Association for Practical and Professional Ethics Conference Presentation, March 2013

NSF Nanotechnology Undergraduate Education grant (#EEC-1138257) focused on creating interdisciplinary modules about the social, ethical, environmental, and economic impact of nanotechnology for all students at the Colorado School of Mines. (For an overview of the project plan, see **NanoSTEP: Nano-Science, Technology, Ethics and Policy Poster Presentation to NSF EEC conference March 2012**) Dr. Corinne Packard, a professor in the department of Metallurgical and Materials Engineering who works with solar cell nanomaterials, was the PI. The team of Co-PIs and Senior Personnel were drawn from the multidisciplinary Liberal Arts and International Studies department which is responsible for delivering core courses in humanities and social sciences. The first part of the project was a module for the freshman ethics and writing course, Nature and Human Values, which included a common lecture and reading assignments and different course activates and discussions about the risks and benefits of the technology. (**See Workshop and Module Design—Part 1—Nature and Human Values**). The second part of the project was a module for the sophomore-level course, Human Systems, a history of sociological, religious, political, and economic systems. For this course, the focus of the module was on policy and international relations in technology development. (**See Workshop and Module Design—Part 2—Human Systems**). We disseminated our work at several conferences and to universities in China and Spain, but most notably contributed a panel discussion with several team members at APPE 2013 in San Antonio (See **Association for Practical and Professional Ethics 2013 Conference Presentations**). We have written two papers about the results (See **Nanotechnology Ethics and Policy Education: Learning and Sharing Across Boundaries**) and another forthcoming.

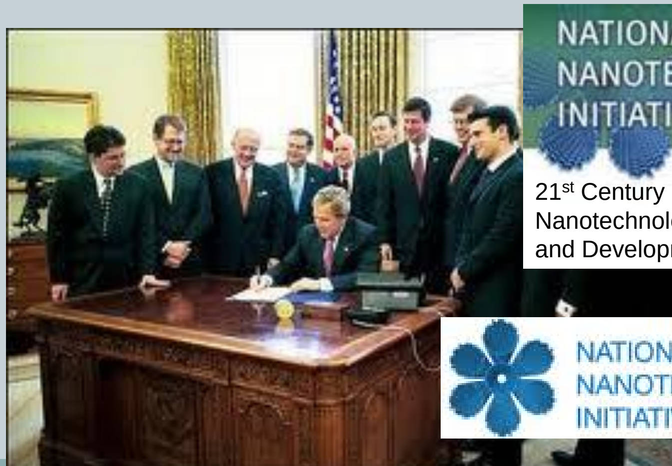
SLIDES FROM APPE 2013 Conference Presentation

President Bill Clinton, 1993-2001

- Clinton announces NNI at California Institute of Technology then signs executive order, 2000

President George W. Bush, 2001-2009

- President Bush signs NNI legislation, 2003



NATIONAL NANOTECHNOLOGY INITIATIVE

21st Century Nanotechnology Research and Development Act

NATIONAL NANOTECHNOLOGY INITIATIVE

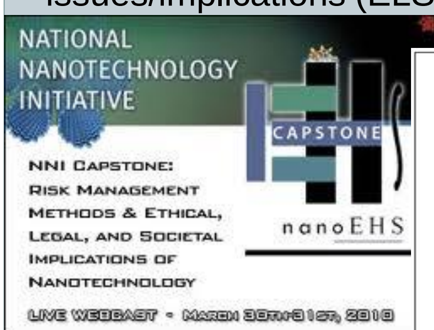
Official NNI Goals

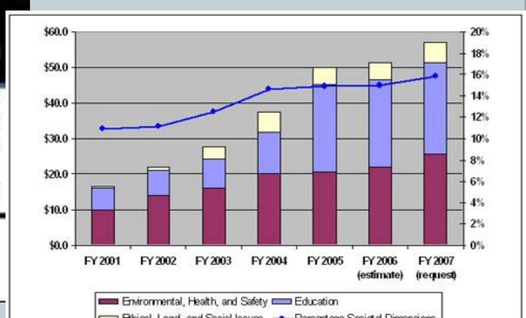
Nano.gov
National Nanotechnology Initiative

1. **Continuing a world-class R&D program**
2. **Fostering the transfer of new nanotechnologies into products for commercial and public benefit**
3. **Educating the workforce, engaging the public, and sustaining an effective nanotechnology R&D infrastructure**
4. **Responsible development of nanotechnology**

The Politics of Nanotechnology

In response to public concerns, NNI had built into it from the beginning an ethical, legal, and social issues/implications (ELSI) component.





NSF fundamental research investments in the societal dimensions of nanotechnology

Nanotechnology Undergraduate Education (NUE) in Engineering

- **Part of the 25-agency National Nanotechnology Initiative (NNI)**
- **Initiated in FY 2003 as one of four components in NSF Nanoscale Science and Engineering (NSE) Program including:**
  - **Nanoscale Interdisciplinary Research Teams (NIRT),**
  - **Nanoscale Exploratory Research (NER), and**
  - **Nanoscale Science and Engineering Centers (NSEC)**
- **Cross-directorate program**
  - **Engineering**
  - **Social, Behavioral, & Economic Sciences**
  - **Education & Human Resources**

NUE at CSM (2011-present): NanoSTEP

- Ambitious Nano-Science, Technology, Ethics, and Policy (NanoSTEP) project
  - focused on Societal, Ethical, Economic, and Environmental (S3E) issues

- 1. Nature and Human Values (required first-year course) module emphasizes ethics
- 2. Human Systems (required second-year course) module emphasizes policy
- 3. International connections: Spain and China
- 4. Research: Pedagogical questions and social justice issues

Nanotechnology, Ethics, and Policy Education: Research and Pedagogy

1

Carl Mitcham, Laura Heller, Derrick Hudson, Cortney Holles
(Colorado School of Mines)
Wang Nan (University of Chinese Academy of Sciences)
Zhu Qin (Purdue University)

NSF Grant # EEC-1138257

Three-Part Presentation

2

- Introduction: The Nano-Science, Technology, Ethics, and Policy (NanoSTEP) project (Mitcham)
- Part I. Pedagogy, Practice, and Outcomes (Heller and Holles)
- Part II. Research and Connections (Mitcham and Hudson)

Part I. Pedagogy, Practice, and Outcomes (Heller and Holles)

1

1. NUE GRANT
2. NATURE AND HUMAN VALUES
3. WORKSHOP FOR FACULTY
4. CURRICULUM DEVELOPMENT
5. PEDAGOGY AND ACTIVITIES
6. ASSESSMENTS AND OUTCOMES

1. NUE GRANT – NanoSTEP

1

AN OPPORTUNITY TO EXAMINE OUR PEDAGOGY AND EVOLVE THE COURSE

Research Questions for Project

1

NanoSTEP

1. Investigating education and experiences of underrepresented groups with emerging technologies

1. Examining impact of undergraduate education on attitudes in Societal, Ethical, Environmental, and Economic (S3E) decision making

⇨ Increased interest in and sensitivity to S3E issues?

