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

This material is developed pursuant to a National Science Foundation grant and is to be used strictly for educational purposes. Developers of the material have used a number of images to enhance understating of various concepts and they are acknowledged accordingly. Any comments or concerns over the use of these images should be directed to Dr. Jitendra S Tate JT31@txstate.edu

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

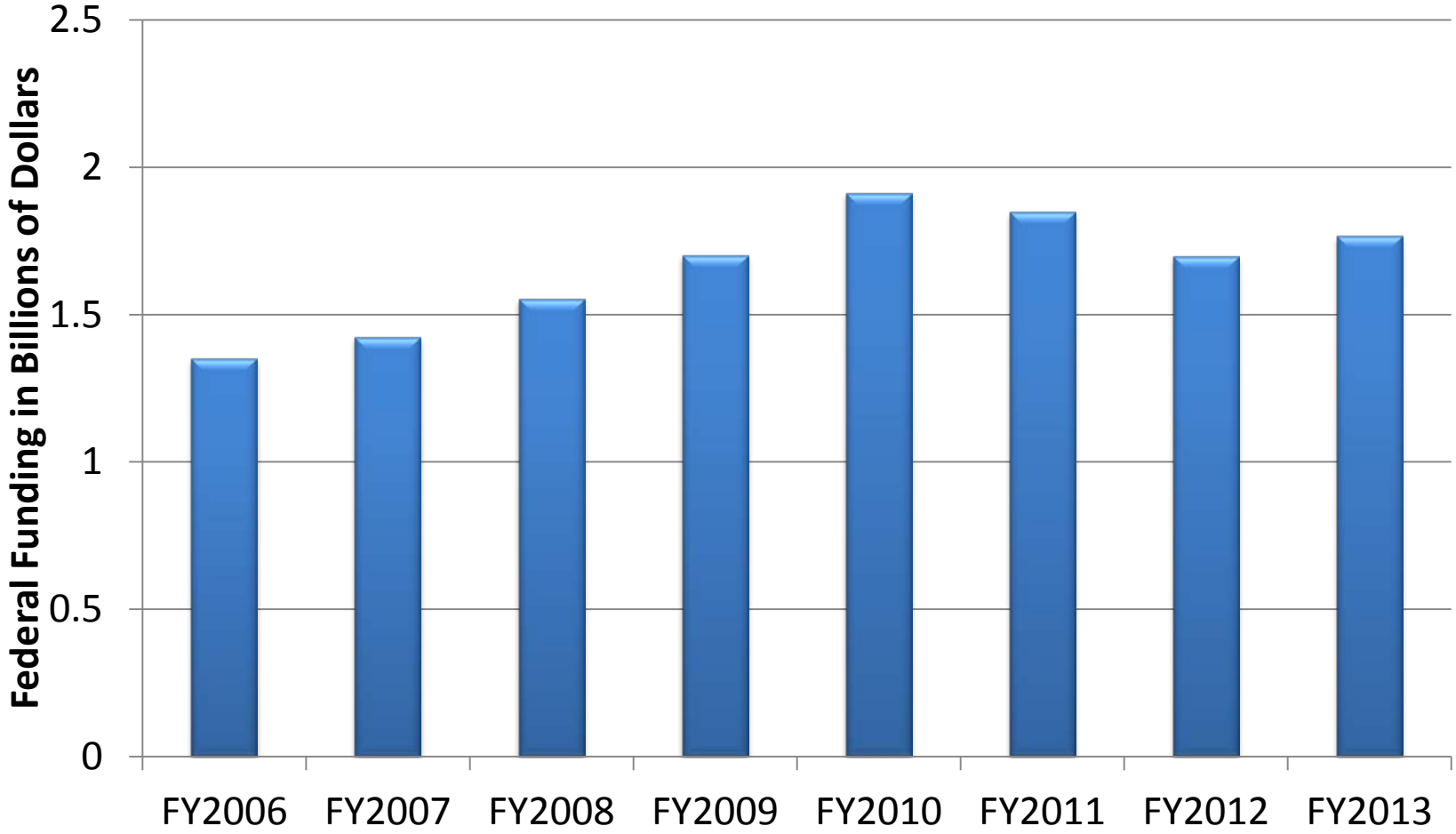
Presentation developed and presented by Dr. Craig Hanks, Texas State University

