Disclaimer:

The material herein is developed under NSF-NUE (Nanotechnology Undergraduate Education) award #1242087, NUE: NanoTRA- Texas Regional Alliance to foster 'Nanotechnology Environment, Health, and Safety Awareness' in tomorrow's Engineering and Technology Leaders. http://nsf.gov/awardsearch/showAward?AWD_ID=1242087

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Fostering Ethical, Social, Environmental, Health, and Safety Awareness in Tomorrow's Engineers and Technologists

A Project of the University of Texas-Tyler and Texas State University

Presentation developed and presented by Dr. Craig Hanks, Texas State University
Co-Authors: Jitendra Tate, TX State; Walter Trybula, Trybula Foundation & TX State; Dominick Fazarro, University of Texas at Tyler; Robert McLean, TX State; Satyajit Dutta, TX State; Fritz Allhoff. Western Michigan University; Seth Barton, TX State; Zach Russell, TX State
The National Nanotechnology Initiative

• Unveiled by president Clinton in 2000, increased nanotechnology funding from $270M in 2000 to $495M in 2001.

• In 2013, $1.8B was allocated for the NNI, with a cumulative total of $18B since 2001.
Nanotechnology Funding

Federal Funding in Billions of Dollars

NanoTRA - Texas Regional Alliance to Foster Nanotechnology Environment, Health, and Safety

http://nsf-nue-nanotra.engineering.txstate.edu/

Nanotechnology will impact (is impacting!)... and many other areas !!!!
By the year 2020 there will be a need for an estimated 6 million workers worldwide in the fields of nanoscience and nanotechnology. 2 million of those jobs are expected to be in the U.S.

National Agenda: US Congressional Testimony on Societal Implications Nanotechnology

• CLICK ON LINKS TO READ TESTIMONY (2003)

From the beginning, the NNI has included an emphasis on ethical and social implications.
OUR GOALS

• **Goal:** The goal for this project is to help prepare students to be responsible developers, users, marketers, critics, workers, administrators, and leaders in nanotechnology.

• **More Generally:** We hope to help students be better citizens in an advanced technological society.

• **Professionally:** Our project will help meet standards for engineering education (ABET), and will help students be ready to address problems and questions in the workplace.

• **Our Plan:** Develop modular courses (more later!)

• **Diversity:** Design and implement course modules to better support members of under-represented groups.
Pedagogical Considerations: Diversity

• Goal of furthering success of traditionally underrepresented groups. (Texas – “Closing the Gaps” initiative)

• Important contributors to such success include:
  – Flexibility in presentation and framing of course material,
  – Interactive classes with hands-on or applied projects,
  – Mentoring and Diverse exemplars.
Pedagogical Considerations: Millennial Generation

- Suspicious of institutions and traditions
- Fewer resources (intellectual, psychological, ethical, social) for resisting pressures to act unethically or to identify and resolve ethical conflicts.
- Respond best to explicit support and greater level of interactions with instructors and material.
Pedagogical Considerations: Resistance to Conceptual Change

• Many studies demonstrate that students’ existing conceptions are very resistant to change.

• This is even true in instances when the students score very highly on formal and technical assessments of content knowledge.
Pedagogical Considerations: Nurturing Student Engagement

• Integrating a new idea into one’s existing conceptual scheme is highly dependent on the social context in which the examination of the ideas takes place.

• Student engagement, interaction, and enthusiasm, as well as perceived instructor enthusiasm and expertise, are important markers of a productive context.
ABET PROGRAM OUTCOMES

Relationship to ABET Program Outcomes:

• (c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical constraints as well as considerations of public health and safety, manufacturability, and sustainability.

• (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 for the need for and an ability to engage in lifelong learning.

• (j) A knowledge of contemporary issues.
NUE: NanoTRA- Texas Regional Alliance to foster 'Nanotechnology Environment, Health, and Safety Awareness' in tomorrow’s Engineering and Technology Leaders.

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- **Senior Personnel:** Dr. Fritz Allhoff (Philosophy, Western Michigan)

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  - Ms. Luna Wilson
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**External Reviewer:**
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  (Sam Houston State Univ.)

