing milk because they couldn't anymore. And when they figured out that they couldn't use this formula anymore, they had no breast milk to feed their children. So it's just like, Nestle-

Student 7: like how do you get away with that?! (outraged)

Student 3: it's just like these water bottling plants that they'll buy or lease land on this river that's feeding into a town, and they'll bottle it all up and sell it back to the town for money.

Student 2: yeah like they sill can __ a bottle of water. Even in like California during the drought, bottling companies have moved out but Nestle is still there pumping it away.

Student 3: that's cause they'll suck out all the water that would've gone to California and helped them out and sold it back to them.

Student 2: I guess the problem is like Nestle is such a HUGE company that's like, even if what they're doing is clearly unethical, it's hard to stop using their products.

Student 3: The biggest example is Monsanto. You're not allowed .. There's like special machines that like grapple all of the scrap and picks out all the seeds from it so you can recycle your dead plants or the plants that have seeded. So you can replant them in your fields. There's huge machines that are capable of doing this, however, Monsanto has made it a requirement that by growing their seeds you're not allowed to take the seeds out again. You have to rebuy them.

Student 8: Yeah they have like a licensing deal.

Student 3: and also, if some Monsanto plant pollen goes into your field and you don't have Monsanto, then it is then legally Monsanto property.

Student 7: How do they do that? That seems like impossible! (Outraged)

Student 2: like how does that work

Student 8: Because they engineer the corn

Student 3: then that farm can no longer take the seeds from its plants because now those are Monsanto seeds.

Student 2: even if they engineer the corn, and just because their plants go onto someone else property doesn't mean

Student 4: well it's the genetics.

Student 3: it's their DNA (referring to Monsanto) they've trademarked the DNA of the plant.

Student 1: yeah they have a monopoly on soy and which enormous in the United States. Soy has a lot of government clout.

Student 8: more than corn.

Jacy: okay. Well thank you all for sharing that.

Student 7: how do they get away with that? (Still outraged)

Student 3: it's ridiculous

(Lots of mumbling and talking under breath)

Student 1: They have good lawyers!!

(Group laughter)

Student 1: AND GOOD LOBBYISTS..

Student 3: at what point- yeah they probably have a safety firm that they deal with- but at what point do they say well, we don't want to be making quite enough money anymore or something.

(Caterers open door to bring in food)

Jacy: alright, now we will move into the last part of the discussion. And they're going to bring in lunch shortly so feel free to stay for that. But uhm, so ideas for improvement for this module.. What do you think could be improved?

Student 5: it felt a little fast, just going through it. Personally it was like oh, information, information. Might be able to slow it down a little bit. Just it was a lot kind of thrown at you. Generally when I do modules, I like some sort of interactive you know oh hey here's what we told you, we've summed it up and now interact with us. I think.

Student 3: maybe a quick question or discussion after the video or something

Student 5: yeahh!

Student 7: I think that you should include more in terms of types of ethics. Like ethics is so broad I guess you can introduce several different examples of it I guess. We were talking about workplace safety, environment, and social things like I guess introducing some subsets of things we should consider. Maybe some examples as well.

Student 1: I like the case studies.

Student 5: there's also one side in particular where there was a lot of talking but it didn't have anything, you talked for like a good minute and half and then after that you talked about what was on the screen. Maybe, make another slide for that. I just remember thinking, whatever your talking about is not appearing visually on the slide and that was little disrupting. Like did I, did I miss something?

Jacy: alright, so how does this module relate to your work or is there a way it could relate more to the work that you're doing?

(Several seconds of silence)

Student 3: have some more examples about Nano typology. Because like the flint water crisis is definitely something that happened with scientists or people neglecting to think about safety but I don't know if that was necessarily Nano particle lead, which is a completely different story.

Student 2: I guess maybe you can like talk to some of the researchers here to like maybe, present an example. Cuz like, something that's obviously relevant to us would be more impactful.

Think it would also be good to use, maybe towards, like had we had this at the beginning of the summer to think about it before you start the research. And like a lot of us are doing very academic separated research. We're at the beginning stages of a product or something. Take a look at well what really are the ethical implications of what we're doing. Maybe that's more in the waste disposal at the processes that we're running. You know, like what are the societal implications of running a.. Something like that. Not entirely sure.