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



http://4.bp.blogspot.com/-KOoHpXmRVrE/UKPoAsWSaBI/AAAAAAAAIc/eyGhLbd7XKY/s640/050812-F-2295B-947.jpg

http://2.bp.blogspot.com/_AbNytNzp2SY/TAKj5tUP7oI/AAAAAAAACfI/KvYCgUHWsNE/s400/Elbphilharmonie2.jpg

http://static5.depositphotos.com/1003595/455/i/450/dep_4556250-Green-energy-label.jpg

NANOTECHNOLOLGY WILL IMPACT (is impacting!)

http://trinitymtjoy.org/welcome/2012/10/clothing-give-away-coming-in-january-2/

http://iigcapital.com/may_2012.jpg

http://www.bestpharmguide.com/magazine/wp-content/uploads/2011/04/online-pharmacy-drugs.png

...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.

Roco, M. C. (2011). Journal of nanoparticle research, 13, 427-445.

National Agenda: US Congressional Testimony on Societal Implications Nanotechnology

- CLICK ON LINKS TO READ TESTIMONY (2003)
  - http://www.gpo.gov/fdsys/pkg/CHRG-108hhrg86340/html/CHRG-108hhrg86340.htm
  - http://www.kurzweilai.net/testimony-of-ray-kurzweil-on-the-societal-implications-of-nanotechnology

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.

NSF Program Manager: Ms. Mary Poats

Investigators:

- **PI:** Dr. Jitendra Tate (Engineering, Texas State)
- **Co-PI:** Dr. Dominick Fazarro (Technology & Management, UT-Tyler)
- **Co-PI:** Dr. Craig Hanks (Philosophy, Texas State)
- **Co-PI:** Mr. Satyajit Dutta (Engineering, Texas State)
- **Senior Personnel:** Dr. Walt Trybula (Engineering, Texas State)
- **Senior Personnel:** Dr. Robert McLean (Biology, Texas State)
- **Senior Personnel:** Dr. Fritz Allhoff (Philosophy, Western Michigan)

Students:

- Graduate:
  - Mr. Andres Alvarez
  - Mr. Seth Barton
  - Mr. Zach Russell
  - Ms. Shadi Maleki
- Undergraduate:
  - Mr. Sergio Espinoza
  - Ms. Luna Wilson
  - Mr. Adam Mokhtari

External Reviewer:

- Dr. Rita Caso (Sam Houston State Univ.)