**Nanotech Advisory Council**

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**NSF-NUE**

Nanotechnology Undergraduate Education
Science, Technology, and Change

• Eric Drexler: author of:

  • *Radical Abundance: How a Revolution in Nanotechnology Will Change Civilization*
  • *Engines of Creation: The Coming Era of Nanotechnology*
  • *Nanosystems: Molecular Machinery, Manufacturing, and Computation*

  — A founder of nanotechnology, a concept he introduced in a foundational 1981 paper in the *Proceedings of the National Academy of Sciences*
NanoTRA - Texas Regional Alliance to Foster Nanotechnology Environment, Health, and Safety
Science, Technology, and Change

- Technological change tends not toward equilibrium, but toward further change.
- Innovation spreads quickly because of a) communications technologies, and b) competition.

Hans Jonas

- Technological Means create new ends, new tools open new possibilities for action and new possible goals.
- Progress - “the juggernaut moves on relentlessly, spawning its always mutated progeny by coping with the challenges and lures of the now”
Science, Technology, and Change

• Our current era is different from earlier eras of human existence with respect to what we know, what we can do, and what we know about uncertainty.
• This means ever new products and techniques, changing individual lives, communities, nations, the international community, and nature itself.
• This also means that change comes to be accepted as the natural state of human existence, as a taken-for-granted background condition.
• Restlessness is thus one of the characteristics of contemporary technological society and of our individual lives and expectations. We now expect change and we wonder what will change next, and in what ways, and this brings hopes and joy as well as fears and threats.
CHALLENGES!

• All new technologies present novel ethical and technical issues that must be explored.

• This issue can be exacerbated by not always knowing the implications, uses, impacts, costs, and benefits, and so on, of new technologies.

• Nanotechnology, like all emergent technology, exists beyond current understandings and consensus.
The ethical cycle

- This framework for addressing ethical issues is modeled on the design process, and can be taught with an emphasis on that parallel.
- This framework also provides a clear process without ignoring the complexity of value conflicts and responsible action.

Emerging Technologies Present Special Challenges for Engineering Education
<table>
<thead>
<tr>
<th>Module</th>
<th>Topics and Subtopics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A [2 Sessions]</td>
<td>What is nanotechnology and nanoethics? And, Societal dimensions of nanotechnology</td>
</tr>
<tr>
<td>2A [2 sessions]</td>
<td>Ethics of Science and Technology; Science and technology as agents of social change; Moral agents: Developing Ethical Frameworks</td>
</tr>
<tr>
<td>3A [2 sessions]</td>
<td>Societal Impacts; Defining ethical and societal implications; Precautionary principle in nanotechnology; Developing Ethical Frameworks; Engineering as Social Experiment Impact of nanotechnology on developing countries</td>
</tr>
<tr>
<td>4A [2 sessions]</td>
<td>Ethical Methods and Processes; Human subject research; Global Dimensions, Ethical framework for technology assessment; Risk and Uncertainty; Model for ethical analysis</td>
</tr>
<tr>
<td>5A [2 sessions]</td>
<td>Nanomaterials and Manufacturing; Processes used (e.g. etching &amp; laser ablation); Framing ethical questions: principles of respect for communities, common good, and social justice; Assessing options for action</td>
</tr>
<tr>
<td>6A [2 sessions]</td>
<td>Environmental Sustainability; Environmentalism and sustainability; Environment risks and nanotechnology; Potential benefits of nanotechnology for sustainable development; Framing ethical questions; Assessing options for action</td>
</tr>
<tr>
<td>7A [2 sessions]</td>
<td>Nanotechnology in Health and Medicine; What are the issues? Context described: pharmaceuticals and therapeutics; diagnostics and imaging; nanoscale surgery; implants and tissue engineering; multifunctional nanodevices and nanomaterials; personalized medicine; broader health care system – Framing ethical questions – Assessing options for action</td>
</tr>
<tr>
<td>8A [2 sessions]</td>
<td>Military and National Security Implications; Nanotechnology and art of war; Nanotechnology and national security; Framing ethical questions; Assessing options for action</td>
</tr>
<tr>
<td>9A [2 sessions]</td>
<td>Nanotechnology Issues in the Distant Future; Challenges and pitfalls of exponential manufacturing; Nanotechnology and life extension; Who will control this technology? Global implications</td>
</tr>
</tbody>
</table>
## Topics Outline: Advanced Course

