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Teaching of Biology: Including ELSI Activities in the Introductory Biology Classroom

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Title:
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Abstract:
The increasing need for public input about ethical, legal, and social issues (ELSI) associated with science and technology implies a corresponding need for ethical education of students in the sciences. The changing goals of college biology courses further reflect growing awareness of such needs. What are the challenges associated with engaging science students—who may expect to focus only on “science” and not “ethics” issues—in such overarching discussions? In this presentation, we will discuss our design, implementation, and study of the use of ELSI deliberative activities in an introductory freshman-level biology course across five semesters. First, we will describe the activities and their goals. Second, we will present results evidencing the impacts of these activities on, for example, student engagement, learning, and evidence for critical thinking about applications of science in society. Finally, we will discuss the challenges and lessons learned from including such activities in the curriculum based on our research and evaluation activities.

Teaching of Biology:

Including ELSI* activities in the Introductory Biology Classroom

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DBER Group Presentation – April 2013

*ELSI – Ethical, Legal and Social Issues

THANK YOU

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NSF SCiSIP. Title: Developing an Empirically-based, Multi-level, Social-Cognitive Model of Public Engagement in Science & Innovation Policy Development; PIs: Lisa Pytlik Zillig (Principal),Yuris Dzenis, Joseph Turner, Rosevelt Pardy, Thomas Morris, Alan Tomkins. 07/01/2010 - 06/30/2013.

Grant Goals & Objectives

- **Primary goal** - develop and test a social-cognitive model of public engagement to address science policy in the area of nanotechnology.
- **Central Hypothesis** - Variations in social contexts and cognitive purposes of public engagements will change individual and group-level mediating *processes*, resulting in different impacts on individual, scientific, and policy *outcomes* commonly used to evaluate the effectiveness of engagement efforts.
- **Educational impact** – Integration into an introductory biology course provided the opportunity to sensitize hundreds of science students of the need to inform the public about science, to have them discover how this might be done, to show how their science information and growth might be applied in a novel and interesting way, to have them gain experience in hypothesis testing, data collection, and evaluation.

- Vision & Change in Undergraduate Biology Education (AAAS 2009) – toward meeting some of the goals of this ambitious national challenge to improve biology education

"A revolution is underway in biology. The major focus of the biological sciences—understanding life— remains the same, but the science has experienced a major transformation. Many of the most exciting discoveries in the biological sciences during the second half of the 20th century occurred at the intersections of established disciplines…. These new integrated fields, spread across the diversity of life sciences, are opening up a vast array of practical applications, ranging from new medical approaches, to alternative sources of energy, to new theoretical bases in the behavioral and social sciences."

Why ELSI? Why Nanobiology?

The Activities

ELSI Engagement Learning Experiences for Students

- **Assignment 1: Reflection (Hwk)**
- **Introductory Lecture** (large group)
- **TED video** (recitation)
- **Assignment 2: Reading (Hwk)**
    - Critical thinking prompts/training
    - Organization of information (notetaking)
    - Control group (explore)
- **Assignment 3: ELSI scenarios (Reci)**
    - Individual
    - Group (moderated/not; hetero/homo)
- **Assignment 4: Input (Hwk)**

Activities Overview

Students were asked to reflect on their beginning knowledge of and attitudes toward nanotechnology.

Many reflected that they knew very little.

New Biology

Considering...

Biological Applications of Nanotechnology

Name:____________________

Pre-Test

Answer the following questions to the best of your ability. It is OK to guess if you don't know the answer! Points will NOT be deducted for incorrect answers.

What is genetic engineering?

A. The method by which taxonomists edit transgenic traits
B. The engineering of electronic devices using genetic materials
C. The changing of the structure of genetic material
D. The engineering of new organisms and life forms

Which of the following is between 2 and 100 nanometers wide?

A. The head of a pin
B. DNA
C. A human hair
D. A hydrogen atom
E. DNA base-pairs

How many nanometers are in one meter?

A. 10^{12}000 (One trillion)
B. 10^{9} (One billion)
C. 10^{6},000,000 (One million)
D. 10^{-6} (One millionth)
E. 10^{-9} (One billionth)

What are "second order effects" of technology?