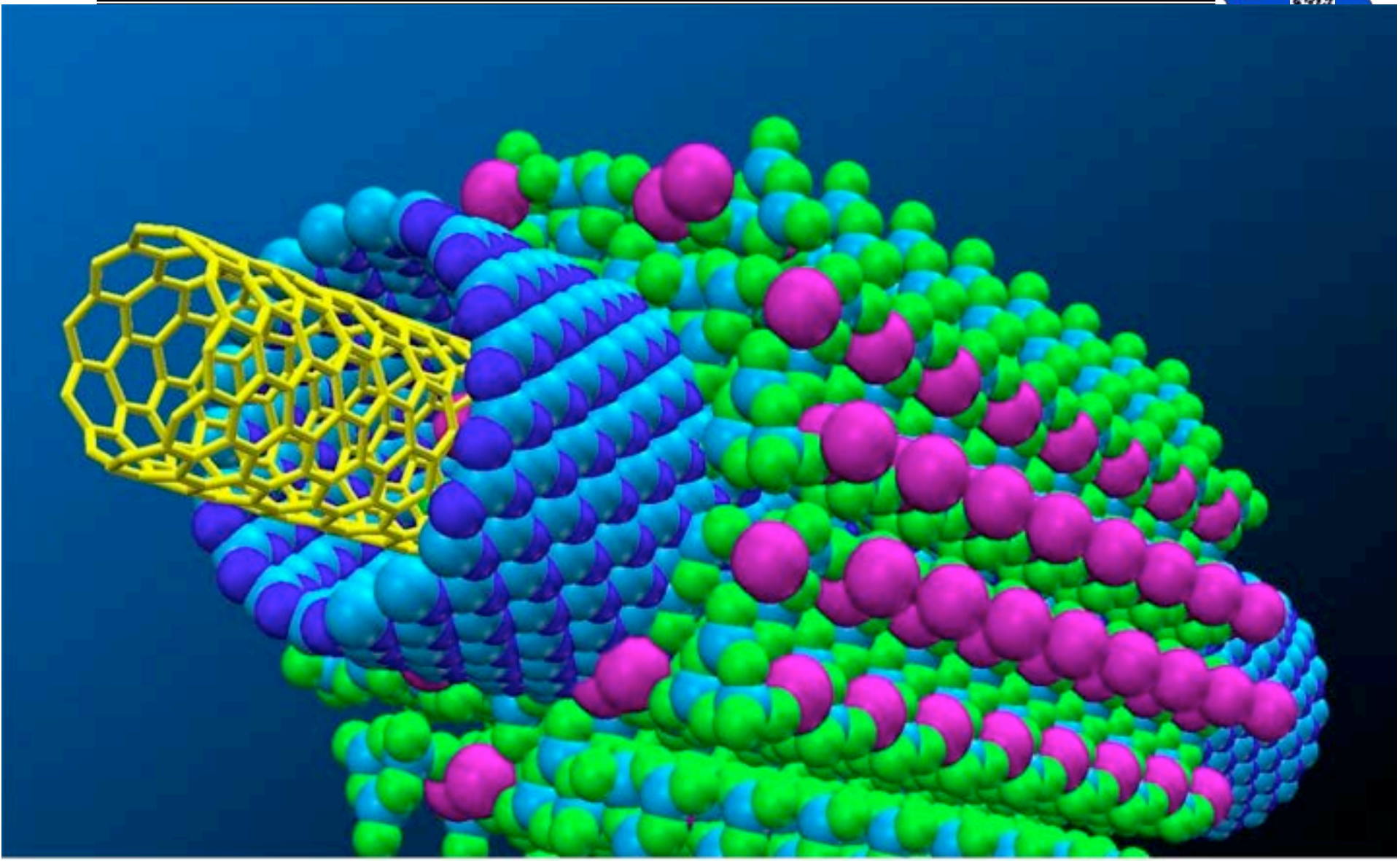
Nanotech Advisory Council

Science, Technology, and Change

- Eric Drexler: author of:

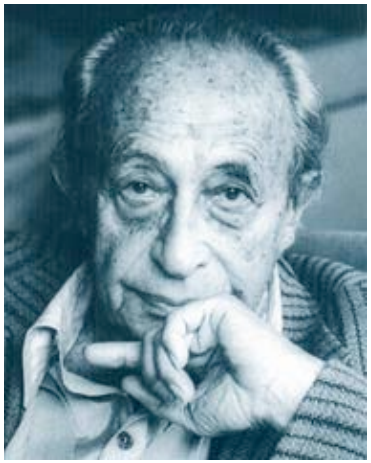
  - ***Radical Abundance: How a Revolution in Nanotechnology Will Change Civilization***
  - ***Engines of Creation: The Coming Era of Nanotechnology***
  - ***Nanosystems: Molecular Machinery, Manufacturing, and Computation***

  – A founder of nanotechnology, a concept he introduced in a foundational 1981 paper in the *Proceedings of the National Academy of Sciences*