2. NATURE AND HUMAN VALUES

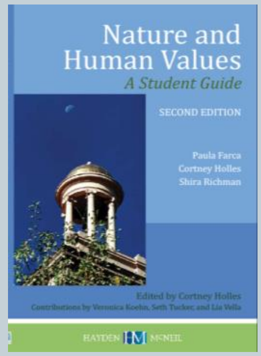
1

A UNIQUE APPROACH TO WRITING AND ETHICS INSTRUCTION

Nature and Human Values (NHV)

1

- Goals: introduce professional & environmental ethics; writing-intensive
- Mines Mission: earth, energy, environment
- Weekly, one-hour lecture
- Seminar sections meet 3 hrs/week
- Evolving content and pedagogy
- Common content
  - Lectures and common exam (10% of grade)
  - Writing Assignments (65% of grade)
  - Reading assignments/ course text



NHV & Ethics

1

Emphases:

- **Personal and professional responsibilities of scientists and engineers**
- **Environmental, social, ethical, and international issues in science and engineering**
- **Intellectual skills that contribute to inquiry, life-long learning, and ethical professional behavior**
- **How the humanities and social sciences shed light on the beliefs, values, attitudes, and world views that shape culture.**

NHV - Major Course Themes

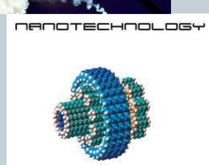
1

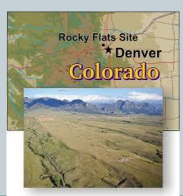
- Professional Ethics
  - History of Engineering as a Profession
  - Codes of Ethics, ABET
  - Cases – Challenger, Citicorp, Manhattan Project
- Ethics of Emerging Technologies
  - Pure Science
  - Precautionary Principle
  - Transformation of Life, Playing God
- Environmental Ethics
  - Anthropocentrism v. Ecocentrism, Instrumental v. Intrinsic Value
  - Population, Pollution, Carrying Capacity
  - Water, Wilderness, Energy, and Natural Resources

Lectures this semester

1

- Professional Ethics Cases
- Intro to Ethical Theory
- Human Genetic Engineering
- Digital Technology
- Nanotechnology
- Energy—*Switch* documentary
- Environmental Ethics
- Nuclear Bombs, Power, & Ethics
- Environmental Law
- CDPHE guest—Rocky Flats
- Mining for Morals
- Negotiating Water
- Wilderness Areas & Resource Use





Course Reading Assignments

Course goal: critical reading skills and argumentation

Common Readings:

Garrett Hardin, Michael Sandel,
Lauren Slater, Aldo Leopold

Nanotechnology:

Jennifer Kuzma
"Piecing Together the Puzzle of Risk"

Ronald Sandler
"Value Sensitive Design and Nanotechnology"

3. WORKSHOP FOR FACULTY

STARTING BY TRAINING THE TRAINERS

CURRICULAR AND PROFESSIONAL DEVELOPMENT

1

Defining course goals and objectives

- Why do we teach ethics?
- What are the goals of ethics courses?
- How are these goals best achieved and measured?

Educating faculty

- What is nanotechnology?
- What are its benefits and risks?
- What are the connections to current course content?

WORKSHOP GOALS

1

Building consensus and consistency

- Creating shared knowledge base
- Defining goals and objectives of module
- Choosing common readings
- Developing classroom activities
- Norming expectations

WORKSHOP PLAN

1

- Develop working knowledge of nanotechnology
- Learn from presenters about S3E impacts
- Evaluate possible reading assignments
- Formulate objectives and goals
- Create classroom activities to apply new knowledge

Building on Expertise

1

- Presentations
  - Visiting Expert - Christopher Preston, University of Montana
    "Emerging Technologies, Ethics, and Public Perceptions"
  - CSM Faculty
    Carl Mitcham – Ethics instruction in STS programs
    Jen Schneider – Communicating scientific uncertainty
    Jason Delborne – The precautionary principle
    Corinne Packard – Nanotechnology, S3E, and solar power
    Derrick Hudson – Nanotechnology and vulnerable groups
    Sandy Woodson – Applying ethical theories to NT

Evaluating Materials

1

Readings for Students

1

- Jennifer Kuzma
  “Piecing Together the Puzzle of Risk”
  - Risk Assessment framework
  - Call for research and policy development for current products
- Ronald Sandler,
  “Value Sensitive Design and Nanotechnology”
  - Engineering is value-laden as a human enterprise
  - Questions to help assess three key parts of design work

Building Consensus on Goals & Objectives

1

Establishing Pedagogical Goals

1

Know	Think	Do
• definition of NT • applications • actual/expected benefits • actual/potential risks • concerns • lack of regulation • questions to ask	• role of politics • funding • developing world • S3E context • values • alternatives • engineer’s role • uncertainty	• articulate & defend ethical position on NT • compare/evaluate alternatives • use values analysis • parallels

4. CURRICULUM DEVELOPMENT

1

BUILDING
ON
CONTENT AND THEMES

Pedagogical Focus

1

Lecture Pedagogy
- Defining concept, positive and negative positions
- Applications today
- Ethical and Environmental concerns

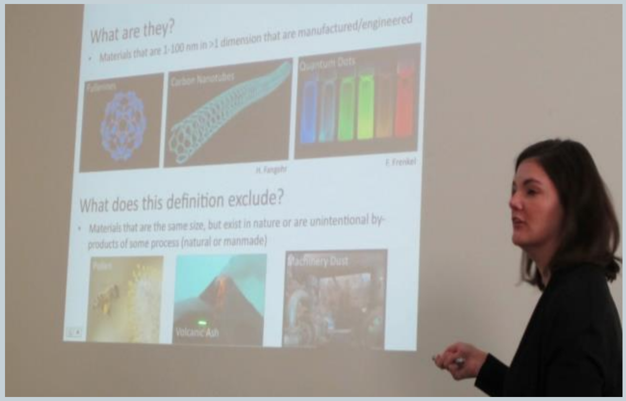
Seminar Pedagogy
- Critical thinking
- Comparing perspectives
- Application to cases and readings
- Risk assessment

