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Evaluating Students' Perceptions for the Ethics Module Content in Nanotechnology Safety: Meeting the Needs for Post-Secondary Students in STEM Areas

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ABSTRACT

The nanotechnology revolution requires an educated workforce, one that will act with technical proficiency and attentive to avoiding risks. While there are efforts throughout the world to create workers with skills in nanotechnology, there has been a dearth of efforts in addressing the potential risks in handling and otherwise employing the novel, and in some ways still unknown properties of nanomaterials.

The program that is described in this paper is one of the first developments of a nanotechnology safety course within the traditional curricular structures of undergraduate education in the United States. The objective of the effort is to provide students with an initial understanding of the implication of developing and deploying nanotechnology. Not only does this effort provides guidance for the proper handling and storage of nanomaterials but also addresses regulations and other official guidance that requires detailed record keeping. Thus, this project helps equip future nanotechnology workers and researchers with certain technical and regulatory knowledge.

The overall effort provides the students with an understanding of the proper approaches to addressing issues with materials whose properties and effects are unknown. Many professional codes and guidelines for engineering and technology indicate that protecting public welfare and safety is an ethical duty. Following this lead, project developers determined that safety education was best presented within the context of a broader consideration of ethics of emerging technologies (Hollander, et al, 2005; Khushf, 2004a). Project investigators were also guided by the goal of designing course materials and modes of presentation that would be most engaging to the current generation of students, the so-called Millennials.

This paper outlines the context of the project, including the relevance of ethics to safety education and the challenges of preparing students to address the implications and risks of new technologies, discusses pedagogical issues particular to Millennials, and describes course development and initial implementation. The first assessment evidence is presented, indicating significant student engagement.

Dr. Dominick E. Fazarro-Associate Professor, Department of Technology at the University of Texas at Tyler has been researching nanotechnology safety and education for eight years. He has been successful in securing grants in this area along with publishing several articles, book chapters and conference papers. Dr. Fazarro is a senior member of IEEE and active on the IEEE nanotechnology council. He also founded the Micro-Nanotechnology focus group for ATMAE.

Dr. Jitendra S. Tate-Associate Professor, Ingram School of Engineering at the Texas State University has established safe handling practices for industrial (such as nanoclay) and engineered (such as carbon nanotubes) nanoparticles in his research and teaching, dealing with advanced polymer nanocomposites. His research lab will serve as the training site on health and safety issues of nanomaterials.

Dr. Walt Trybula, Adjunct Professor-Ingram School of Engineering and past Director, Nanomaterials Application Center is a nationally recognized advocate for nanotechnology safety. His 30-plus years of experience in the semi-conductor and nanotechnology industries provide him the ideal background for addressing safety issues associated with new technology. Both an IEEE and an SPIE Fellow, he is recognized for promoting nanotechnology applications for commercialization.

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Introduction

Nanotechnology, the scientific study of and engineered development of materials in the range of 1-100 nanometers, has become increasingly important to our society over the past fifteen years. A cursory overview of consumer applications includes lighter and stronger baseball and softball bats, static- and stain- free shirts and pants, self-cleaning toilets, sunscreens, new stringer and lighter wind-turbine blades, and anti-microbial socks and underwear. So great is the promise of nanotechnology that many have argued that we are in the middle of a new technological revolution (Crow and Sarewitz, 2001; Kurzweil, 2006; Allhoff, 2007; Drexler, 2013). In testimony to the U.S. Congress regarding the passage of The Nanotechnology Research and Development Act of 2003, technologist Ray Kurzweil noted, "Nanotechnology and related technologies of the 2020s will bring us the opportunity to overcome age-old problems, including pollution, poverty, disease, and aging" (Allhoff, 2007, p. 40). Nanotechnology, along with advances in genetics and biotechnology, and information and communications technologies, "will not simply generate incremental change, but rather will be a technological leap over what we currently have" (McGregor and Wetmore, 2009. p. 18). Significant public/private cooperation is developing a convergence of nanotechnology, biomedicine, information technologies, and cognitive science (De Rosnay, 2001; Khushf, 2004b; Roco and Bainbridge, 2002). Proponents envision alterations of human aging, advanced human-machine interfaces, smart autonomous robotics, and breakthroughs in fields from space-science to human reproduction (Roco and Bainbridge, 2002; Moore, 2003; Nicolelis, 2003).