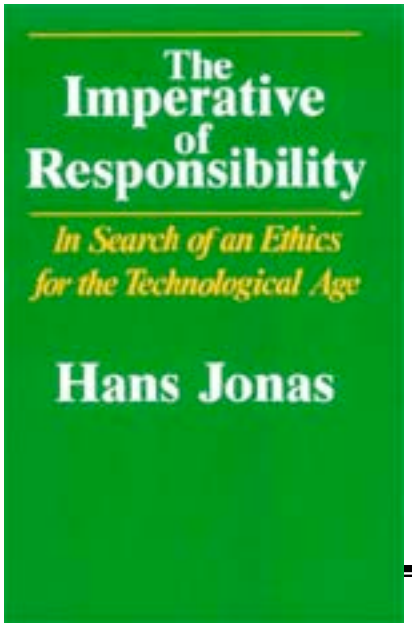


Science, Technology, and Change

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

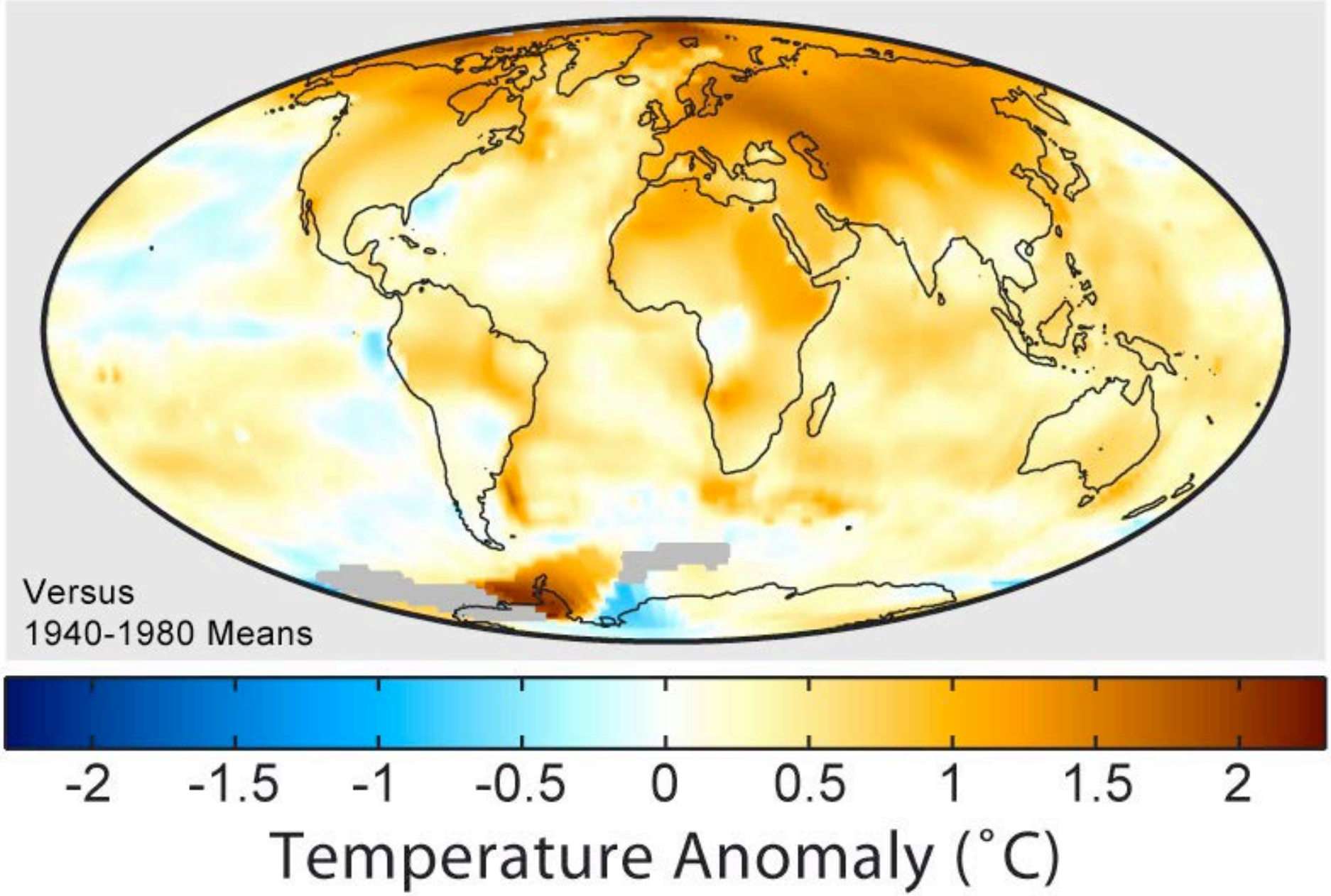


Hans Jonas



- 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"