Components of Module - Lecture

1

Dr. Corinne Packard

- Defining Nanotechnology
- Current uses and products
- Solar energy applications and research
- End of Life concerns; e-waste comparison



Components of Module - Readings

1

Common Readings

Jennifer Kuzma, "Piecing Together the Puzzle of Risk"

- Risk Assessment framework and
- Call for research and policy development for current products

Ronald Sandler, "Value Sensitive Design and Nanotechnology"

- Engineering is value-laden as a human enterprise
- Questions to help assess three key parts of design work
- Choosing a Project, Defining Success, Means & Byproducts

Jigsaw

1

Developing Curriculum

1

Brainstorming & Sharing Ideas

5. SEMINAR ACTIVITIES

1

**HELPING STUDENTS
TO CONTEXTUALIZE
AND PERSONALIZE
WHAT THEY HAVE LEARNED**

Seminar Activities

1

Values Clarification

Students are given a list of 10-12 different engineering projects and asked to prioritize them according to:

1) which ones they would be most interested in getting involved in

2) which ones are the most important

Then they discuss how and why they ranked the projects and what values underlie their decisions.

Value-Sensitive Design

1

- 1. Choosing a project
  - Who benefits by solving this problem? How much?
  - What other problems could be addressed using these resources?
  - Addressing causes or effects?
  - Less technologically sophisticated approaches?
- 2. Defining success
  - What outcomes = success?
  - How does technical success differ from social/ecological?
  - What are relevant social factors & how can they be addressed?
- 3. Means and byproducts
  - What are some potential unintentional byproducts?
  - Would any of these byproducts be problematic? How problematic?
  - Could these byproducts be prevented or mitigated through the design?

Seminar Activities

1

Value Sensitive Design and Solar Energy

Imagine you are part of a group of engineers and scientists at a cutting edge solar energy technology company.

Create a value-sensitive road map for the company to follow in developing and bringing third generation solar photovoltaics to market.

What are the next steps?
What questions should the company be asking?
Who should be consulted?
What alternatives should be considered?

Seminar Activities

1

Nanotechnology Show and Tell

Prepare a three-minute presentation on a currently available product that uses nanotechnology. Describe and analyze the product and the company's marketing for it.

Seminar Activities

1

Cost-Benefit Analysis v. Precautionary Principle

Using a case study such as the solar energy hypothetical or the LifeSaver bottle technology, work in groups to assess the new product from first a cost-benefit perspective, then from the precautionary principle approach.

What different decisions or priorities emerge from the different analyses?

Which approach best satisfies your ethical principles?

Seminar Activities

1

Company Role-Play:

Students choose from a selection of different roles in a company

(CEO, CFO, Env. Engineer, Sales, PR)

In these roles, they assess the benefits and risks of taking their nanotechnology product to market, and how best to do so, and then prepare a written recommendation reached by consensus.

Seminar Activities

1

Nano-geography

Choose a nanoproduct and do a very basic life-cycle analysis:

- where did you buy it?
- where was it produced?
- where is it used?
- where does it end up?

Seminar Activities

1

Know/Think/Wonder Discussion

In three columns, list everything you

1) know about NT;
2) think about it;
3) wonder about it (have questions about)

Then share & put on board—ask students:

How do you know this? Where did information come from?
Why do you think this?
What makes you wonder about this?

Repeat at end of NT unit

Seminar Activities

1

The Nano Warning-label

Assignment: Use information on implications of nanotechnology from lecture, readings, and your own research to create a warning label for a real or invented nano-product.

Student Work

1

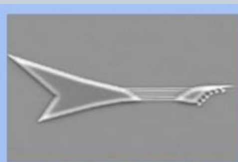


image: CCMR/CNF, Cornell University

Are you sad and require a pick me up?

Don't know how to play the violin?

Well here is the next best thing,

THE NANOSCALE GUITAR!

Why not impress your friends with the world's smallest guitar? Now you can jam out to Freebird whenever you please. The best part is, nobody can hear how terrible you are. That's right, using your laser pick you can create tiny vibrations on that no one will ever be able to complain about. Wasn't it Aldous Huxley who said, "After silence that which comes nearest to expressing the inexpressible is music." Now you can have the best of both worlds.

The New York Times raves, "It's even cooler than smoking."

US Weekly claims, "The lasers hurt my fingers, and eyes."

"A must buy for hipsters." -Fox News

"I don't hear it." -Ludwig Van Beethoven

CAUTION: Nanoscale guitar is very easily lost, and may cause damage to cells due to the high rate of exposure to possibly beta radiation.
CAUTION: Laser may burn through skin
CAUTION: Laser may also cause alpha particle radiation, if side effects such as fatigue, dizziness, or lapses of sanity persist, contact a doctor immediately.
CAUTION: There are still some kinks in particle physics that have not been worked out mathematically, manipulation on the atomic scale may create a singularity.

Student Work

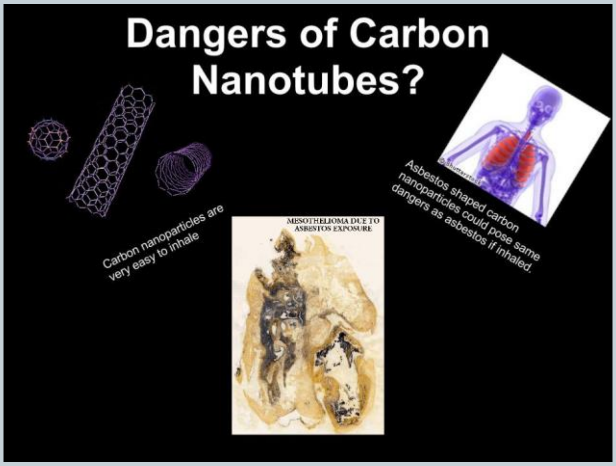
1

Nikon Lenses

WARNING! The lenses are coated with nano-size crystallized particles. These particles are extremely small. If you touch or lick the lenses the particles could possibly come off. We are not completely sure what would happen, except that they may enter your body. Keep away from small children, because we care about them more than you. Once again, use at own risk. Particles could be toxic or uncontrollable, but we really don't actually know.