Student 4: us as researchers I just thought of this. Knowing, these big companies aren't going to care, and then so us taking some preliminary thought into what we're doing. Knowing that these big companies aren't going to care, and us making in whatever way we an in our capacity, the process as safe as possible. Or the application as safe as possible. I mean its kind of unknown, like end goal is unknown. But us doing as much as we can to make sure we are being safe and are not going to kill everybody knowingly.

Jacy: knowingly..

Student 7: and unknowingly!!

(Everyone begins to say unknowingly)

Jacy: okay, so was the length of the module appropriate? Would you have liked if it were longer or shorter with less information?

Student 4: I thought it was good!

(Everyone agrees)

Student 4: maybe just more questions of these questions (referring to focus group discussion questions) scattered through or additional.

(Several seconds of silence)

Jacy: would you have.. Oh (notices someone has hand raised)

Student 5: me personally, if there is a way on the web to interact with us, that's one of my things, interact with us. I think it's a big part of learning. You talk about a lot

of different case studies, it would be really cool to see something where you could click on a picture and go to that case study and learn more about that because with relating to the nanotechnology field, what their saying (referring to interns) with the flint water crisis was that really Nano lead or was that something else? I would be more interested in or be able to do something like that.

Jacy: so this module, down the line, is intended for researchers to take individually. So the pictures and stuff that we shown throughout has the link to where you can go to get more information. I understand, that in this setting you aren't able to click on those links and stuff like that's, which is interesting.. So, in your case, I know you would prefer to probably take it by yourself own your own laptop that way you could take your time to click on the links and go outside. So do yall think it would be better to view this module individually or in a group setting? What do you think?

Student 4: I think as a group. Because then you get all this outside input.

Student 3: yeah I think as a group it helps.

Student 7: I also think if you try to make people do it individually they may not pay as much attention. They could just like press play and go do something else.

Student 4: Because their stuck in something else! They have their own thinking. You know they think the way they think so I'm not going to think of something that Student 2 would say and I might be more insightful in a group setting.

Student 5: you could so something like a webinar to try to combine the two

(Group groans in protest)

Student 5: I know, everyone hates the word webinar.

(Group laughter)

No way!!

Student 5: it's a way to access both on your laptop and in a group setting. Or have it be available afterwards. I like that when I get presentations. Here's the presentation that I showed you and we can email it to you later if you'd like more information or if you'd like to have it. No one ever remembers everything. No one is taking notes. Like any other lecture, you're not going to remember.

Student 3: I find it works much better in a group setting like this.

Student 2: yeah I feel like as an individual it would be easy to avoid the thoughts or questions you don't want to think about.

Student 3: it'd be easier to just not say anything ad to just view it and be like, hmm okay. So if you're in a group session you actually have to say something.

I think if you did it in an individual, you would have to make it like more interactive. Like have some sort of quiz or something to make sure that people are actually watching it.

Yeah I've definitely had videos where I've just hit play and

Student 3: Yeah and you kind of just spacing out?

Yeah
(Group agrees)

Student 3: you watched it but you don't actually know what you watched.

Jacy: Right. So as far as retaining the information, the consensus is that in a group setting it's a lot better?

Yeah group setting!

Student 3: I mean other people bring up topics and examples you wouldn't have heard of or haven't thought of.

Consensus: group setting works best for view the module. More accountable for paying attention.

Jacy: so, besides that, what else could be included in this module to help you retain the information better or more?

Student 1: I would have liked to have heard something about like how public opinion can really sway the ethics of something. Because, at least one examples, there's like some oil spill off the coast of Alaska or something. And it would've been much better for the environment to just burn it off, but they cant do that because its going to be on the news and their getting Exxon is going to be this big evil corporation for burning oil. Instead it was just muddied up all the beaches and it was way worse. So like kind of, talking about public opinion and how that really

sways a lot. It's like a big reason big corporations are paying so much money for safety…

Student 8: I think there was a suggestion about trying to talk to the leaders here. That would be really interesting just to see who in the organization here that we worked under or interacted with see them engage with this. I don't know what ties would connect us to this place at this point since we're leaving soon but the general thought if REU Coordinator was up there or whoever then give us some type of end to connect with her and engage with her and the people here.

