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. Students will learn nanotechnology safety issues, develop skill sets to assess and determine appropriate actions to maintain a safe working environment. To provide a holistic and engaging learning experience, workshops 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 improving the quality of the contents in each course. 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.

Project
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Objective
- 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.
- Facilitate 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, technology, science, and industrial management/technology majors.

Acknowledgment
This NUE Project is funded by the National Science Foundation (NSF) award ECC-1242087. Investigators are grateful to NUE Program Manager Mary Poats. Investigators are also thankful to Dr. Stephen Sedman, Dean, College of Science and Engineering; Dr. Stan McElhinney, Director, and Dr. Harold Stern, former Director, Ingram School of Engineering; Ms. Sarah Rivas, Engineering Secretary and Mr. Brad Nichols, University Copyright Officer.

Incorporation of Nanotechnology Safety Courses in Curriculums or Modules into Existing Courses

<table>
<thead>
<tr>
<th>Location</th>
<th>Program</th>
<th>Course Code and Title</th>
<th>Course/Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX-State</td>
<td>BS (Industrial Technology): Focus Nano Management</td>
<td>TECH 4330: Introduction to Nanotechnology Safety (Online)</td>
<td>FULL COURSE</td>
</tr>
<tr>
<td>TX-State</td>
<td>BS (Industrial Technology): Focus Nano Management</td>
<td>TECH 4330: Principles of Risk Management for Nanomaterials in Manufacturing Processes</td>
<td>FULL COURSE</td>
</tr>
<tr>
<td>TX-State</td>
<td>BS(MGGE), BS(EE), BS(EET), BS(IT), BS(ET), BS(CIM), BS(CSM)</td>
<td>PHIL 1320: Society and Ethics</td>
<td>1B, 4A, 6A, 6B, 6C, 6D</td>
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<tr>
<td>TX-State</td>
<td>BS(MGGE), BS(EE), BS(EET), BS(IT), BS(ET)</td>
<td>ITE 4380: Industrial Safety</td>
<td>6A, 48, 4B, 8B, 7B</td>
</tr>
<tr>
<td>TX-State</td>
<td>BS(MGGE), BS(EET), BS(IT), BS(ET)</td>
<td>ENGR 2300: Materials Engineering</td>
<td>1A, 3A</td>
</tr>
<tr>
<td>TX-State</td>
<td>BS(MGGE), BS(EE)</td>
<td>ENGR 2332: Materials Selection and Manufacturing Processes</td>
<td>3A, 6A, 8A</td>
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<tr>
<td>TX-State</td>
<td>BS(MGGE), BS(EE), BS(EET)</td>
<td>MGEE/EE/TEC 4393: Microelectronics Manufacturing-1</td>
<td>3B, 48, 6A, 6B, 6C</td>
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<tr>
<td>TX-State</td>
<td>BS(MGGE), BS(EET), BS(ET)</td>
<td>MGEE/EE/TEC 4393: Microelectronics Manufacturing-2</td>
<td>3A, 3B, 4A, 6A, 6B</td>
</tr>
<tr>
<td>TX-State</td>
<td>BS(MGGE), BS(EE), BS(EET)</td>
<td>MGEE/EE/TEC 4399: Polymer Nanocomposites</td>
<td>2B, 4B, 58, 59, 96, 97</td>
</tr>
</tbody>
</table>

Course 1: Introduction to Nanotechnology Safety
Module | Theme of the Module |
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1A</td>
<td>What is nanotechnology and nanosciences?</td>
</tr>
<tr>
<td>2A</td>
<td>Ethics of Science and Technology</td>
</tr>
<tr>
<td>3A</td>
<td>Social Impacts</td>
</tr>
<tr>
<td>4A</td>
<td>Ethical Methods and Processes</td>
</tr>
<tr>
<td>5A</td>
<td>Nanomaterials and Manufacturing</td>
</tr>
<tr>
<td>6A</td>
<td>Environmental Sustainability</td>
</tr>
<tr>
<td>7A</td>
<td>Nanotechnology in Health and Medicine</td>
</tr>
<tr>
<td>8A</td>
<td>Military and National Security Implications</td>
</tr>
<tr>
<td>9A</td>
<td>Nanotechnology issues in the distant Future</td>
</tr>
</tbody>
</table>

Course 2: Principles of Risk Management for Nanomaterials
Module | Theme of the Module |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1B</td>
<td>Overview of Occupational Health &amp; Safety</td>
</tr>
<tr>
<td>2B</td>
<td>Applications of Nanotechnology</td>
</tr>
<tr>
<td>3B</td>
<td>Assessing Nanotechnology Health Risks</td>
</tr>
<tr>
<td>4B</td>
<td>Sustainable Nanotechnology Development</td>
</tr>
<tr>
<td>5B</td>
<td>Environmental Risks Assessment</td>
</tr>
<tr>
<td>6B</td>
<td>Ethical and Legal Aspects of Nanotechnology</td>
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</tbody>
</table>

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 University.

Multidisciplinary and Ethnically Diverse NSF-NUE Team of Investigators
- Dr. Jitendra S. Tate, Principal Investigator, Ingram School of Engineering, Texas State University
- Dr. Dominick E. Faraiaz, Department of Human Resource Development and Technology, University of Texas at Tyler
- Dr. Craig Hawks, Department of Philosophy, Texas State
- Mr. Satyajit Dutta, Ingram School of Engineering, Texas State University
- Dr. Walt Trybula, Ingram School of Engineering, Texas State University
- Dr. Robert Mclaren, Department of Human Resource Development and Technology, University of Texas at Tyler
- Dr. Fritz Albroff, Department of Philosophy, Western Michigan University
- Graduate Researcher: Mr. Lucio Andres Alvaraz Arevalo, Texas State; Ms. Adam Mokhtari, UT Tyler
- Undergraduate Researcher: Mr. Sergio Espinosa, Ms. Luna Wilson, Texas State University

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 Respiratory Care, Texas State
- Ms. Deb Newberry, Director, NSF-Nanolink Center
- Ms. Barbara Foster, MIP (Microscopy and Imaging)
- Dr. Chuck Geraci, NSOH
- Dr. Mark Wissner, Director, CEINT (Center for Environmental Implications of Nanotechnology) at Duke University

Expected Impact on Undergraduate Minoriites
- Total enrollment in Engineering and Engineering Technology programs at Texas State University is 1,100+ students, more than 35% minorities, including 15% Hispanic, 10% African-American, and 5% African-American.
- The majority of these students in programs will be impacted, either by taking required courses that include new modules developed on this project or by taking the semester-long courses.

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 injury 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.