Student Work

1



6. ASSESSMENTS AND OUTCOMES

1

ASSESSING STUDENT UNDERSTANDING AND ENGAGEMENT

Team Questions

1

How much do students know about nanotechnology?
What are student attitudes about risks and benefits?
What are student attitudes about handling risks?
What role should scientists or engineers play?

Interviewing Students

1

- How has NHV influenced your understanding of science and engineering ethics?
- How has NHV influenced your understanding of the implications of nanotechnology?
- What is your impression of risks v. benefits?
- What should scientists or engineers do (or not do) regarding use of nanomaterials?
- What should society do (or not do) regarding use of nanomaterials?
- What aspect of module was most/least helpful in answering questions today?

Interviewing Students

1

Nano-Scale Informal Science Education (NISE) Network “Same Sides” video

Two sisters
- -working research scientist
- -biology student

Argument on risks and benefits
- -environmental concerns
- -health concerns
- -enormous potential
- -who is in charge?

What does society need?

1

“The public should trust science—scientists are putting their own lives at risk too. It's not all about the money for scientists; we do have morals & aren't going to put out deadly substances.”

“We shouldn’t turn things blindly over to scientists.”

“The public needs to be more aware of nanotechnology and be educated about it.”

“Don’t depend on companies to research or adhere to regulations.”

“Government should be operating on the precautionary principle…I’m pretty sure that the regulations already exist to protect us from nanotechnology.”

Instructor Observations

1

Lower baseline knowledge on nanotechnology

- -current applications
- -environmental and health concerns
- -lack of regulation
- -lack of studies

Hands-on activities stimulated discussion

Optimism about systems

Less engagement on “in principle” arguments

Increased interest in further pursuit

What role should scientists play?

1

“We need to be more patient with research, find out more about NT before putting it out in the environment.”

“Scientists shouldn’t treat it lightly, but also shouldn’t treat it differently than other forms of technology. There are risks in all kinds of technology.”

“You always have a duty to not hurt people or animals. You have to go to sleep at night and look yourself in the mirror.”

“You have to have a position on NT, but you shouldn’t let that get in the way of the research. You have to stay unbiased in your research.”

“We should be going full in on research. There should be more funding.”

NHV Impacts

1

Influence on understanding of science & engineering ethics:

"I had no exposure before NHV; it expanded my mind."

"I didn't think morals had a place in science before this."

"I didn't really consider that ethics would be important to my career. I am so glad for the wake-up call right after starting school here."

"I took a lot of ethics in high school, but the application to technical fields was new. The class made me reevaluate my duty as an engineer to the community."

"It is the first class where you could argue both sides with science, but you needed values to figure out what to do."

NHV Impacts

1

Influence on understanding the implications of NT:

"I learned a lot about environmental applications."

"I did my paper on water purification with NT."

"My impression is that the public has a lot of fear."

"It hasn't changed how I think about it, but I am more aware."

"I don't think I have a great understanding of the implications because I don't feel like I know much about the risks."

"I use NT now and it has never been a bid deal; I'm confused about why it is controversial."

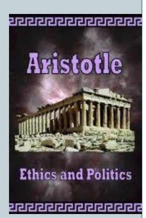
"It has influenced me quite a bit. I work in a nano-research lab and was never informed of the drawbacks."

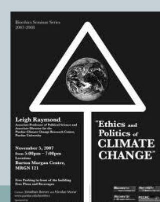
Part II. Research and Connections (Mitcham and Hudson)

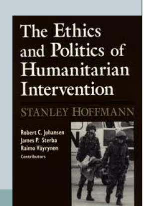
1. The Policy Turn in Ethics
2. International Connections
3. African Americans, Africans, & More

1. The Policy Turn in Ethics

- Early 20th century: Ethics becomes meta-ethics
- 1970s: The applied turn in philosophy and the rise of applied ethics
  - Environmental ethics
  - Biomedical ethics
  - Computer ethics
  - Professional ethics (and APPE, founded 1991)
- 2000s: Ethics to politics and policy
  - Ethics (focused on individual) → political philosophy & policy







2. International Connections

1

- Spain: University of the Basque Country

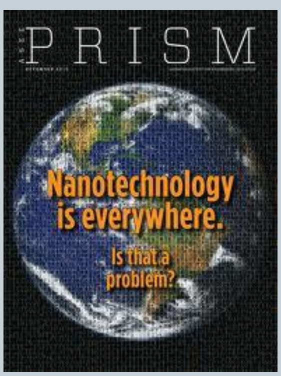
- China: University of the Chinese Academy of Sciences

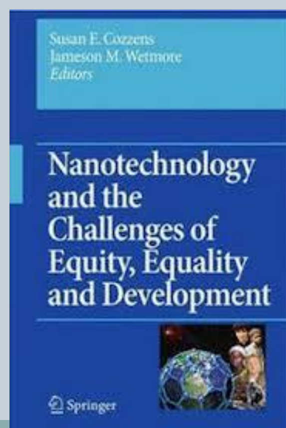
3. African Americans, Africans, & More

1

- Nanotech may be everywhere

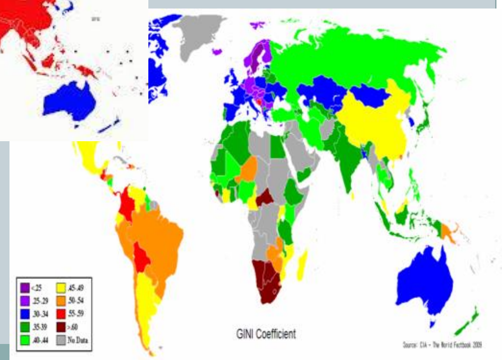
  BUT NOT EQUALLY EVERYWHERE





Nanotechnology and Development in Africa?

Little research explores nanotechnology in Africa and other parts of the Global South



UN Millennium Development Goals (MDGs)

I. Eradicate Extreme Poverty and Hunger
II. Achieve Universal Primary Education
III. Promote Gender Equality and Empower Women
IV. Reduce Child Mortality
V. Improve Maternal Health
VI. Combat HIV/AIDS, Malaria and other Diseases
VII. Ensure Environmental Sustainability
VIII. Develop a Global Partnership for Development

Sample Application
Nanotechnology for Development

1

Application	Relevant MDGs
Nanoporous zeolites for slow release of water and fertilizers for more efficient plant growth	I Eradicate extreme poverty IV Reduce child mortality V Improve maternal health VII Environmental sustainability

Two Sides of Nanotechnology

1

"Nanotechnology and the Developing World: Will Nanotechnology Overcome Poverty or Widen Disparities?" — Noela Invernizzi and Guillermo Foladori

Potential #1: Could make low-skilled work more highly productive using fewer materials and less energy

Potential #2: Could displace and disrupt economies of poorer nations

Some scholarship does not that the relationship between science and society is much more complex than simply identifying a technology and its potential benefits. (Sarewitz, 2004)

How Does Ethics Engage Nanotechnology and Development in Africa and other parts of the Global South?