The United States is among the countries pursuing the many benefits of nanotechnology. Through the National Nanotechnology Initiative (NNI), funding for nanotechnology in the U.S. has increased from $275M to $1.8B from 2000 to 2013 (NNI supplement), and as noted above the number of consumer products using nanotechnology has also increased (Fiorino, 2010). Nonetheless, concern has been raised regarding the ability of the U.S. to keep up the pace in terms of technological innovation. Some have made the case that basic research in the U.S. has suffered for multiple reasons and that it must change course in order to continue to lead in the global technological marketplace: "It is not the biggest that will succeed, but the fastest with the most valuable innovations" (Duke and Dill, 2004. p.5). Studies also demonstrate a general lack of knowledge about nanotechnology among the general public and business professionals, and suggest integrated science and "design education" in engineering as ways of mitigating the problem (Holley, 2009).

An additional challenge is that the implications, risks as well as benefits, of nanotechnology are in many ways uncertain (Kulinowski, 2004; McCray, 2005; Berube, 2006). In any case the requirements of safety and ethics are sometimes difficult to determine, and this is especially the case with emerging technologies. When we cannot predict the impacts or risks, creative, careful, and thoughtful engagement with work and context is necessary. Maximizing the gains of nanotechnology while minimizing the problems means attention must be paid to technical concerns, and also to ethics (Lightman, Sarewitz, and Desser, 2004; Guston and Sarewitz, 2002). As McGregor and Wetmore note, "To realize the benefits of and to avoid problems associated with emerging technologies will require significant attention to social, political, and ethical systems as well as the scientific and technical" (McGregor and Wetmore, 2009. p. 18). This is especially important given the complexity of nanotechnology and the difficulties of public understanding (Arnall, 2003). We need educated and reflective designers, developers, and producers of nanotechnology.

The future outlook for nanotechnology is promising, but educators face a tall task in building the new workforce for the 21st century. Researchers, technicians, manufacturing engineers, and production workers will be needed for future development of nanomaterials for everyday life. (National Nanotechnology Initiative, 2009). By the year 2020, an estimate of six million nanotechnology workers will be needed to produce nanomaterials worldwide, with two million in the U.S. (Roco, 2011). Because of the requirements of this new and emerging technology, specialized training of personnel is vital for long-term success (Roco, 2001). There are significant requirements for increasing access to and quality of, technical training. The challenges of preparing a 21st century nanotechnology workforce for safety and ethical concerns are at least as great, as noted by the ethics and social implications requirements of the National Nanotechnology Initiative. In order to realize the full potential of revolutionary nanotechnologies and at the same time minimize undesirable consequences, engineers and technologists need to be educated in how to judge health and safety risks, how to weigh ethical considerations, and how to make informed decisions. As Khushf stresses, "Nanoscience cannot be based on traditional models in which ethical/social reflection is a second, later step in the assessment of the use and/or abuse of previously configured science. Ethical reflections must accompany research every step of the way, and this should be a defining feature of nanotechnology, not just a statement about how ethical issues should be addressed" (Khushf, 2004a. p.41).

There have been important efforts to begin addressing this need for ethics and safety education. Fazarro and Trybula have developed professional workshops on safety issues in nanotechnology (Fazarro and Trybula, 2011). But, there has been no systematic effort to transform standard university engineering and technical curricula to integrate education in nanotechnology, safety, and ethics. Such efforts are needed because they will 1) introduce people to the questions and issues before entering the workplace (professional education workshops are essential, but are addressed to later stages in individuals' careers), and ii) be "responsive to the interests and aptitudes of engineering students" (Herkert, 2000. p. 31; see also Tucker and Ferguson, 2007).