Student 7: for future generations..

Jacy: and what would help you as a researcher to stay up to date with information about societal and ethical implications?

Student 7: someone could put together like a

Student 3: A blog!

Jacy: a blog? You would like a blog.

Student 7: a newsletter that would get sent out

Student 3: I think a blog or website. I would actually look at a newsletter before I look at a blog

Student 7: Yeah, I think that something that emails. You can just get like a weekly email.

(Group all laughs about deleting emails)

Student 4: oh yeah, I will not check my email if its that! (Referring to newsletter)

Student 3: well if it's a blog I would never go there.
Student 4: most websites now are blogs.

Student 3: yes, but if its about the social and ethical implications of my research and dealing with those awful things happening in my research I'm not going to go there.

Student 4: not awful! I mean it could be good too but I mean I think like having one place or one place to go to

Student 5: (something about a seminar) All those emails just go to junk.

Student 7: yeah, like anything that's individually based, or anything people are supposed to do, as an individual would be difficult to enforce that.

Student 8: yeah I need a friend to tell me about it.

Student 7: or like a meeting that talks about like..

Student 2: ughhh. I don't think mandatory meetings either.

Student 3: oh yeah just sneak it into another meeting (sarcasm)

(Group laughter)

Student 2: its like ohm we have this ice cream social about the social and ethical implications (more sarcasm)

Jacy: so like an SEI social?

Student 7: well actually if you call it that

Student 5: give people food, free food and tell them to come we're just having a lunch meeting and we're going to talk about some stuff.

Student 2: yeah be really vague about it!

Student 4: I would just be eating and not answering anything

Student 3: you can sneak a few questions into a meeting,

Jacy: okay, of all the things that we have discussed today, what was the most important to you?

Student 4: I just think bringing this into the conversation probably most important. Because its something that when we have dinner every night, we don't sit around and talk about this you know? We just talk about…

Student 2: maybe you don't. (Referring to conversation about SEI)

Student 4: well whatever! Bringing this into the conversation is a good place to start

Student 2: I think learning about the role we play in it is also important. I guess most of us are like some higher order or organization handles this stuff but we do also play a pretty important role.

Student 8: maybe not so much right now but maybe later on in our research or our regular careers it'll definitely be something we have to pay attention to.

Student 5: I think it was interesting seeing how people are talking about this is an ethical problem that we looked at and this is what we did. Just from where I'm at now I wouldn't know how to approach that or know where to begin. But having like a springboard is always useful.

Jacy: Student 6 do you have anything?

Student 6: I don't have anymore to add.

Jacy: what about you? (Referring to Student 1)

Student 1: I came into this thinking it was kind of pointless.. Now, it's not that pointless.

Jacy; its not THAT pointless?

(Group laughter)

Jacy: So you're saying it 's still a little pointless? (Jokingly)

Student 1: no no it's not pointless.

Jacy: but, you learned something right?

Student 1: yeah,

Jacy: yeah..

Student 1: yeah just like Student 3 said its not much that we can do as undergraduate researchers. We're kind of doing the bitch work and then other people are more concerned with this stuff think they need to hear a lot of this.

Student 3: but you'll have to think about this stuff eventually right?

Student 7: Eventually we're going to be the ones making people do the bitch work

Student 1: yeah, so I guess start now. Yeah.

Student 7: hopefully.

Student 5: be exposed to it now at least so that when you start whatever research or job you will have the resources and insight to think about it

Student 7: it triggered like my sub consciousness that like bring it to the forefront. Because I don't know if I necessarily.. I learned some new terms but I mean like I already knew stuff that I'm doing could be having ethical implications. It's just I didn't like learn anything fundamental but it just like brought it to the forefront of my mind.

Jacy: alrighty. So lastly, is there anything else?

(Group banter of one intern about wanting to say something. He doesn't)

Jacy: oh, did you have something?

Student 2: no!!

Student 7: are you sure? Please share it.

Student 2: no, I've talked too much already.

Jacy: oh no, it's fine. Uhm, any final thoughts, comments, suggestions? Anything like that?