1

--Ethical Questions (Deal with paradigms of human good and harm)

–However, Ethics in the American tradition is culturally bounded by:

----Western thought (W)

----Formal Education (E)

----Individuality and Choice (I)

----Riches and Wealth (R)

----Democracy and rule of the many (D)

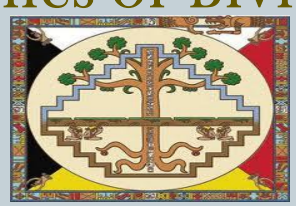
Beyond "WEIRD" Ethics?: The Maya Ceiba Tree as an Illustration

1

--ETHICS OF AUTONOMY

--ETHICS OF COMMUNITY

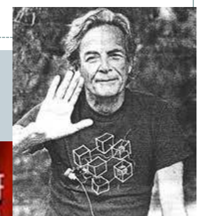
--ETHICS OF DIVINITY

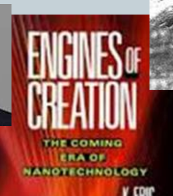


Introduction

1

- 1959: Richard Feynman CalTech talk, “There’s Plenty of Room at the Bottom”
- 1974: Norio Taniguchi coins term “nanotechnology”
- 1986: K. Eric Drexler, *Engines of Creation: The Coming Era of Nanotechnology*
- 1991: NSF staffer (and engineer) Mihail Roco initiates US government nanoscale science and engineering program
- 1999: Formally proposes NNI to President Clinton



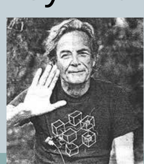


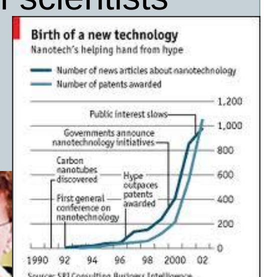
Nano and Science Policy

1

Nanoscience and nanotechnology are as much the political creations of NSF policy entrepreneur Mihail (Mike) Roco and Presidents Bill Clinton (Democrat) and George W. Bush (Republican) as of scientists and engineers.

Feynman, Yes. Roco, double Yes!





TITLE: Nanotechnology, Nature, and Human Values: A Pedagogical Demonstration

PROPOSAL: Pedagogical Demonstration

PRESENTERS: Cortney Holles and Laura Heller, Colorado School of Mines, LAIS Division

PURPOSE: This pedagogical demonstration will present course activities and pedagogy for Nature and Human Values at the Colorado School of Mines (CSM) and will introduce our efforts to assess student reactions to the risks and benefits of nanotechnology for an NSF grant (Award #EEC-1138257). We will describe our course content and pedagogical focus, demonstrate several class activities for the module on nanotechnology, provide resources and handouts to attendees, and lead a discussion of best practices.

BACKGROUND: At the Colorado School of Mines, all freshmen take an interdisciplinary writing and ethics course called Nature and Human Values (NHV). This four hour course includes a weekly large-group lecture for one hour and small 20-student seminar sections that meet three hours per week. Lectures are designed to introduce students to key concepts and debates in professional and environmental ethics and analysis of benefits and risks of cutting edge technologies. Seminars are designed to develop students' writing and argumentation skills by connecting with the content and reading assignments from the lecture series. The course goals and objectives are to engage students' writing, critical thinking, and reading skills as they learn about the importance of ethics in their professions and the consider varying perspectives in today's controversial issues in science and engineering.

DEVELOPING PEDAGOGY: As the course has developed over the last 17 years, the focus has shifted to ethics instruction as an important corollary to the required writing component of the course. Students are much more engaged in improving their communication skills when they have compelling content to work with in the seminars and lectures. Our interdisciplinary team of instructors and lecturers for this course, including full time faculty and adjuncts, meets regularly to evaluate the goals and objectives of the course and develop best practices for teaching ethics and writing to beginning undergraduates. Conlon and Zandvoort argue that engineering ethics classes often revolve around case-based analysis but need to move away from micro-ethical focus on the problems of the individual to the macro-ethical issues of the profession itself. NHV includes some specific, individual-focused cases in lectures and course activities, but by and large focuses on broader, complex ethical dilemmas in society. We begin the semester with professional codes of ethics for engineers but then expand to discuss broad ethical theories and ask students to consider debates over GMOs, human genetic engineering, and digital technology. The second half of the course covers environmental ethics and debates over land use, water scarcity, energy challenges, mining, and resources. We ask students to consider not only their personal perspectives as potential engineers, but also the perspectives of various stakeholders involved with each dilemma. In the final writing assignment, students are asked to research a case from multiple perspectives and negotiate solutions that balance the needs of diverse interest groups. This pedagogy "moves students away from the idea of engineering as a purely technical activity to consideration of it as a social activity that involves choices which affect people's lives" (Conlon and Zandvoort).

NANOTECHNOLOGY PEDAGOGY: The National Science Foundation's NUE (Nanotechnology Undergraduate Education) grant program funded CSM to incorporate content modules on social, ethical, environmental, and economic impacts of nanotechnology into required freshman and sophomore classes and selected upper division courses. We are surveying students over the duration of their education at Mines to gauge the impact of these modules on their attitudes about ethical and social responsibility of engineering professions. Since there are many instructors of the required courses, the grant also involves conducting faculty workshops to train the instructors and develop and standardize the modules. Instructors of the freshman class (NHV) met in January 2012 and instructors of the sophomore class will meet in December 2012. As a result of the NHV faculty workshop, we developed objectives, lecture material, reading assignments and in-class activities; this demonstration will disseminate these materials and discuss our initial implementation of the module.