With these considerations in-mind, faculty from two public universities in Texas have undertaken a project to develop new instructional materials, deliverable as entire courses or in modules infused in existing courses, workable on-line and face-to-face, and attentive to characteristics of the current generation of university students, the Millennials. This article is based on a funded National Science Foundation-Nanotechnology Undergraduate Education project.

Educating the Millennials in Nanotechnology Education Safety

There is a new generation of workers who will carry the torch in future developments of nanotechnology. By 2025, millennials will make up the majority of the U.S. workforce (Kabani, 2013). Fazarro & Trybula (2011) stressed, "…nanotechnology safety research is novel; however, there is a need for a parallel effort to implement education and training" (para 4). When developing engineered nanomaterials (ENMs), there is a critical need to research their characteristics and their health and toxicity effects in order to adequately educate and train managers who work with nanomaterials at the 1-100 nanometer realm (Fazarro& Trybula, 2012).

Today's traditional approaches (i.e. lecture or linear learning) to teaching are outdated and not effective. Twenty-first century classrooms in higher education need to change. Online and hybrid education models are becoming more prevalent. Additionally, the current generation of students, the millennial generation, is different from earlier generations of students. In higher education Neil Howe and William Strauss (2000) described the millennial students' personality traits as: 1) special, 2) sheltered, 3) confident, 4) team-oriented, 5) conventional, 6) pressured, and 7) achieving. The task for educators is designing teaching materials and modes of delivery and interaction that will be most effective with these students.

One maturing tool is new information and communication technologies (ICTs). Perhaps the most important and far-reaching of these is the internet. Millennials are the first generation that has grown-up with the internet (and mobile phones), and members of this generation tend to be heavy-users and technologically savvy (Nielson, 2014). The internet is most commonly used for social purposes – staying in-touch with friends, sharing photos and music, gossip and social activism – and Millennial users show a distrust of and detachment from traditional institutions (Pew, 2014). , However; according to Belderrain (2007), since the emergence of distance learning in higher education, there has been a paradigm shift in pedagogy and theoretical approaches to learning. The advent of online software packages such as Blackboard, WizIQ, Camtasia, and MOOC-type platforms allow educators to increase student enrollment and provide the convenience of learning while on the go. Additionally, students now have access to a global storehouse of information, knowledge that to a previous generation was often contained within specialized libraries at elite institutions (Cukier, 2010).

For nanotechnology educators, one obvious question is "how do we get this on-line, plugged-in Millennial generation to become interested in nanotechnology using online teaching?" Further, "how do we spark interest in the safety and ethical issues in this emerging technology?" With emerging technology, such as nanotechnology, there are some amazing innovations that will advance society. However, we as educators and researchers must examine the negative consequences and be proactive in educating the future workforce to work with nanomaterials safely and responsibly. Furthermore, learners (students) must learn advanced and complex content to holistically understand nanomaterials and their impact. U.S. Senator Mark Pryor (2010) addressed future health and safety concerns in the Nanotechnology Safety Act of 2010. He stressed:

> Nanotechnology is one of the most important and enabling technologies being developed right now, and it has hundreds of promising applications – from new cancer treatments to improved military machinery to stain-resistant pants," . . . "As these products are developed and used, we must understand any potential risks to human health, safety or the environment. My legislation will help ensure public safety and confidence in the marketplace, and it will support companies that employ nanotechnology materials (para. 1).