Student 8: that was you on the voiceover right?

Jacy: yes, unfortunately. It's very hard too.. I did majority of it when I was sick so that's why if the volume changed and stuff like that..

Student 4: maybe not record it, a presentation, like… I don't know the scope of this if it could just be emailed to people to facilitate or if you plan on doing all of these in person here uhm but if their given in person I think any PowerPoint lecture with an actual person in real life talking, I'm more engaged. That would be the only thing. But that's minor.

Jacy: okay. Anything else?

Student 3: think you need more examples about nanotechnology related SEI. You had like the microbeads, but like a few more.

Student 7: that was an interesting example.

Jacy: alrighty then that concludes our focus group discussion. I really want to extend another thank you to you all for taking time out to be here with us.

APPENDIX E. REU FOCUS GROUP NOTES

Observations during playing of the module
- yawn at slide 2 rubbing eyes
- Participants look engaged
- Another yawn at ethics slide
- Yawn at ethical doubts and stretching
- Participants are still
- Heavy sigh during 4 levels of considerations
- Yawn at individual level
- Heavy sigh at individual responsibilities
- During UW vid participant smiled and looked excited
- Fidgeting about half way through
- Stretching at the end of the UW video
- Participant losing interest towards end of video, rubbing eyes, yawning, fidgeting
- Participant left at the end of the vid to go to bathroom

Question 1: Initial thoughts
(Long pause before anyone answered)
Student 3: Good topics, good to think about SEI, should apply to research in making products that influence. I'm not too knowledgeable.
Student 7: Made me think about my research
Student 2: That's the point
Student 3: Not immediately obvious
Student 7: Deeper knowledge
Student 4: It's important for the professor I work with to think about it about it, but not primary focus.
Student 3: This is not taught at all
Student 4: Mentioned in my classes, but up to us
Student 7: I had a 1 hr. general seminar
Student 3: I've had zero (education on SEI), but occasionally it's brought up. Brought up in Waco. We hear don't do that (agreement from group)
Student 2: I had a course about ethics, workplace policies, safety over everything else with big companies. Nano is new so there is less info
Student 3: (questioning Student 2) Do you believe in genetically modifying babies?
Jacy: Would SEI training have been helpful for your current work?
Student 1: What can we do before there are huge implications? I understand chemical plant explosion, but there's nothing I'm working with that would result in that.
Student 8: we received some workplace safety instruction between tool trainings and safety "Hellish" training. That addressed safety, but down the line my research is not consumer products.

Student 7: My research is 15-20 years away from being to consumers. There could be thousands of implications.
Student 2: What happens to these materials? We should consider this. These Student 8ples are small, but they won't always be. (also spoke about hazardous materials with etching)
Student 7: Are they doing industrials scale yet?
Student 5: I'd like to see positive impacts of ethics in science.
Student 8: That's hard to find (agreement from group)
Student 3: There's a reason that we have smart phones and TV's. (laughing from group and agreement)

Question 2: Did you learn anything? If so what?
Student 6: Ethics and science think about biology, I've talked about that in class. With nano I don't think about it cause it's harder to see implications.
Student 1: I always think about it in terms of safety levels.

Question 3: Can you envision using this knowledge in your decision-making? How?
Student 1: In the lab?
Jacy: repeats question
Student 5: that's a lot to ask, but before starting the project to go through ethics process. The lab is about research (implying that it's not about ethics).
Student 1: You should always investigate we shouldn't do things because of potential implications.
Student 2: To counter act (counter acting Student 1's previous statement) Someone from my lab accidentally produced mustard gas in the lab.
Student 3: at what point do you stop? Used bird example. When results of research are interesting when do you actually look at ethics?
Student 2: that's a pervasive question, there are no fine lines
Student 4: electric car batteries are good, but disposal of batteries isn't.
Student 3: mining of lithium in 3rd world countries.
Student 4: SEI is an afterthought, after decades, considering SEI before hand leads to slower product launch. If legislation enforced nothing would ever be safe enough.
Student 3: product launches then we see the effects. (brought up leaded gas as example) released lead into the air. Now gas has to be unleaded.
Student 2: We should be investigating first. EPA is for this.
Student 1: Solution is more engineering, not less.
Student 2: I agree with that (Student 1's point) engineering shouldn't stop.
Student 8: I liked integrating philosophers into the process. I don't spend all my time with scientists so I've seen benefits of having friends with different viewpoints.
Student 8: Ethics not a part of formula cause it's easy to omit.
Student 7: Could create SEI departments in labs just to evaluate research projects.
Student 2: But researchers understand most (in relations to their projects)
Student 7: They need to work together.