Our nanotechnology learning module has three main components and we will demonstrate the key concepts of each: a common lecture, two common reading assignments, and a suite of in-class activities chosen by the instructor. The lecture is presented by Corinne Packard, an assistant professor in Materials Engineering and employee of NREL (National Renewable Energy Lab) and focuses on defining nanotechnology and its potential benefits and risks. Dr. Packard also explains her research on improving efficiency in solar cells using nanoparticles. Students read two articles during the week of the lecture and apply them in their seminar activities and discussions. Both articles include nanotechnology as an example of a larger thesis about engineering work and ethical deliberation. Jennifer Kuzma's "Nanotechnology: Piecing Together the Puzzle of Risk" introduces students to concepts of risk management and risk communication, while Ronald Sandler's "Value-Sensitive Design" proposes that engineering is inherently value-laden and that values should be considered at each stage of design and implementation. In the class activities, we emphasize the precautionary principle versus cost-benefit analysis and make students aware of how widespread nanotechnology already is. As part of the NSF proposal, students are surveyed before and after the module to gauge their knowledge and ethical analysis as a result of the module.

Instructors in NHV have developed a suite of class activities for the nanotechnology module which could easily be modified to work with similar content modules at other institutions. The focus of the session will be to introduce and model several of these class activities and their pedagogical foundations. For example, one instructor asks students to research and report on products using nanotechnology that are currently on the market. Another asks them to analyze a new nanotechnology from both a cost-benefit analysis and from the precautionary principle approach. A third instructor assigns a video role-play of a debate over nanotechnology risks and has students continue the debate in class. As we share these exercises, we will demonstrate how the three components of the module interrelate and discuss some of the important resources that inform our teaching and assessment of this material. PEN (The Project on Emerging Nanotechnologies), NISE (Nanoscale Informal Science Education) Network, and NNI (National Nanotechnology Initiative) all have valuable websites for developing this curriculum. We hope to end the presentation with a discussion of best practices and field questions about implementing or adapting this curriculum at other institutions.

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Project on Emerging Nanotechnologies Consumer Products Inventory

National Nanotechology Initiative

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Class Content and Activities Developed for Nature and Human Values (NHV) Module

Cortney Holles and Laura Heller, Liberal Arts and International Studies

LECTURE OUTLINE

- Defining nanotechnology and engineered nanoparticles
- Extreme positions on benefits versus risks; need to seek middle ground
- Products and techniques already on the market
- Lab-scale use versus Industrial use: Safety, expertise and duration
- Solar energy and nanotechnology innovations
- Ethical and Environmental concerns; end of life cycle; comparison to electronic waste

SEMINAR ACTIVITIES

Nanotechnology Show and Tell: Prepare a three-minute presentation on a currently available product that uses nanotechnology. Describe and analyze the product and the company's marketing for it, the potential benefits or risks of the product, and whether there are comparable or better alternatives.

Cost-Benefit Analysis v. Precautionary Principle: Using a case study such as the solar energy hypothetical or the LifeSaver bottle technology, work in groups to assess the new product from first a cost-benefit perspective, then from the precautionary principle approach. What different decisions or priorities emerge from the different analyses? Which satisfies your ethical principles best?

Company Role Play and Negotiation: Students are assigned different roles in an company (CEO, CFO, Env. Engineer, Marketing, PR, etc) They assess benefits and risks of taking their nanotechnology product to market and prepare a written recommendation reached by consensus.

Values Clarification: Students are given a list of 10-12 different engineering projects and asked to prioritize them by 1) which ones they would be most interested in getting involved in, and 2) which ones were the most important.

The Nano Warning-label: Students use information on implications of nanotechnology from lecture, readings, and research to create a warning label for a real or invented nano-product.

Nano-geography: similar to "The Story of Stuff" (storyofstuff.org) – choose a nanoproduct and do a basic life-cycle analysis: where did you buy it, where was it produced, where was it used, where does it end up

Know/Think/Wonder discussion: in three columns, list everything you 1) know about NT; 2) think about it; 3) wonder about it (have questions about) Discuss as a class and draw conclusions from student responses. Repeat again at end of NT unit (can be done for any subject you think will be novel for students)

The Association for Practical and Professional Ethics

Nanotechnology, Underrepresented Minorities and People of Color Globally: The Need to Consider an Ethics of Autonomy, an Ethics of Community, and an Ethics of Divinity in the Engineering Classroom

Derrick Keith Hudson

Colorado School of Mines

Abstract

Although the goal of science education, to include the emerging field of nanotechnology, is to make science available to all students, there continue to be disconnects in the participation of science for underrepresented minorities in the United States and people of color globally. Additionally, while there have been concerted efforts to require systematic ethical courses in engineering education as sanctioned by the U.S. Accreditation Board for Engineering and Technology (ABET), such as the use of science fiction in the engineering classroom, considerable gaps persist. This critical review will argue that although there has been substantial progress in developing ethical education relative to the Science, Technology, Engineering, and Math (STEM) professions, many approaches to ethical education are couched in western, individualistic, developed and democratic social contexts. Ethical approaches need to also take into account different "ethical cultures." Drawing from moral psychological approaches, this article will argue that there are two other ethical approaches that might be better suited to reach underrepresented minorities and people of color. They are an ethics of community *and an ethics of* divinity*. The article's conclusion is that the development of curriculum and pedagogy utilizing these different ethical approaches could reach more underrepresented minorities in the United States and people of color globally, and thus, include these groups in the conversation of how to apply the potential benefits of nanotechnology.*

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Introduction: Nanotechnology and the Developing World

Science and ethics have long occupied different portions of the intellectual spectrum. For numerous reasons—some good, some bad—students in science and engineering tend to have little training in ethics beyond general "standards of practice" rules against moral transgressions such as plagiarism and falsifying data. Even though philosophical ethics is certainly not relevant to every facet of scientific research, it has deep significance to some areas.