There have been a number of projects in developing educational materials for the purpose of educating the next generation of people who work with nanotechnology. For instance, Fazarro and Trybula (Fazarro and Trybula, 2012) reported success in the development of nanotechnology safety learning materials in a variety of educational situations. Using funds from an OSHA Susan Harwood grant, they conducted courses in eight locations throughout the U.S. and Puerto Rico. Comparison of pre- and post-test survey results showed with significance that students did learn from the training materials. It was also determined that participants were satisfied with the training. Also, Shabani (Shabani et al., 2011) had positive results with a sample of undergraduate engineering students using a dual top-down/bottom-up approach to the module design, as part of an attempt to increase interest in nanotechnology. Shabani found that interest was increased between pre- and post-survey times (in-between two guest lectures). We followed this design approach in developing our modular courses.

The Impact of Ethics on Nanotechnology Safety with the Millennial Generation

Emerging technologies, such as nanotechnology, present special challenges for engineering and technology education in order to provide tomorrow's engineers and technologists with the knowledge and skills necessary to responsibly address the ethical, social, health, safety, and environmental dimensions of their work. Without clear attention to these dimensions, engineers and technologists will tend to either focus only on efficiency maximization and cost minimization or avoid developing new technologies out of caution. The great possibilities and unknown risks of nanotechnology call for special attention to ethics and safety education. (Fazarro & Trybula, 2012).

These general concerns about the importance of ethics education for responsibly dealing with emerging technologies must be understood in the context of the audience. The current generation of undergraduate students is known as the Millennial Generation (Pew, 2010). Research suggests that generational experiences shape ethical worldviews (Strutton, et al, 1997; Ramsey, et al, 2007). The Millennial Generation is the first generation that has grown up always connected through information and communications technologies such as the internet and cell phones (Pew, 2010). Additionally, these students have grown up in a culture that has been characterized as serious doubts about generalizable ethical norms (Lyotard, 1984). Contemporary culture in the United States is one in which many traditional values, (including truthfulness-,) have been replaced with valuing personal preferences and tolerance of difference (Gross, 2011). As a result, this culture increasingly glamorizes unethical behavior (Pew, 2010).

Research suggests that Millenials tend toward high levels of ethical relativism (VanMeter, 2013), conflict avoidance (Blum, 2009), risk avoidance (Howe & Strauss, 2003), and higher levels of narcissism than previous generations (Twenge and Foster, 2008, 2010). Risk and conflict avoidance means they are less likely than previous generations to call attention to ethical or safety violations if they can thereby avoid workplace tension or conflict, or avoid new workplace pressures and responsibilities. Surveys of Millennials reveal that only 22% believe their peers are ethically trustworthy, and only 58% of Millennials believe that they themselves are ethical (World of Work, 2008). Another study highlights the fact that younger workers are more likely to feel pressure to violate ethical standards (Verschoor, 2013). Finally, research reveals that Millennials have fewer resources (intellectual, psychological, social, and moral) to address ethical conflicts or resist pressure to transgress than have previous generations (Ethics Resource Center, 2007). All of these considerations have led some to conclude, "In view of the [generational] differences, Millennials face special challenges in the workplace" (Hull, 2011).

Further research gives some guidance in designing ethics education for this current generation of students. Millennials bring many skills to the classroom and workplace, especially in use of information technologies. Millennials tend to have short attention spans, lack of experience in prioritizing, and are unpracticed in systematic or reflective thinking (Twenge, 2009). All of these skills are necessary to responsible scientific and technological work. Millennials are likely to resist, or even ignore, authoritarian or strongly hierarchical approaches to education (Gross, 2011). At the same time, Millennials are found to respond well to clear structures and explicit support, including greater access to and interactions with instructors (VanMeter, 2013, Behrens, 2009). Millennials also respond well to experiential learning (Dennison & Waring, 2010, Johanson, 2012), and they are often motivated by meaning and purpose (Howe & Strauss, 2003).