Student 8: Fundamental tension, SEI takes away from research, SEI isn't your job. It's a different job.
Student 4: Having SEI (expert/employee) being highly trained on science aspect. Taking philosophy class taught by physics professor. Holes if not form science background. I don't know how to begin the process.

Question 4: Definition of ethical leader
Student 2: Can we watch the module again? (laughter from group)
Student 8: Did a good job of explaining that (module). Reinforced value and SEI considerations.
Student 3: They are willing to ask hard questions, think about impact on population, kids, the future.
Student 4: Talking with mentor, his responses mention looking into the safety of it. Protecting the students. "Lets make sure we don't kill everyone," If something goes wrong what can we do? No environmental concerns yet, only personal safety.
Student 1: Ethical leader would be willing to give up some money.
Student 5: Willing to think about SEI and actually pursue it. Link ethics and safety, but there's more to it. Scientists get the safety aspect more. Big companies spend a lot of money making people safe.
Student 2: Economic aspect. Exon does spend a lot of money on safety.
Student 4: While they (Exon) make materials bad for the environment.
Student 3: Apple phones made with child labor.
Student 8: Global paradigm. We make these choices as a society driven by money. I wish we had power over that but we're just students.

Question 5: What examples were most helpful to you?
(Long pause for 10-15 seconds)
Student 4: Video mentioning stem brain depression (UW Video), having that mindset, taking the extra step "What could go wrong, even if it's not a ton of time just ask that question to yourself would be good, that it's okay to do that."
Student 5: Wheelchair example (UW Video) as scientist we think our interests. We need to think about problems society needs more help with.
Student 2: Good concrete examples in module, establishing basic vocab.
Student 6: I agree with Student 2, module was helpful. Now I feel more confident using SEI in my work. Good examples.
Student 3: I agree

Question 6: Why is it important to consider ethical implications of what we do?
Student 7: I wouldn't want to be a part of a project that was a disaster.
Student 1: Future applications concerns. Seeing things in the market.
Student 5: Self-preservation. Direct effects on my family and me. What hits the hardest gets most considered.
Student 2: I'm opposite (of Student 5) human aspect is implied, environment concerns are improving.

Student 7: We are so stuck in our ways, so important to our society. Impossible to just stop. We are far from it.
Student 2: San Francisco's ban on Styrofoam is in the right direction.
Jacy: (brought up plastic bag example)
Student 8: UT gives us crappy plastic grocery bags.

Question 7: What role does ethics have within your research, in your opinion?
Student 3: my research? (laughs)
Student 7: I don't know "We don't do that," the waste is a concern but I don't know about the applications.
Student 2: nano potential, toxic environment, first thing that pops into my head (agreement from group)
Student 4: Renewable energy. We have good goals.
Student 7: Risk vs. Reward
Student 4: Military applications
Jacy: The role of ethics?
Student 8: My research is at the academic level. No large societal impact. We don't need to think about. It's not in the foreseeable future. We need to consider proper disposal. With arsenic disposal procedures I trust the facility to deal with it. I should question the disposal at the facility level.
Student 2: (asked the question to be repeated) begins with individual, grows to more. More conversations with more people. You should question it.
Student 8: When is it relevant? There is no point cause it's so out there. (Appropriateness)

Question 8: What are some consequences of ignoring societal and ethical implications in research?
Student 3: Bad
Student 2: Ozone layer
Student 5: Dependence. Too engrained into society. Cigarettes. We don't care
Student 3: Fossil fuels, plastic.
Student 7: We don't have practical alternatives at this stage.
Student 5: Tech/SEI background, work with researchers.
Student 2: Consulting firms to deal with SEI
Student 7: Lower level SEI applications.
Student 3: Big companies, fracking = cheap gas.
Student 8: A lot of obvious things that are terrible. This need to be talked about.
Student 7: I saw a movie about mining with a big company. 33 people were trapped. This should have been stopped.
Student 2: No set laws against it. Public is unaware.
Student 3: Not cool (agreement with Student 2)
Student 8: Laws are reactive
Student 2: Should consider SEI first