1999-2008 Mean Temperatures



Science, Technology, and Change

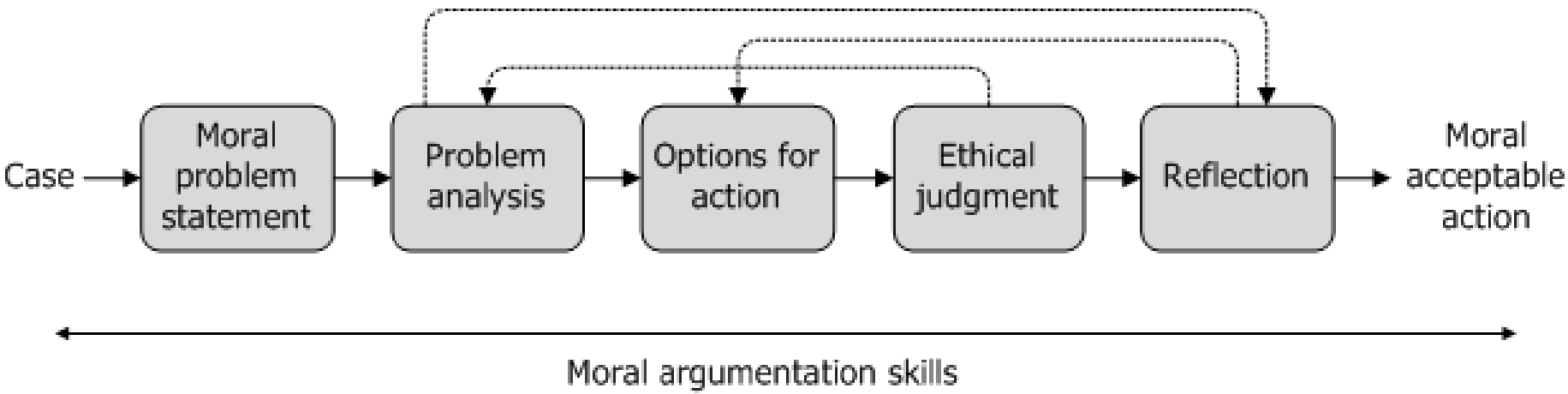
- Our current era is different from earlier eras of human existence with respect to what we know, what we can do, and what we know about uncertainty.
- This means ever new products and techniques, changing individual lives, communities, nations, the international community, and nature itself.
- This 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 mustt 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



Source: The ethical cycle by Lamber Royakkers, Ibo van de Poel and Angele Pieters. Eindhoven: LIvET (2009)

- 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

Module [# sessions]	Topics and Subtopics
1A [2 Sessions]	What is nanotechnology and nanoethics? And, Societal dimensions of nanotechnology
2A [2 sessions]	Ethics of Science and Technology; Science and technology as agents of social change; Moral agents: Developing Ethical Frameworks
3A [2 sessions]	Societal Impacts; Defining ethical and societal implications; Precautionary principle in nanotechnology; Developing Ethical Frameworks; Engineering as Social Experiment Impact of nanotechnology on developing countries
4A [2 sessions]	Ethical Methods and Processes; Human subject research; Global Dimensions, Ethical framework for technology assessment; Risk and Uncertainty; Model for ethical analysis
5A [2 sessions]	Nanomaterials and Manufacturing; Processes used (e.g. etching & laser ablation); Framing ethical questions: principles of respect for communities, common good, and social justice; Assessing options for action
6A [2 sessions]	Environmental Sustainability; Environmentalism and sustainability; Environment risks and nanotechnology; Potential benefits of nanotechnology for sustainable development; Framing ethical questions; Assessing options for action
7A [2 sessions]	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
8A [2 sessions]	Military and National Security Implications; Nanotechnology and art of war; Nanotechnology and national security; Framing ethical questions; Assessing options for action
9A [2 sessions]	Nanotechnology Issues in the Distant Future; Challenges and pitfalls of exponential manufacturing; Nanotechnology and life extension; Who will control this technology? Global implications