Educating students means challenging them, but it also requires reaching them. Without merely creating curricula that Millennials will enjoy, important characteristics of curricula to address ethical, social, environmental, health, and safety issues in nanotechnology for Millennials are (Buono & Nurick, 2008, pp.1-4):

- Presenting clear, specific, and transparent information and methodologies about possibilities, risks, and uncertainties and about the importance of safety considerations and the relevance of ethics
- Emphasizing that their efforts make a difference, that they will have an impact and can increase safety and help create ethically responsible outcomes
- Highlighting the motivations and underlying reasons for actions and conclusions (McGlone et al, 2011) to underscore the purposes
- Structuring courses with individual recognition, interaction, and dialogue
- Integrating experiential activities.

Prospectus of Project

The National Science Foundation, Division of Nanotechnology Undergraduate Education funded Texas State University and The University of Texas at Tyler, for a two-year project with funding starting in January 2013. Researchers began designing modules in the Spring semester of 2013. The two-year project is called NUE: *NanoTRA - Texas Regional Alliance to foster Nano-technology Environment, Health, and Safety Awareness in tomorrow's Engineering and Technology Leaders.*

The goal of the NanoTRA is to educate engineering and technology undergraduate students in 'nanotechnology safety' including societal, ethical, environmental, health, and safety issues. NSF has funded research and education on ethical and value dimensions of science and technology since 1976 (Hollander, et al. 1995). Considerations of social and ethical implications of nanotechnology have been part of the National Nanotechnology Initiative since the beginning (Roco, 2003). The project investigators and senior scholars are an interdisciplinary and multi-institutional team, including natural scientists, engineers, and ethicists from three different universities, and they represent both higher education and industry. The project plan calls for developing two modular courses, one introductory and one at the upper-level, that can be offered as complete semester-length courses, or broken into discreet modules infused throughout an existing curriculum. Drake, et. al. have demonstrated that full semester courses and infused modules are equally good at cultivating moral reasoning abilities (Drake et al, 2005). The courses each consisted of eight modules that can be offered as full courses or can be infused into Engineering, Engineering Technology, Industrial Technology, and Ethics.

Courses were designed for multiple delivery formats, including fully on-line, hybrid, and face-to-face. Project personnel were especially attentive to developing materials likely to engage Millennial students.

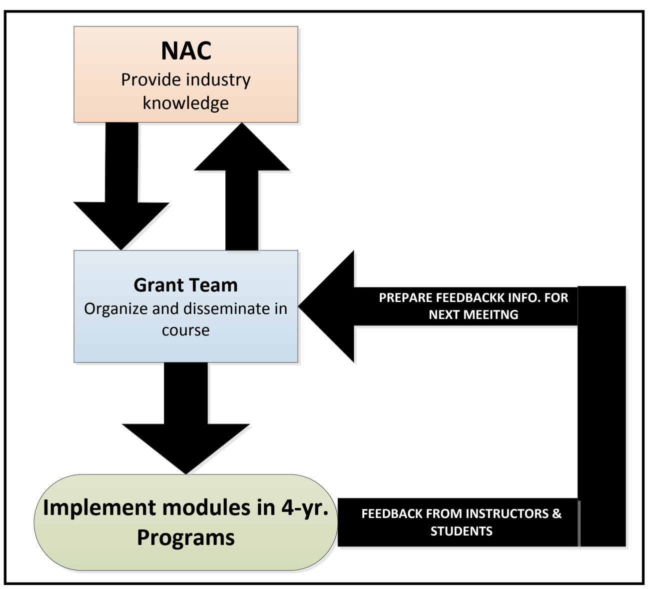
The first rollout of project results was an on-line offering of the introductory course. The course called TECH 4350, Introduction to Nanotechnology Safety was taught online in the month of July 2 to August 6- Summer-II session of 2012. This three credit course involved introduced nanotechnology, nanomaterials and manufacturing, national security implications, and societal and ethical issues of nanotechnology. This course was introduced as a freshman/sophomore level course. The student learning outcomes consisted of: (a) understand the ethical and societal impact of nanotechnology, (b) understand fundamental concepts in sustainable nanotechnology, and (c) understand the nature and development of nanotechnology. The summer course was taught online using Blackboard based delivery all PowerPoint lectures/modules. Students were surveyed throughout, and at the end of the course, to assess how they were doing with respect to the learning outcomes. Project personnel have evaluated the results, and here present the first published results, reviewing the results for two ethics modules. The authors believe that this project holds promise to transform technology education.

