Online Ethics Center
FOR ENGINEERING AND SCIENCE

NanoTRA: Texas Regional Alliance to Foster Nanotechnology Environment, Health, and Safety Awareness in Tomorrow’s Engineering and Technology Leaders

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Description

This activity is considered an NAE Exemplar in Engineering Ethics Education and was included in a 2016 report with other exemplary activities. The activity describes two modular courses that include societal, ethical, environmental, health, and safety issues related to nanotechnology designed for undergraduates in engineering and engineering technology.

Body

Exemplary features: Collaboration with academia and industry; multidisciplinary and multi-institutional faculty collaboration; integration of ethics content in both technical and nontechnical courses

Why it's exemplary: The extent of this effort is exemplary: We developed, implemented, and assessed two modular courses that include societal, ethical, environmental, health, and safety issues related to nanotechnology for undergraduates in engineering and engineering technology. The courses were developed in consultation with leaders from academia and industry who have expertise in mechanical and manufacturing engineering, civil engineering, electrical engineering, industrial education and technology, physics, biology, philosophy, and ethics. An important goal of the project is to recruit, engage, prepare, and encourage students from traditionally underrepresented groups to careers in science and engineering, with a focus on nanotechnology. Texas State University, a Hispanic serving institution (HSI), and the University of Texas at Tyler (UT Tyler), whose student population is 60% women, collaborated on the project. When fully deployed, we had two online courses and modules infused in 18 face-to-face courses for the first through fourth years.

Program description: A multidisciplinary team conducted the work. Members of the development and implementation team brought experience in industry, policy, and academia and expertise in mechanical and manufacturing engineering, civil engineering, electrical engineering, industrial education and technology, physics, biology, philosophy, and ethics. They are from three universities: Texas State, UT-Tyler, and Western Michigan. The implementation team includes all team members affiliated with Texas State University and UT-Tyler as well as some additional teaching faculty at Texas State. Two full-semester online courses are offered at UT-Tyler, each with the same instructor. At Texas State, project modules have been infused in 18 courses in the existing curriculum, at all levels from first to last semester, and taught by 13 faculty members.

Our central goal is to help foster ethical awareness, broadly understood to include safety, health, environmental, and social dimensions, in the next generation of engineers. We focus on emerging technologies, especially nanotechnology. Another goal is to recruit, engage, prepare, and encourage students from traditionally underrepresented groups to careers in science and engineering, with a focus on nanotechnology. A third goal is to keep students engaged: research suggests that many students—enough to stem the shortfall of US engineers—who originally intend to pursue science or engineering switch to nonscientific fields.

Our approach differs from most previous NSF-funded projects addressing social and ethical dimensions of nanotechnology in that we are seamlessly infusing modules into existing courses across the curriculum. Curricular modules are infused in nontechnical introductory courses, including a required core course in philosophy, and in technical courses from sophomore through senior level. Students engage the material in multiple contexts and through multiple methods. The central ethics modules assist students in developing moral creativity, moral judgment, and moral sensitivity. These are characteristics of morally responsible professionals and necessary for navigating situations where existing rules are silent, unclear, or require interpretation. As Mike Martin argues, moral creativity is significant in science and engineering, and developing moral creativity not only supports morally responsible work but leads to more creative and better science and technology. Moral sensitivity is a precondition of moral reasoning and action. One must recognize the possibility of moral dimensions to a situation before one can evaluate, judge, and act.

To develop moral creativity, moral judgment, and moral sensitivity and help students stay engaged with the learning process and education more generally, the project team uses multiple and varied teaching approaches. Traditional lectures are punctuated by short videos and film clips, question and answer discussion, and short individual and group assignments, with an emphasis on active learning and integrated lessons, simulations, or projects that show the relationship of concepts to the real world. One example of active learning is researching and writing case studies. As part of the mandatory philosophy course, in a special section for engineering and engineering technology students, groups of students select a topic and explore the ethical dimensions by developing a case study. Students hone scholarly research skills, including critical engagement with peer-reviewed publications, practice working in groups, create presentations, and draft articles explaining the technical and ethical dimensions of their topic to the public. The best work is submitted to Wikipedia to contribute, if approved, to public knowledge. Analysis of case studies is part of many of the modules and central to the work of the second set of modules.