Student 8: We need people to care.
Student 4: Leading focus to start this?
Student 2: (brought up Nestle as an example of a bad big company) Made milk formula with lead to be sold to 3rd world countries.
Student 3: They (Nestle) leases land on rivers and sells the water to the town on the river.
Student 2: Water is still being bottled in CA even with the drought.
Student 2: Such big companies, it's hard to stop using their products.
Student 3: (brought up Monsanto ex) requirement to rebuy seeds. (Raised question of how did this happen to group) Legally they own the plant DNA, they have a monopoly on soy.
Student 7: How do they get away with it?
Student 8: Lawyers and lobbyists.

Question 10: How could this module be improved?
Student 3: More nano examples. Flint was not nanoparticle lead.
Student 2: Talk with researchers here (MRC) to get more relevant examples.
Student 5: Training at beginning of summer. How this applies to our experiences in the lab.
Student 4: researchers knowing big companies don't care, so we have to make application as safe as possible.
Student 2: unknowing dangers.

Question 12: Was the length of the module appropriate? Longer or shorter?
Student 4: Good, but need more question scattered throughout. (agreement from group)
Student 5: More interactive. Click on image and then be directed to the case study and learn more about that. Was Flint really Nano or something else?
Jacy: Module intended for individual consumption. Different in this setting. Is it better to view module in a group setting or individually?
Student 4: Groups are better for viewing. You get more insight.
Student 7: (agreed with Student 4)
Student 4: All of this discussion is helpful.
Student 5: Webinar (disagreement from the group). Availability afterwards. Email the lecture because we won't remember. Here's the presentation and receive email afterwards.
Student 3: Much better in a group for viewing.
Student 7: If individual more interactive. Quiz or something to make sure ppl are actually watching it.
Student 3: Easy to get distracted while viewing by yourself and not think about the questions that cause discomfort.
Consensus: **g**roup setting works best for view the module. More accountable for paying attention.

Question 13: What could be included to help you retain the information?

Student 1: public opinion should be added to discussion and how it can sway ethics. (brought up exon oil treatment and how public opinion effects how big companies deal with it)
Student 8: Talk to leaders here, who we can talk to, see leaders engage in SEI. (If REU Coordinator engaged in it.)

Question 13 B: What would help you as a researcher to stay up to date with SEI information?
Student 4: Blog
Student 7: Newsletter
Student 3: Newsletter over blog monthly. (Disagreement). Some favor blogs. Weekly emails.
Student 5: Seminar, emails just go to junk. Individual level is harder. Needs to happen together.
Student 3: Sneak SEI into other meetings so people are forced to hear it.
Student 5: Give people free food, lunch meetings, Be vague about the content of the meeting.

Question 14: Of all things we discussed today, what is the most important to you?
Student 4: Starting the conversation. We don't normally discuss this. It's really important.
Student 2: We typically think a higher level person plays a bigger role but the role we play is important.
Student 3: Not right now, but later on it is something we need to pay attention to.
Student 5: I don't know where to begin, but having this as a spring-board is always useful. It's interesting to here how others approach this subject to talk about ethical issues.
Student 1: Came in thinking this was pointless. There is not much we can do as REU's. (feelings of helplessness)
Student 3: We'll have to think about this eventually as we move up. Eventually we will be the ones with interns.
Student 5: Being exposed to this now so that when we start those jobs we will have the insight to deal with this.
Student 7: Triggering the self-conscious. Learned new terms. I already knew stuff I was doing could have ethical implications. Brought to forefront of my mind.
Jacy: Any final thoughts, questions or suggestions?
Student 4: Lectures even in person and not a recording would be better. Email presentation to others to facilitate. More engaging to have a person in real life talking.
Student 3: More nano related examples for SEI.
Student 4: is this module going out for industry?
Jacy: I'm not sure how far it will go. Will be on UT website eventually.

End of focus group

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