Designing the Ethics Modules

The Co-Principle Investigators for the project are experts in their fields. Two professors who are experts in nanoethics designed the modules, assisted by team members with specialties in engineering, technology management, and biology. The two ethics modules (ethics of science and technology (2a) and ethical methods and processes (4a)) were designed to fit the learning styles and characteristics of Millennial students. The instructional approaches for the modules integrated YouTube videos, case studies, news stories, and special links (i.e. research definitions for complex terms) to help students understand the content.

The content for the two ethics modules were validated by the Nanotechnology Advisory Council (NAC). The NAC is composed of five industry experts in areas of toxicology, safety technology management. These experts used a model (see Figure 1) developed by the project team to promote continuous improvement of the module content.

FIGURE (1): Continuous Improvement Module Content Model



The initial development of the modules took 5 months (beginning in January 2013 when NSF funding started and completed in May). Based on the student learning objectives, the researchers developed four research questions to indicate if the learning outcomes were achieved for the ethics modules. Evidence suggests that students are more likely to learn and retain course material when they feel an attachment with the material, when they find the instructor engaged with both course material and the 'real' world, and when they believe the material adequate and useful (Case, 2008; Martin, Hounsell, and Entwistle, 2005). The assessment questions are designed to elicit information relevant to these concerns.

1. What was the students' perspective on how well the topics were covered in sufficient detail?
2. What was the students' perspective on the usefulness of the materials, handouts, and activities?
3. What was the students' perspective on the instructor's ability to provide real world experience?
4. What was the students' rating of the overall quality of the modules?

Module Content

Module 2A

Module 2A was designed to introduce students to Ethics of Science and Technology and explore the social impacts of scientific and technological change. Starting with Eric Drexler's history of technological revolutions, (Drexler, 2013) students explore the idea that science and technology can have significant impacts on human values, ways of living and social organization, and ways of thinking. This material is supplemented with the work of Hans Jonas (1985) and Jacques Ellul (1964). Through the work of these important 20th Century analysts of technology, students investigate the idea that the problems, often these are unintended consequences of science and technology, call for scientific and technological solution. Here the students first encounter and debate the Precautionary Principle. The upshot of this section of the module is: *Engineering processes and products impact the lives of many people, and often in unpredicted ways. For this reason practitioners need to consider the social and ethical dimensions of their work.*

The next step is to examine case studies in which some failure in science or technology had negative impacts. Instructors may select the cases they know best and believe best illustrate the complexity of morally responsible engineering and science. The course developers prepared materials to support discussions of the Tuskegee Syphilis Study, DDT, the Kansas City Hyatt Regency, and the Challenger Space Shuttle. As part of examining these cases, students consider the influence of public policy and business on technical and ethical decisions.

The final section of Module 2A introduces students to some basic concepts in ethics and two important ethical theories, or frameworks – Deontology and Utilitarianism. Concepts studied include Moral Agency, Moral Standing, Positive and Negative Duties, Descriptive and Normative Ethics, Experimental Control, Ethical consequences, and Ethical Principles, and Value Conflict. The ethical theories are presented as tools that are useful in analysis of difficult situations, as well as foundational for ethics policies and codes of ethics. Throughout the module, students are required to find examples and cases that illustrate topics discussed and that are related to nanotechnology. (Bennett-Woods, 2008).

Module 4A

Module 4A was designed to review major ethical frameworks, introducing two additional views – virtue ethics and pragmatist ethics – and to introduce and begin use of an ethical decision process called the Ethical Cycle. (van de Poel and Royakkers, 2011). As part of introducing the Ethical Cycle, students are asked to consider the global dimensions of technological change. (Salamanca-Buentello, et al, 2009).