The first set of eight course modules, at the freshman/sophomore level, introduces students to nanotechnology, nanomaterials and manufacturing, national security implications, and societal and ethical issues of nanotechnology. After completing this course students will be able to (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 modules introduce a method for ethical reasoning that is modeled on the design process to help engineering students think about ethical problem solving as similar in structure to engineering problem solving. The second set of nine modules, an upper-level course, addresses ethical, health, and environmental risks of nanotechnology. After completing this course, students will understand (a) the health and environmental risks of nanotechnology, (b) how to work in a group and conduct systematic research to write a group-based term paper on case studies and/or research topic, and (c) approaches to assessing lifecycle risk assessment of nanotechnology. As we go forward, we will develop separate module-packets for students and instructors. The instructor information will be more detailed, with additional references and suggestions for integrating the module into existing courses, to ensure that instructors who are not part of the development team have the resources necessary to lead the modules. Student packets will include less detailed write-ups but additional links to videos, background information, and reference materials. Both institutions are committed to continuing to offer these modules and courses. We will follow up with students to assess long-term impacts. We are also initiating an ancillary project developing materials to assist technically trained faculty members, who may not have a strong background in the formal study of ethics, to master the material and infuse active-learning modules in their courses.

Assessment information: The modules were evaluated according to how well we met the learning outcomes. There are many components to the evaluation process: evaluation of module design by the academic and industry advisory council, assessments of learning outcomes through in-class assignments, student evaluations of each module when offered, interval evaluations, site visits by an external evaluator, and follow-up evaluations by the academic and industry advisory council. Ongoing assessments during the fall 2013 and fall 2014 courses at Texas

State were largely positive, and assessments of the summer 2013 online course were quite positive. These assessments, both interval and end-of-term, focused on student understanding, engagement, and satisfaction (the latter two are strongly correlated with positive learning outcomes). At UT-Tyler, 87–93% of respondents rated the course good or excellent on a 5-point scale; there were no ratings of fair or poor. At Texas State, evaluations ranged from a high in which 93% of students rated the modules good or excellent and none rated them fair or poor, to a course in which 11% rated the modules fair or poor. This feedback helped project leaders focus on better integrating instructors not originally part of the project team. In November 2013, six focus groups were conducted at Texas State by Dr. Rita Caso, an expert in program assessment and academic evaluation. Participants were students enrolled in courses in which project modules had been presented during the fall 2013 term. On April 23, 2014, Dr. Caso conducted three focus groups with students enrolled in courses at Texas State that incorporated modules: PHIL 1320: Society and Ethics for engineering and engineering technology majors (A-Modules); TECH 4380: Industrial Safety for concrete industry management majors and construction science & management majors; and IE 4380: Industrial Safety for industrial engineering majors (1A and B-Modules). On April 24, 2014, she conducted a focus group with students at UT-Tyler who had completed the B-Module whole course. They reported a high level of interest in nanotechnology and in its ethical implications, and said that outside of class they had encountered issues and information relevant to the material in the modules.

Our assessments show that students are excited about the possibilities of nanotechnology to solve problems and promote better standards of living. Students tell us that the modules have helped them understand the important ethical, sustainability, and social dimensions of emerging technologies, especially nanotechnology. Student feedback is guiding revisions of all modules for future semesters. Student retention is high, and enrollment in the Ingram School of Engineering at Texas State continues to set yearly records.

Additional resources:

1. Project web page: http://nsf-nue-nanotra.engineering.txstate.edu/home.html
2. HSI Research Day, Texas State University, San Marcos, March 20, 2013: http://gato-docs.its.txstate.edu/nanotechnology-undergraduate-education/poster.pdf

3. Micro and Nano Technology Conference: http://gato-docs.its.txstate.edu/nanotechnology-undergraduate-education/Nanotechnology-Safety-Education-Dr-Trybula-As-Presented/Nanotechnology%20Safety%20Education-Dr%20Trybula%20As%20Presented.pdf
4. Infusing Ethical, Safety, Health, and Environmental Education in Engineering and Technology Curricula, New Horizons in Texas STEM Education Conference: http://nsf-nue-nanotra.engineering.txstate.edu/publications/conferences/contentParagraph/0/content_f+SA+STEM+Conference.pdf
5. The Continuing Shock of the New: Some Thoughts on Why Law, Regulation, and Codes Are Not Enough to Guide Emerging Technologies, 121st ASEE Annual Conference and Exposition: http://nsf-nue-nanotra.engineering.txstate.edu/publications/conferences/contentParagraph/0/content_f+ASEE+presentation.pdf
6. We Are Seed Planters: A Look at Teaching Students Nanotechnology Environment, Health, and Safety Awareness, Association of Technology, Management, and Applied Engineering: http://nsf-nue-nanotra.engineering.txstate.edu/publications/conferences/contentParagraph/0/content_f

Rights

Resource Type

Educational Activity Description

Parent Collection

NAE Exemplars in Engineering Ethics Education

Topics

Public Well-being
Risk
Safety
Sustainability

Discipline(s)

Computer, Math, and Physical Sciences

Engineering
Nanoscience and Nanotechnology
Teaching Ethics in STEM