<table>
<thead>
<tr>
<th>MODULE</th>
<th>TITLE</th>
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<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</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>
</tr>
<tr>
<td>7B</td>
<td>Developing a Risk Management Program</td>
</tr>
<tr>
<td>8B</td>
<td>Presentations of Case Studies or Research Project</td>
</tr>
<tr>
<td>9B</td>
<td>Hands On Composites and Plastics Lab, Texas State</td>
</tr>
<tr>
<td>10B</td>
<td>Plant Local Nanotechnology Industry:</td>
</tr>
</tbody>
</table>

Possible Guests: Academic/Scholar, Industry Representative, Safety Officer
<table>
<thead>
<tr>
<th>Location</th>
<th>Course # and Title</th>
<th>Instructor</th>
<th>Course/module</th>
</tr>
</thead>
<tbody>
<tr>
<td>UT at Tyler</td>
<td>TECH 2303/4350: Introduction to Nanotechnology Safety</td>
<td>[Fazarro]</td>
<td>Full course/On-Line</td>
</tr>
<tr>
<td>Texas State</td>
<td>US 1100: Seminar</td>
<td>[Ms. Romanella]</td>
<td>2A</td>
</tr>
<tr>
<td></td>
<td>Fall 2013, Fall 2014</td>
<td></td>
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</tr>
<tr>
<td>Texas State</td>
<td>PHIL 1320: Society and Ethics</td>
<td>[Hanks]</td>
<td>1A, 2A, 3A, 4A, 6A, 7A, 8A</td>
</tr>
<tr>
<td></td>
<td>Fall 2013, Spring 2014, Fall 2014</td>
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<tr>
<td>Texas State</td>
<td>TECH 4380: Industrial Safety</td>
<td>[Dr. Juan Gomez]</td>
<td>1A, 3B, 4B, 6B, 7B</td>
</tr>
<tr>
<td></td>
<td>Fall 2013, Fall 2014</td>
<td></td>
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<tr>
<td>Texas State</td>
<td>ENGR/EE 2300: Materials Engineering</td>
<td>[Drs. Londa and Lawrence]</td>
<td>1A, 3A</td>
</tr>
<tr>
<td></td>
<td>Fall 2013, Spring 2014, Fall 2014</td>
<td></td>
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</tr>
<tr>
<td>Texas State</td>
<td>MFGE 2332: Material Selection and Mfg Processes;</td>
<td>[Dr. You]</td>
<td>6A, 8A</td>
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<tr>
<td></td>
<td>Fall 2013</td>
<td></td>
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<tr>
<td>Texas State</td>
<td>IE 3330: Quality Engineering</td>
<td>[Dr. Walters]</td>
<td>7B</td>
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<tr>
<td></td>
<td>Spring 2014</td>
<td></td>
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<tr>
<td>Texas State</td>
<td>EE 2400Circuits and Devices</td>
<td>[Dr. Casey]</td>
<td>1A, 2B</td>
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<tr>
<td></td>
<td>Spring 2014</td>
<td></td>
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<tr>
<td>Texas State</td>
<td>MFGE/EE/TECH 4392: Microelectronics Manufacturing</td>
<td>[Dutta &amp; Other]</td>
<td>9A, 3B, 4B</td>
</tr>
<tr>
<td></td>
<td>Spring 2014</td>
<td></td>
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<tr>
<td>Texas State</td>
<td>IE 4380: Industrial Safety</td>
<td>[Dutta]</td>
<td>1A, 3B, 4B, 6B, 7B</td>
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<tr>
<td></td>
<td>Fall 2013, Fall 2014</td>
<td></td>
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<tr>
<td>Texas State</td>
<td>MFGE 4367: Polymer Prop. and Proc.</td>
<td>[Tate]</td>
<td>7A, 8A, Guest</td>
</tr>
<tr>
<td></td>
<td>Spring 2014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texas State</td>
<td>MFGE 4399: Polymer Nanocomposites</td>
<td>[Tate]</td>
<td>2B, 4B, 5B, 9B, Guest</td>
</tr>
<tr>
<td></td>
<td>Fall 2014</td>
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</tbody>
</table>
## Assessment