Pragmatist Ethics and Virtue Ethics are noted for taking account of the complexity of ethical decisions in practical contexts, and for emphasizing the importance of a clear conception of the purpose and values that drive any project or decision. Pragmatism, additionally, is a pluralist tradition, and is thus quite applicable to multicultural and internationalized workplaces and projects. (Emison, 2004).

The Ethical Cycle is a decisions map that presents moral problem solving as analogous to the design process. That is, resolving an ethical problem is similar to resolving a design problem – both require identification of the nature of the problem, the exploration of multiple possible solutions, involvement of stakeholders, evaluation of possible courses or action, and ongoing monitoring and assessment of solutions. Additionally, both are iterative processes. This helps students understand that ethical decisions are ongoing and require a careful and thoughtful approach in order to reach the best, and safest, result for all concerned. Once again, students are expected to identify relevant examples and cases from nanoscience and nanotechnology. (Alhoff, et al, 2007).

Methodology

1. Research Design

The researchers used a descriptive survey research design to obtain participants' perspectives on the course material, the engagement and expertise of the instructor, and the overall level of engagement. The goal was to determine student progress on the three learning objectives. According to Isaac and Michael (1997), this research method is used "to describe systematically a situation or area of interest factually and accurately" (p. 46). This type of design generates means and frequencies to obtain the students' perspectives of the ethics modules.

2. Statistical Analyses Used

Descriptive analysis was used to analyze the data necessary to answer the research questions. The Crosstab function in Statistical Package for the Social Sciences (SPSS) Version 20 generated the results. The rationale for the descriptive analysis was to collect the frequency of the participants' perception based on a 5-Point Likert scale.

3. Survey Used to Assess Students' Perspective

The survey consists of seven questions with a 5-Point Likert scale (poor, fair, neutral, good, and excellent). The questions were designed to ascertain how the respondents felt about the quality of the course. The survey also included a demographic section (gender, ethnicity, age, and major). This data was important to describe the types of students who were enrolled in the course. An optional response section was included to get a better insight on the students' perspectives and on progress toward the three learning outcomes. Furthermore, the students' perspectives were important to improve the modules for use in Fall 2013 and Spring 2014. Members of our Nanotechnology Advisory Council reviewed the survey questions to assess whether or not the questions were appropriate to assess the students for the course.

4. **Participants**

There were a total of thirty-two students enrolled for the summer course. Tables 1, 2, 3, and 4 illustrate the demographic (gender, ethnicity, age, and major) landscape of the students for the course. In this section, not all students responded to the surveys.

TABLE (1): Gender of Students in the Course

Gender		Total
male	female	
25	4	29

TABLE (2): Ethnicity of Students in the Course

Ethnicity				Total
Caucasian	African American	Asian Pacific	Other	
24	1	3	1	29

TABLE (3): Age of Students in the Course

AGE			Total
18-23	24-30	30-35	
19	5	5	29

TABLE (4): Major of Students in the Course

Major		Total
Industrial Technology	Other	
9	20	29

**Note : Students are in other majors-Business, Computer Science, Bachelor of Applied Arts & Science*

5. **Data Collection Procedures**

The data from module surveys were collected from July 2 to August 6 of 2012. Students completed the survey at the end of each module lesson. Data were collected and stored in a data sheet in SPSS version 20 at the end of each module. The data was stored until the end of the course. After all eight module survey results were collected and analyzed, the project investigators were able to create an end-of-the-semester report for NAC and NSF.

Results

Survey Results

The results are displayed in this section for the four research questions. SPSS-Crosstab Function was used to generate frequencies by the 5-point Likert Scale for each statement. There was a 46.9 % response rate for the seven survey questions for the two ethics modules 2a and 4b. Please note that four students in the course did not respond to the surveys.

The first research question was- *What was the students' perspective on how well the topics were covered in sufficient detail?* See table 5 for students' responses.