Some argue that science and technology, to include the arena of nanotechnology, should proceed democratically according to choices that are consistent with the public will, while others argue that the scientific and technological agenda should be set by the curiosity of the scientist alone. Questions about justice and fairness are at the very center of deliberations over whether to put research money into appropriate technologies. Nanotechnology is no exception to these questions. In one study, Salamanca-Buentello, et.al., brought together leading scientists in the field of nanotechnology and asked them to articulate some of the possible benefits of utilizing nanotechnological applications to address the United Nations Millennium Development Goals (MDGs). The eight goals are listed as follows:

The Eight United Nations Millennium Development Goals (MDGs)

- **I. Eradicate Extreme Poverty and Hunger**
- **II. Achieve Universal Primary Education**
- **III. Promote Gender Equality and Empower Women**
- **IV. Reduce Child Mortality**
- **V. Improve Maternal Health**
- **VI. Combat HIV/AIDS, Malaria and other Diseases**
- **VII. Ensure Environmental Sustainability**
- **VIII. Develop a Global Partnership for Development**

Scientists working in various aspects of nanotechnology were then asked to provide some of the possible applications that could benefit developing countries and the daunting challenges they face relative to development. The summary of those applications are provided in the next table:

Top Ten Applications of Nanotechnology for Developing Countries

Rank	Applications of Nanotechnology	Examples	Comparison with the Millennium Development Goals (MDGs)
1.	**Energy storage, production, and conversion**	**Novel hydrogen storage systems based on carbon nanotubes and other light-weight nanomaterials**	**VII**
2.	**Agricultural productivity enhancement**	**Nanoporous zeolites for slow release and efficient dosage of water and fertilizers for plants, and of nutrients and drugs for livestock**	**I, IV, V, VII**
3.	**Water treatment and remediation**	**Nanomembranes for water purification, and detoxification**	**I, IV, V, VII**
4.	**Disease diagnosis**	**Quantum dots for disease diagnosis**	**IV, V, VI**
5.	**Drug delivery systems**	**Nanocapsules, liposomes, buckyballs, nanobiomagnets, and attapulgite clays for slow and sustained drug release systems**	**IV, V, VI**
6.	**Food processing and storage**	**Nanocomposites for plastic film coatings used in food packaging**	**I, IV, V**
7.	**Air pollution and remediation**	**Nanosensors for detection of toxic materials and leaks**	**IV, V, VII**
8.	**Construction**	**Self-cleaning surfaces (e.g., windows, mirrors, toilets) with bioactive coatings**	**VII**
9.	**Health monitoring**	**Nanotubes and nanoparticles for glucose, carbon dioxide, and cholesterol sensors**	**IV, V, VI**
10.	**Vector and pest detection and control**	**Nanosensors for pest detection Nanoparticles for new pesticides**	**IV, V, VI**

Table 1: From Deborah G. Johnson and Jameson M. Wetmore, eds. (2009) *Technology and Society: Building Our Sociotechnical Future*. Cambridge, MA: MIT Press.

In this last table, comparisons are drawn between the MDGs and the nanotechnologies most likely to benefit developing countries leading up to 2015.

Comparison between the MDGs and the Nanotechnologies Most Likely to Benefit Developing Countries in 2004-2014 Period

I. Eradicate Extreme Poverty and Hunger (2, 3, and 6)
IV. Reduce Child Mortality (2, 3, 4, 5, 6, 7, 9, 10)

V. Improve Maternal Health (2, 3, 4, 5, 6, 7, 9, 10)

VI. Combat HIV/AIDS (4, 5, 9, 10)

VII. Ensure Environmental Sustainability (1, 2, 3, 7, 8)

Table 2: From Deborah G. Johnson and Jameson M. Wetmore, eds. (2009) Technology and Society: Building Our Sociotechnical Future. Cambridge, MA: MIT Press.

Nanotechnology and the Poor: Left Out Again ?

In another work, Noela Invernizzi and Guillermo Foladori warn the nanotechnological community that nanotechnology, like many emerging technologies, has often widened disparities between the developed and developing world. While the authors acknowledge four positive aspects of nanotechnology, which include: 1) the revolutionalization of the manufacturing process, 2) the minimal differences between abiotic and biotic matter which allow for application of biological processes to material processes, 3) the differences that nanoparticles possess relative to the same elements at the macroscopic scale, and 4) the ability of nanotechnology to combine several kinds of technologies and sciences such as information technology, biotechnology and materials technology, the authors are concerned that nanotechnologies could have unintended negative consequences that might disrupt the developing economies of the developing world. While nanotechnology has the potential to transform low-skilled work, such as cleaning, cooking, and subsistence farming into highly productive and cheap outputs and may require only modest amounts of material and energy to do so, this transformation from subsistence to efficiency could disrupt cultural norms, such as the traditional division of labor of

men and women in many parts of the developing world. The division of labor is not only about work, but allowing space for men and women to deepen relationships in shared work settings. Stories are told and advice is often passed from the old to the young. Efficiency and productivity could undermine some of these important cultural constructs. The major critique being leveled here is that current conversations about the application of nanotechnology do not take into account that the relationship between science and society is much more complex than simply identifying a technology and its potential benefits. (Sarewitz, 2004)

One of the most tragic and painful experiences the developing world has had with technology has been with HIV/AIDs pharmaceuticals. Nanotechnological applications have the ability to develop quantum dots to detect HIV/AIDs molecules in early stages and thus intervene to mitigate against the disease. According to Salamanca-Buentello, this nanotechnological application could meet the goals of MDG goal VI. Unfortunately and regrettably, World Trade Organization (WTO) and Multinational Pharmaceutical Corporations (MPCs) policies and guidelines have driven up the costs to obtain patents from $30,000 in the United States to $250,000 on the world market. While that figure might not seem high in the developed world, these costs are hard to justify in the developing world. One must also keep in mind that this is just the cost to obtain the intellectual property rights to these medications, let alone the cost to obtain the medications themselves.

The authors from this study suggest that there are three lessons to be learned from the developing world's experience with nanotechnology up to this point:

- Provide Legislation on Nanotechnology Products in such a way that Public Participation will not be Undermined by Science-Based Assessment
- Label Products with Nano components in order to gain acceptance with the corresponding empowerment of the consumer
- Use the *Precautionary Principle* in a way that could prevent serious risks without limiting the possible development of the sciences

While these are helpful suggestions, some limitations of the conclusions are that nano products are already in the market. There are already 1,300 nano-products in the US consumer market, and there is pressure to get on the "innovation" bandwagon to move this technology forward. To use a more colloquial phrase, "the horse is already out of the stable." Second, abiotic and biotic products are manipulated in a way that is not natural and will have to undergo extensive trials

and be potentially subject to intellectual property rights issues. There could be pressure for scientists to "neutralize" this process to avoid these debates.

Even more glaring, however, is that underrepresented minorities and people of color globally, who are often poorer, with less formal education and training, continue to not have a voice in science and the debates about nanotechnology. First, academics, to include faculty in developing countries, are not necessarily representative of the views of their societies. Second, there is disproportional influence of pharmaceuticals on the research and development process. Third, colleges and universities, especially those with ambitious research agendas, aggressively seek federal funding for the continued development of nanotechnology and other applied scientific programs. This funding brings prestige to these institutions. It is difficult to bring issues of how these technologies might impact society, and those in society who may have little to no input on how those impacts will be felt by these communities. It is important, therefore, to strongly consider and think about how to bring in society alongside emerging debates in nanotechnology to avoid these pitfalls.