Topics Outline: Advanced Course

MODULE	TITLE
1B	Overview of Occupational Health & Safety
2B	Applications of Nanotechnology
3B	Assessing Nanotechnology Health
4B	Sustainable Nanotechnology Development
5B	Environmental Risks Assessment
6B	Ethical and Legal Aspects of Nanotechnology
7B	Developing a Risk Management Program
8B	Presentations of Case Studies or Research Project Possible Guests: Academic/Scholar, Industry Representative, Safety Officer
9B Hands On	Composites and Plastics Lab, Texas State
10B Plant	Local Nanotechnology Industry:

Location	Course # and Title [Instructor]	Course/ module
UT at Tyler	TECH 2303/4350: Introduction to Nanotechnology Safety **[Fazarro]**	Full course/On-Line
UT at Tyler	TECH 3303: Principles of Risk Management for Nanoscale Materials **[Fazarro]**	Full course/On-Line
Texas State	US 1100: Seminar **[Ms. Romanella]** **Fall 2013, Fall 2014**	2A
Texas State	PHIL 1320: Society and Ethics **[Hanks] Fall 2013, Spring 2014, Fall 2014**	1A, 2A, 3A, 4A, 6A, 7A, 8A
Texas State	TECH 4380: Industrial Safety **[Dr. Juan Gomez] Fall 2013, Fall 2014**	**1A, 3B, 4B, 6B, 7B**
Texas State	ENGR/EE 2300: Materials Engineering **[Drs. Londa and Lawrence] Fall 2013, Spring 2014, Fall 2014**	1A, 3A
Texas State	MFGE 2332: Material Selection and Mfg Processes; **[Dr. You] Fall 2013**	6A, 8A
Texas State	IE 3330: Quality Engineering **[Dr. Walters] Spring 14**	7B
Texas State	EE 2400Circuits and Devices **[Dr. Casey] Spring 14**	1A, 2B
Texas State	MFGE/EE/TECH 4392: Microelectronics Manufacturing **[Dutta & Other] Spring 14**	9A, 3B, 4B
Texas State	IE 4380: Industrial Safety **[Dutta] Fall 2013, Fall 2014**	**1A, 3B, 4B, 6B, 7B**
Texas State	MFGE 4367: Polymer Prop. and Proc. **[Tate] Spring 2014**	7A, 8A, Guest
Texas State	MFGE 4399: Polymer Nanocomposites **[Tate] Fall 2014**	2B, 4B, 5B, 9B, Guest

Assessment

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

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.

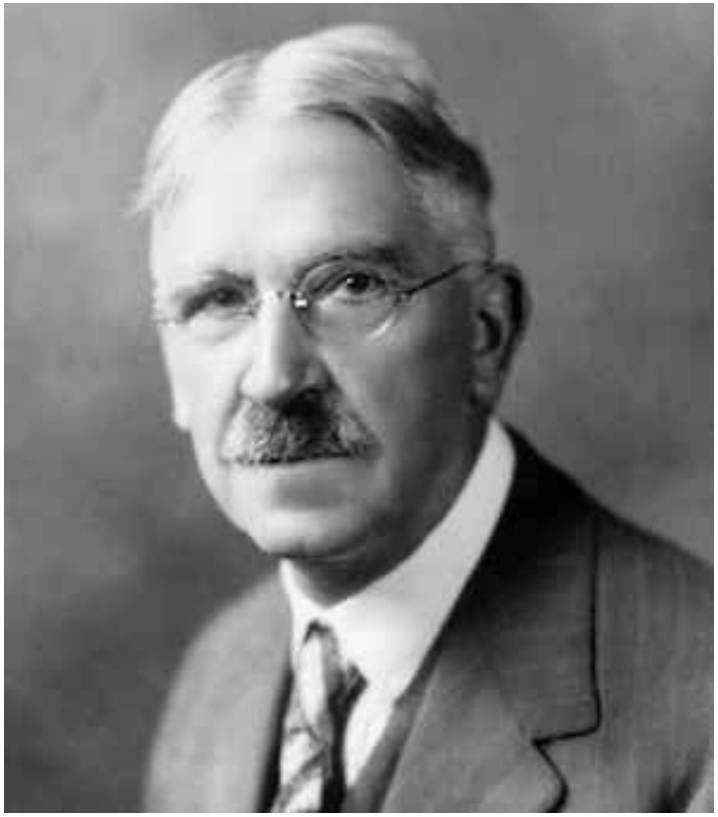
Initial Evaluations: Focus Groups and Module Evaluations

