# NSF-NUE NanoTRA: Texas Regional Alliance to Foster Nanotechnology Environment, Health, and Safety Awareness in Tomorrow's Engineering and Technology Leaders

**Abstract**: Texas State University - San Marcos and the University of Texas at Tyler, have been awarded NSF-NUE (Nanotechnology Undergraduate Education) grant to develop introductory and advanced curricula that address the 'nanotechnology safety issues' that include social, ethical, environmental, health, and safety issues of nanotechnology. The curricula will be modular in nature, suitable for use either as two full-semester courses that will be taught online at UT at Tyler or for insertion as separate modules into undergraduate engineering, engineering technology, and industrial technology courses in face-to-face manner at Texas State.

## Project

In the next ten years, nanotechnology will emerge as the next industrial revolution. Therefore, the next generation of engineers and technologists must be prepared to address social, ethical, and environmental issues related to nanotechnology, particularly health and safety issues. The proposed effort will address this need by developing courses that consist of new teaching modules addressing critical issues related to nanotechnology. Students will learn nanotechnology safety issues, developing skill sets to assess and determine appropriate actions to maintain a safe working environment. To provide a holistic and engaging learning experience, students will take part in hands-on experimentation, tour and nanotechnology companies, lab training at the host institution, watch videos, write a group-based term paper based on case studies, engage in guided small-group learning, and listen to expert guest speakers. A Nanotechnology Advisory Council consisting of leading scientists and industry professionals in nanotechnology will assist in ensuring the quality and relevance of course content. The research team is highly interdisciplinary with extensive experience in nanotechnology, ethics, and nanotechnology safety, representing mechanical/manufacturing engineering, civil engineering, electrical engineering, industrial education and technology, physics, environmental biology, and philosophy.

## Goal

To educate engineering and technology undergraduate students in 'nanotechnology safety' that includes societal, ethical, environment, health, and safety issues.



## Objectives

❖Develop two modular undergraduate-level courses dealing with nanotechnology environment, health, and safety awareness. These courses will better prepare undergraduate students to advance to graduate nanotechnology programs and to work with nanomaterials in their future careers;

❖Build on pedagogical research by employing a variety of teaching methods to engage students, particularly women and Hispanic students, including hands-on training, socially-relevant case studies, plant tours, videos and guest lectures;

❖Elucidate emerging needs in nanotechnology environment, health, and safety, and incorporate them into basic education that can be immediately employed in industry;

❖ Promote interdisciplinary interactions among engineering, engineering technology, science, and industrial management/technology majors.

## Acknowledgment

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## Course 1: Introduction to Nanotechnology Safety / Course 2: Principles of Risk Management for Nanoscale Materials

| Module | Theme of the Module | | Theme of the Module |
|---|---|---|---|
| 1A | What is nanotechnology and nanoethics? | 1B | Overview of Occupational Health & Safety |
| 2A | Ethics of Science and Technology | 2B | Applications of Nanotechnology |
| 3A | Social Impacts | 3B | Assessing Nanotechnology Health Risks |
| 4A | Ethical Methods and Processes | 4B | Stustainable Nanotechnology Development |
| 5A | Nanomaterials and Manufacturing | 5B | Environmental Risks Assessment |
| 6A | Environmental Sustainability | 6B | Ethical and Legal Aspects of Nanotechnology |
| 7A | Nanotechnology in Health and Medicine | 7B | Developing a Risk Management Program |
| 8A | Military and National Security Implications | 8B | Presentations of Papers or Case Studies |
| 9A | Nanotechnology Issues in the distant Future | 9B | Hands-on Training on Using Safety Gear in Non-manufacturing |

## Incorporation of Nanotechnology Safety Courses in Curriculum or Modules into Existing Courses

| Location | Program | Course # and Title | Course/ Module |
|---|---|---|---|
| UT-Tyler | BS (Industrial Technology): Focus: Nano Management | TECH 4350: Introduction to Nananotechnology Safety (Online) | FULL COURSE |
| Texas State | BS (Industrial Technology): Focus: Nano Management | TECH 4330-Principles of Risk Management for Nanoscale Materials | FULL COURSE |
| Texas State | BS(MFGE), BS(IE), BS(EE), BS(ET), BS(IT), BS(CIM), BS(CSM) | PHIL. 1320: Society and Ethics | 1A-4A, 6A-8A |
| Texas State | BS(MFGE), BS(IE), BS (IT), BS(ET) | IE 4380: Industrial Safety | 1A, 3B, 4B, 6B, 7B |
| Texas State | BS(MFGE), BS(IE),BS(EE),BS(ET) | ENGR 2300: Materials Engineering | 1A, 3A |
| Texas State | BS(MFGE), BS(IE) | ENGR 2332: Materials Selection and Manufacturing Processes | 6A, 8A |
| Texas State | BS(MFGE), BS(EE), BS(ET) | MFGE/EE/TECH 4392: Microelectronics Manufacturing-I | 3B, 4B |
| Texas State | BS(MFGE), BS(EE), BS(ET) | MFGE/EE/TECH 4394: Microelectronics manufacturing-II | 5A, 9A |
| Texas State | BS(MFGE) | MFGE 4399: Polymer Nanocomposites | 2B, 4B, 5B, 9B, Guest |