<table>
<thead>
<tr>
<th>Planned Activities</th>
<th>Personnel</th>
<th>Dates</th>
<th>Objectives</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAC first meeting</td>
<td>All investigators and NAC</td>
<td>12/12</td>
<td>Provide input for course content</td>
<td>Improvement in quality of course content</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/13</td>
<td></td>
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</tr>
<tr>
<td>Teach first course and modules</td>
<td>Tate, Fazarro, Hanks and other faculty</td>
<td>Fall 13</td>
<td>Teach introductory course and modules</td>
<td>Student education in nanotechnology society and ethics</td>
</tr>
<tr>
<td>External evaluator assesses course outcomes</td>
<td>Caso</td>
<td>12/13</td>
<td>Determine effectiveness of the course offerings</td>
<td>Recommendations for improvement</td>
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<tr>
<td>Teach advanced course and modules</td>
<td>Tate, Fazarro, Hanks and other faculty</td>
<td>Spring 14</td>
<td>Teach advanced course and the modules</td>
<td>Student education in nanotechnology environment, health, and safety</td>
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<tr>
<td>External evaluator assesses course outcomes</td>
<td>Caso</td>
<td>5/14</td>
<td>Determine effectiveness of the course offerings</td>
<td>Recommendations for improvement</td>
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</tr>
<tr>
<td>NAC second meeting</td>
<td>All investigators and NAC</td>
<td>9/14</td>
<td>Discuss recommendations of external evaluator</td>
<td>Refining of course content and future strategy</td>
</tr>
</tbody>
</table>
Initial Evaluations: Focus Groups and Module Evaluations

• Two modes of gathering information from students:
  – Regular surveys for feedback throughout the courses
    • This allows during semester revisions
    • Provides immediate student responses – in context
  – End of course focus groups
    • Allows more extended and reflective responses – after-the-fact
    • Helps uncover the different ways students experience the course material and the conceptual challenges
Initial Evaluations:
Focus Groups and Module Evaluations

• Summer 2013 – On-line evaluations at UT-Tyler:
  – 87-93% of respondents rating the course Good or Excellent on a 5-point scale.
  – There were no ratings of Fair or Poor.
Initial Evaluations: Focus Groups and Module Evaluations

• November 2013 – Focus Groups at Texas State
  – 6 groups
  – Expert External Consultant conducted the group evaluations
Initial Evaluations:
Focus Groups and Module Evaluations

November 2014 – Focus Groups at Texas State & UT-Tyler

– 4 groups
– Expert External Consultant conducted the group evaluations
Initial Evaluations:
Focus Groups and Module Evaluations

• The overall impression related by the focus group findings was that student acceptance and learning of instruction through infused NanoTRA modules can be improved through a combination of:
Initial Evaluations:
Focus Groups and Module Evaluations

– small to moderate revisions to instructional information and activity content;
– Stronger and fewer power point slides;
– Consistent presenter delivery; and
– perhaps most importantly, for courses not led by project personnel - better preparation of and communication with host-course faculty to more effectively introduce and frame the modules infused in each course.
Initial Evaluations:
Focus Groups and Module Evaluations

• (all modules) further reworking of the presentations to
  – better incorporate student participation in the lecture and discussion
    (for on-line this allows and encourages time for reflection during
    viewing of the presentation); and
  – remove video and other links that students found uninteresting
    because following these links can lead students to disengage;

• (B-Modules) more explicit explanation of the ethical issues
  present in the technical material; and

• additional editing of B-Modules to bring them to the level of
  polish of the A-modules.
What Is The Next Step?

• Additional Students – STEM LC – Fall 2014

• Further revision of modules.

• Develop new exercises, modules, and scripts for infusion into technical courses.

• Develop support materials for faculty.

• Greater involvement of faculty who are not project personnel.
  – Draw on expertise, experience, and diversity.
  – Greater buy-in and readiness to address these issues.
• Speaking without personification, we who have a powerful and perfected instrument in our hands [science and technology], one which is determining the quality of social changes, must ask what changes we want to see achieved and what we want to see averted. . . . Till now we have employed science absentmindedly as far as its effects upon human beings are concerned. The present situation with its extraordinary control of natural energies and its totally unplanned and haphazard social economy is a dire demonstration of the folly of continuing this course.

REFERENCES


REFERENCES Continued


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