TABLE (5): Modules 2a & 4a-How well the topics were covered in sufficient detail

	Rating		
	Neutral	Good	Excellent
MODULE 2A	3	7	4
MODULE 4A	1	9	5

The majority of the students found for modules 2a and 4a, the topics were covered in sufficient detail. The students rated this question from good to excellent.

The second research question was stated- *What was the students' perspective on the usefulness of the materials, handouts, and activities?* See Table 6 for student responses.

TABLE (6): Modules 2a & 4a-Students' Perspective on the Usefulness of the Materials, Handouts, and Activities

	Rating			
	Fair	Neutral	Good	Excellent
MODULE 2A	1	2	6	5
MODULE 4A	0	0	10	5

For the question above, the majority of students were good to excellent for the usefulness of the materials and activities for the modules.

The third research question was stated- *What was the students' perspective on the instructors' knowledge of the subject?* See Table 7 for results.

TABLE (7): Modules 2a & 4a- Students' Perspective on the Instructor to Provide Real World Experience?

	Rating		
	Neutral	Good	Excellent
MODULE 2A	3	7	4
MODULE 4A	1	9	5

The majority of the responses were good to excellent which reflects on the expertise of the project team.

The fourth and last research question was stated- *What was the students' rating of the overall quality of the modules?* Table 8 illustrated students' responses.

TABLE (8): Students' Rating of the Overall Quality of the Modules

	Rating			
	Fair	Neutral	Good	Excellent
MODULE 2A	1	2	7	4
MODULE 4A	0	0	9	6

Overall, students rated the quality of the modules good to excellent for the course.

Conclusion and Discussion

For much of the recent history of engineering and technology the guiding assumption about ethics and safety was that common sense and observing good workplace and professional examples would suffice. The consensus has changed, in part because of the complexity of our rapidly developing technological landscape, and in part because of increased recognition that good sense and good examples alone do not suffice to teach and encourage ethics and safety (Bird, 2004). The Accreditation Board of Engineering and Technology requires that accredited programs include education in ethical, social, environmental, health, and safety issues and implications, and that accredited programs demonstrate positive outcomes in student learning along these dimensions (ABET, 2003). The modular courses developed under this project address five of the ABET student outcomes criteria: "(f) an understanding of professional and ethical responsibility; (g) an ability to communicate effectively; (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context; (i) a recognition of the need for, and an ability to engage in life-long learning; (j) a knowledge of contemporary issues" (ABET, 2013).

The ethics modules taught for the Introduction to Nanotechnology safety concluded with positive results. The researchers did achieve a reasonable response rate to determine the students' perspective of the two ethic-based modules; however, for a small class size, there should have been a higher response rate. One external variable that could not be controlled was the ability to make every student respond. The researchers wanted a natural setting to evaluate the learning process and evaluations of this course.

Two modular courses with 18 modules in total are under development to assist students in acquiring the skills to understand and evaluate emerging technologies. The modules emphasize nanotechnology, and are an important step toward addressing the recognized gap in ethics and safety education (McGinn, 2003). A teaching approach of dual top-down/bottom-up to the nanotechnology module design provides positive results with a sample of undergraduate engineering students (Shabani et al., 2011). Student engagement was assessed in order to evaluate receptivity to the modular approach and content.

Addressing on the application of nanotechnology for the new generation of students, these modular courses expand workforce training and enhance ethics and safety education, treating safety as part of the larger ethical and social context of science and technology. This addresses the idea that technical expertise itself is not enough to be a responsible professional (Hanks, et al, 2014). The course module assessment evaluates pertinent student perceptions of the technology and related safety and ethical issues. Nanotechnology holds the promise to be the next great technological revolution. This emerging science requires a strategy to address the social, ethical, safety, environmental, and health implications, and thus requires new educational opportunities for designers, developers, and producers of nanotechnology. The course modules evaluated here are an important step in that process.

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