## Multidisciplinary and Ethnically Diverse NSF-NUE Team of Investigators


- Dr. Jitendra S. Tate, Principal Investigator, Ingram School of Engineering, Texas State
- Dr. Dominick E. Fazarro, Department of Human Resource Development and Technology, University of Texas at Tyler
- Dr. Craig Hanks, Department of Philosophy, Texas State
- Mr. Satyajit Dutta, Ingram School of Engineering, Texas State
- Dr. Walt Trybula, Ingram School of Engineering, Texas State
- Dr. Robert McLean, Department of Biology, Texas State
- Dr. Fritz Allhoff, Department of Philosophy, Western Michigan University
- Graduate Researcher: Mr. Lucio Andres Alvarez Andrade, Texas State; Mr. Adam Mokhtari, UT Tyler
- Undergraduate Researcher: Mr. Sergio Espinoza, Ms. Luna Wilson, Texas State


## Nanotechnology Advisory Council (NAC)

This project is being advised by a forward-thinking team of experts from academia and industry. The NAC will assist in improving the quality of the contents in each course

- ❖ Ms. Christie Sayes, RTI International
- ❖ Dr. Greg Marshall, Chair, Department of Respirator Care, Texas State
- ❖ Ms. Deb Newberry, Director, NFS-Nanolink Center
- ❖ Ms. Barbara Foster, MIP (Microscopy and Imaging)
- ❖ Dr. Chuck Geraci, NIOSH
- ❖ Dr. Mark Wiesner, Director, CEINT (Center for Environmental Implications of Nanotechnology) at Duke University

## Government Agencies Involved in Nanotechnology

## Expected Impact on Undergraduate Minorities


❖ Total enrollment in Engineering and Engineering Technology programs at Texas State 1,100+ students, more than 35% are minorities (10% women, 23% Hispanic, and 5% African-American). The majority of students in these programs will be impacted, either by taking required courses that include new modules developed on this project or by taking the semester-long courses.

## What is Nanotechnology?

Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers (1 nm = $10^{-9}$ m)

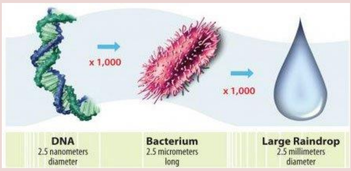


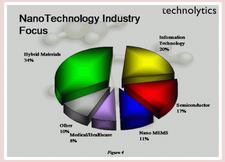


Image Courtesy: National Nanotechnology Initiative, www.nano.gov

## What is so special about the Nanoscale?

Materials can have different properties at the nanoscale. Some are better at conducting electricity or heat, some have different magnetic properties, some are stronger, some reflect light better, or change color as their size is changed. Nano molecules have far larger surface areas than similar volumes of large-scale materials. This means that nano molecules have a large interaction area for superior performance optimization in the materials around them.

## Nanotechnology Applications

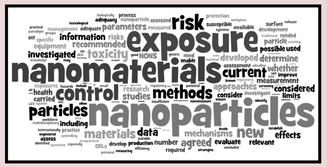
❖Future medical nanotechnology is expected to employ nanorobots injected into the patient to perform work at a cellular level. Nanorobotics in medicine include early diagnosis and targeted drug-delivery for cancer, pharmacokinetics monitoring of diabetes, and health care.

❖Nanoelectronics refer to the use of nanotechnology on electronic components. Applications include displays using carbon nanotubes (CNT), memory storage, nanoradios, and optoelectronic devices. Displays would reduce power consumption while decreasing the weight and thickness of the screens.

❖Green nanotechnology refers to the use of nanotechnology to enhance the environmental sustainability of processes producing negative externalities. Major applications include solar cells and water treatment.

❖A wide range of nanostructures have been proposed as delivery mechanisms for cosmetic ingredients in moisturizers, anti-ageing creams, and other skincare products.

## Nanotechnology Safety




❖ The physicochemical properties that make nanomaterials, industrial or engineered, attractive technologically also raise questions and concerns from industry, consumers and regulators regarding their toxicity and potential for exposure. Engineered particles such as carbon nanotubes require certain safety protocol while working with them. Medicine nanoparticles in the industry may pose threats to human heart and lung functions. Therefore it is required for engineers to develop and implement safe handling practices that are included in modules such as, nanoparticle transport, administrative controls, theories of accident causation, and use of ASTM/OSHA guidelines for working with nanomaterials.

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