- (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.
- John Dewey, "Science and Society," in *Technology as a Human Affair*, ed. Larry Hickman (New York: McGraw-Hill, 1990). For the complete text in the critical edition see *John Dewey: The Later Works, 1925-1953*, vol. 6: 1931-1932, ed. Jo Ann Boydston (Carbondale: Southern Illinois University Press, 1985).



REFERENCES

- Allhoff, F., Lin, P., Moor, J., Weckert, J., and Roco, M.C. (2007) *Nanoethics: The ethical and social implications of nanotechnology*. Hoboken, NJ: Wiley-Interscience., 2007
- D.E. Fazarro, & W. Trybula. Nanotechnology Safety Training: Addressing the Missing Piece. Journal of Technology Studies, *38*(1), 43-52, 2012.
- Pew Research Center. Millennials: A Portrait of Generation Next. Retrieved from: http://pewsocialtrends.org/files/2010/10/millennials-confident-connected-open-to-change.pdf .
- Bird, S. (2004). Integrating Ethics Education at All Levels: Ethics as a Core Competency. In *Emerging Technologies and Ethical Issues in Engineering: Papers from a Workshop, October 14-15, 2003.* Washington, D.C.: National Academies Press.
- Khushf, G. (2004a). The Ethics of Nanotechnology: Vision and Values for a New Generation of Science and Engineering. In *Emerging Technologies and Ethical Issues in Engineering: Papers from a Workshop, October 14-15, 2003.* Washington, D.C.: National Academies Press.

REFERENCES Continued

- Kabani, C. (2013). Study reveals surprising facts about millenials in the workplace. *Entrepreneurs*. Retrieved from http://www.forbes.com/sites/shamakabani/2013/12/05/study-reveals-surprising-facts-about-millennials-in-the-workplace/#
- Twenge, J.M. (2009). Generational changes and their impact in the classroom: teaching generation me. *Medical Education*, 43(5): 398-405.
- Howe, N. & Strauss, W. (2000) *Millennials Rising: The Next Great Generation.* Toronto: Random House, Inc.
- Tobias, S. (1990). *They're Not Dumb, They're Different – Stalking the Second Tier*. Tuscon, AZ: Research Corporation.
- Camacho, M.M. and Lord, S.M. (2011). Quebrando Fronteras: Trends Among Latino and Latina Undergraduate Engineers, *Journal of Hispanic Higher Education*, 10(2) 134–146, 2011.
- Young, M. (1989). *The technical writer's handbook*. Mill Valley, CA: University Science.

REFERENCES Continued

- Ramsey, R.P., Marshall, G.P., Joshnston, M.W. and & Deeter-Schmelz, D.R.(2007) Ethical ideologies and older consumer perceptions of unethical sales tactics. *Journal of Business Ethics*, *70*(2): 191–207.
- J-F Lyotard. (1984). *The Postmodern Condition: A Report on Knowledge.* Minneapolis, MN: University of Minnesota Press.
- Gross, E. (2011). Clashing values: contemporary views about cheating and plagiarism compared to traditional beliefs and practices. *Education*. 132(2): 435-440.
- R. VanMeter, R., Grisaffe, D., Chonko, L., and Roberts, J. (2013). Generation Y's ethical ideology and its potential workplace implications. *Journal Of Business Ethics*, 117(1): 93-109.
- Howe, H. and Strauss, W. (2003). *Millennials go to college*. Washington, DC: American Association of Collegiate Registrars and Admissions Officers.
- World of Work Survey. (2008) *The Randstad USA World of Work*. Retrieved from: http://us.randstad.com/content/aboutrandstad/knowledge-center/employer-resources/World-of-Work-2008.pdf.