Overcoming "Ethical-Phobia"

As was noted at the end of the last section, there needs to be more proactive encouragement to engage society and students in the STEM professions, to include nanotechnology. However, an ongoing challenge at the college and university level is the high degree of academic specialization, especially at the graduate level. Scientists, it is thought, have one particular role, while ethicists, political scientists, historians, poets, writers, etc. have another. Due to important considerations related to the objectivity of their work, scientists, it is further supposed, are more or less *prohibited* from engaging tough social and ethical questions concerning what should or should not be done (Preston, 2011). Science is about 'just the facts' and so any subjective proselytizing on values and preferences should be left to somebody else. American culture, which is decidedly positivistic, therefore steers science away from anything but the most superficial engagement with philosophical ethics.

It should be obvious, but it worth noting three things. First, scientists are the people best informed about the reality of the problems and the technologies that might be used to fix them. More than anyone else, the scientist knows the scientific and technical hurdles that need to be overcome before certain problems can be remedied. Second, scientists are not just experts relative to their research, they are citizens who live in society that will receive the fruits or bear the costs of decisions made about the direction of research. Third, many scientists are often supported by public research money and/or teach at public institutions (Preston, 2011). It is

arguable, then, that they owe the public something in return for the tax money that fund their research agendas and pay their salaries. For these and other reasons, there is a strong presumption that scientists should not and cannot pretend to wipe their hands clean of difficult ethical decision-making (Shrader-Frechette, 1994).

Philosophical Ethics in the Western Tradition: A "WEIRD" Morality?

Philosophical ethics in the Western tradition has tended to be dominated by three main variations of thought. The three traditions are Deontological, Consequentialist, and Virtue Ethics. Deontological approaches to ethics have a long history in the West, stretching back to Plato. A deontological approach to ethics points to the idea of a "science of duty." A deontologist studies the reasoning behind why a person might find herself with a duty to act, or refrain from acting. Deontologists look for clear-cut principles that serve as reliable guides to behavior. To put this in another way that is less academic, deontologists suggest that the mind rules the heart. These approaches lean towards systematizing reasoning. They also require high degrees of formal training in philosophical thought, and as was mentioned, they are heavily couched in the Western tradition.

Next, consequentialism, or utilitarianism, tends to focus on the outcome, or the good. The common used phrase, "the ends justify the means" is the cliché to encapsulate this approach. Like deontology, this approach has a long history in the West, with David Hume and John Stuart Mill being two very notable figures. In addition to these approaches being couched in the West and requiring a high degree of formal training, much of this line of thinking is also focused on individual choice.

Finally, virtue ethics is the third major tradition. To the extent that ethics has been engaged with science and technology debates, virtue ethics is the most marginal relative to science and technology debates. Rather than placing the focus on action and the reasons why certain acts are right or wrong, the virtue ethicist looks instead at the person who is acting and asks whether they are demonstrating appropriate moral character. For example, instead of putting emphasis on whether a person should lie, the focus is on whether their character is honest.

Moving Towards An Ethics of Community and Divinity

What is glaringly missing in the analysis so far of the role of ethics is not acknowledging that all three of these traditions are couched in what one scholar terms a "WEIRD" morality (Haidt, 2011). Most training in ethics is built upon the assumption that one sees the world as full of separate objects, rather than relationships. It is no coincidence, then, that academic specialization reinforces this dynamic. It has long been reported and studies that Westerners have a more independent and autonomous concept of the self than do Asians. Americans are much more apt to start sentences with "I" and refer to internal psychological characteristics

(happy, outgoing, interested in jazz), whereas Asians are more likely to list their *roles* and *relationships* (a son, husband, an employee). None of the three approaches to ethics summarized above take into account roles and relationships. In many parts of the world, to include portions of underrepresented minorities and people of color globally, they are more likely to see themselves from an ethic of community or an ethic of divinity.

The ethic of *autonomy* is based on the idea that people are, first and foremost, autonomous individuals with wants, needs, and preferences (Haidt, 2011). People should be free to satisfy these wants, needs, and preferences as they see fit, and so society is developed with moral concepts such as liberty, justice, which allow people to coexist peacefully without interfering too much in each other's affairs. So, to come back to John Stuart Mill, in many of his utilitarian writings, he argues that he values justice only to the extent that increases human welfare, or Kant, the quintessential deontologist, who argues that justice is the prize even in case where it might reduce human welfare.

However, a vast portion of the world does not operate under an ethics of autonomy. The ethic of *community* is based on the idea that people, are first and foremost, members of larger entities such as families, teams, armies, companies, tribes, and nations (Haidt, 2011). These larger entities are more than the sum of the people who compose them; they are real, they matter, and they must be protected. People have an obligation to play their assigned roles in these entities. Many societies develop moral concepts such as duty, hierarchy, respect, reputation, and patriotism. In such societies, the Western insistence that people should design their own lives and pursue their own goals is selfish and dangerous.

Finally, an ethic of *divinity* is based on the idea that people are, first and foremost, temporary vessels within which a divine soul has been implanted (Haidt, 2011). This is certainly the case for the Q'chei' Maya of northern Guatemala (Hudson, 2012). People are children of God, the divine, and have a duty to act accordingly. The body is a temple, not a playground. Even if a person does something that is degrading and no one knows about it, it is degrading to the Creator, the universe, the divine. Many societies therefore develop moral concepts such as sanctity, sin, falleness, purity, and pollution. To point back to the Maya once more, there is an entire cosmological arena that focuses on when the cosmos is out of balance, or misaligned, and that individuals with certain portions of those "energies" or *nuales*, that person must exercise great care to realign one's inner soul.

Conclusion: The Movement Towards an Ethics of Community and Divinity to Engage Underrepresented Minorities and People of Color Globally

Thinking about these two ethics of community and divinity could serve as a way to engage underrepresented minorities and people of color globally. The Maya, who arguably operate under an ethic of divinity, would likely want to ask questions of how nanotechnology might alter the cosmos and the individual soul. While such a question might sound strange to a Westerner, if the intent is to engage all students in ethical discussions about emerging technologies to include nanotechnology, then this conversation is needed to have a fruitful dialogue. In an ethic of community, there might be a view that not all members *should* be involved in conversations about science if that is not their *role.* Again, the argument is not whether which ethic is better, but rather, which ethic might need to be employed to have a dialogue.

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