REFERENCES Continued

- Jonas, H., (1979) "Toward a Philosophy of Technology," *Hastings Center Repor*t, (February, 1979), 34-43.
- Jonas, H. (1984) *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*. Chicago: The University of Chicago Press.
- Verschoor, C. (2013) Ethical behavior differs among generations. *Strategic Financ*e, 95(8), 11-14.
- Ethics Resource Center, *National Government Ethics Survey 2007*. Retrieved from: http://www.ethics.org/files/u5/The_National_Government_Ethics_Survey.pdf
- H. Hull. (2011) Legal ethics for the millennials: avoiding the compromise of integrity. *UMKC Law Review*, 80(2), 271-286.
- Drexler, K. E., (2013). *Radical Abundance: How a Revolution in Nanotechnology will Change Civilization*, New York: Public Affairs.
- Fazarro, D.E. and & Trybula, W. (2011). Empowering academia to look into the future: *Nanotechnology safety education-creating the workforce that you will need.* Paper session presented at the meeting of IEEE NANO 2011 Conference, Portland, Oregon.

REFERENCES Continued

- Baker, M. (2010). Quantum dots, nanodiamonds and other nanomaterials broaden researchers' tools for watching biology. *Nature Methods*, 7 , 957-962.
- Bennett-Woods, D. (2008). *Nanotechnology: Ethics and Society*. London: Taylor & Francis Group.
- Dvir, T., Timko, B. P., Kohane, D. S., & Langer, R. (2010). Nanotechnological strategies for engineering complex tissues. Nature Nanotechnology .
- EDinformatics. (2005). Nanomedicine. Retrieved June 21, 2013, from EDinformatics: http://www.edinformatics.com/nanotechnology/nanomedicine.htm
- Gordon, N., & Sagman, U. (2003, February). Nanomedicine Taxonomy. Retrieved June 21, 2013, from Nanomedicina: http://www.pain.cz/nanomedicina/files/taxanomy.pdf
- Lewinski, N., Calvin, V., & Drezek, R. (2008). Cytotoxicity of nanoparticles. *Small*, 4 , 26-49.
- Marchant, G. E. (2009). Small is Beautiful: What Can Nanotechnology Do for Personalized Medicine? . *Current Pharmacogenomics and Personalized Medicine*, 7 , 231-237.

REFERENCES Continued

- Pfundt, H. and Duit, R. (1994). *Bibliography: Students Alternative Frameworks and Science Education (4th ed)*. Kiel, UK: IPN.
- Scheps, M.H. and Sadler, P.M. (1988). *A Private Universe* Pyramid Films
- Leach, J., and Scott, P. (2003). Individual and Sociocultural Views of Learning in Science Education. *Science and Education*, 12 (1): 91-113.
- Carew, A.L., and Mitchell, C.A. (2002). Characterising Undergraduate Engineer8ng Students' Understanding of Susuatinability. *European Journal or Engineering Education.* 27(4): 349-361.
- Strauss, A.L. (1987). *Qualitative Analysis for Social Scientists.* Cambridge, UK: Cambride University Press.
- Case, J. (2008). *Educational Theories on Learning: An Informal Guide for the Engineering Education Scholar.* Leicestershire, UK: Higher Education Academy Engineering Subject Center.
- Marton, F., Hounsell, D. and Entwistle, N., (eds.) (2005). *The Experience of Learning: Implications for teaching and studying in higher education.* 3rd (Internet) edition. Edinburgh: University of Edinburgh, Centre for Teaching, Learning and Assessment.