A. Impacts of new technology on the offspring of the individual who was exposed to the technology
B. Social impacts, or changes in society that result indirectly from the new technology
C. The increase in choices that are available as a result new technologies
D. All of the above
E. None of the above

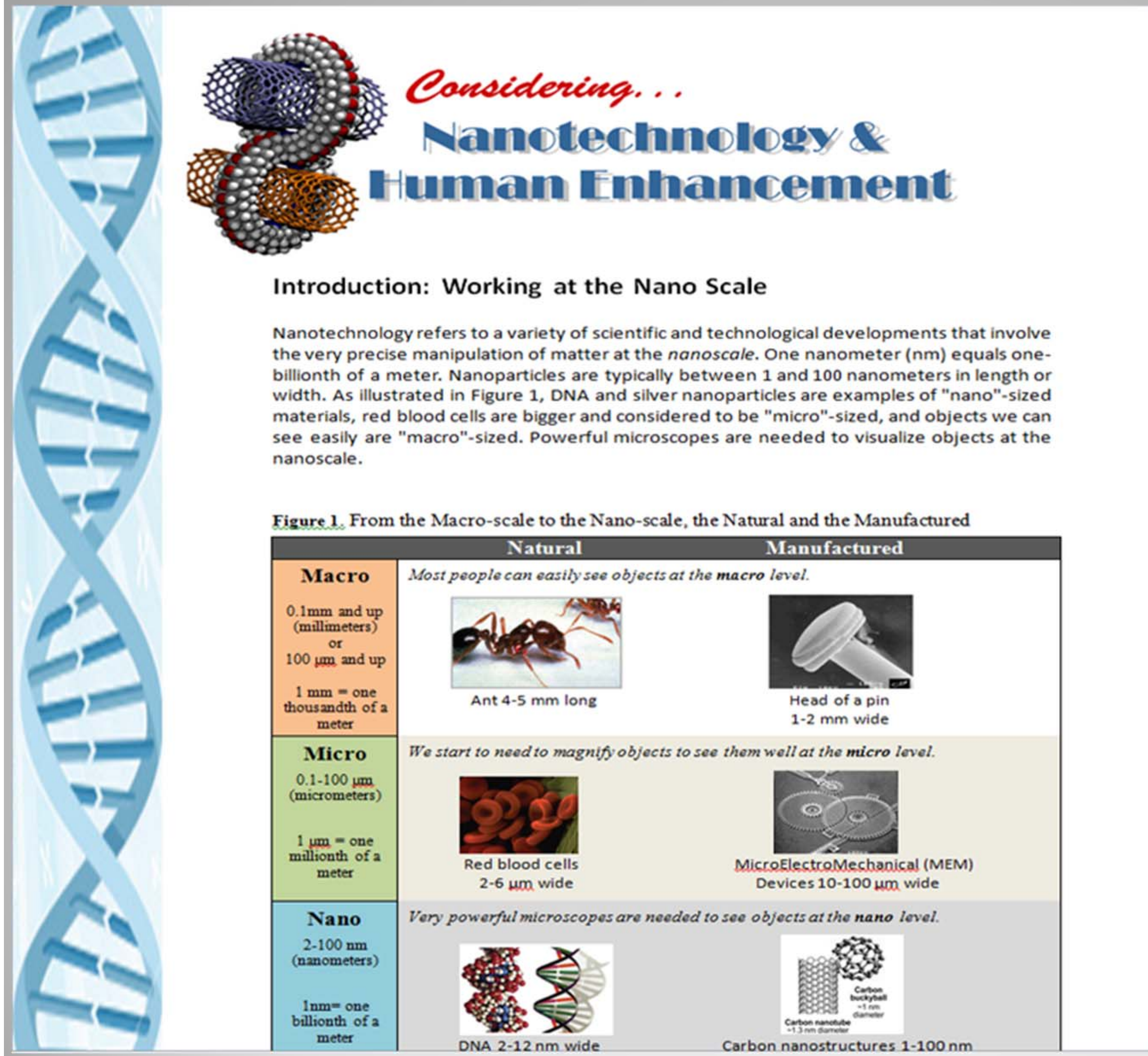
Assignment 1: Reflection

Students then had a guest lecturer who discussed ethical, legal, and social implications (ELSI) in a broad sense.

They also watched a 10-15 min video in recitation (e.g., "The genomic revolution")

These activities were designed to inspire interest and relevance

Lecturer : Dr. Alan Tomkins
Video: Richard Resnick (TED)



Considering. . .

Nanotechnology & Human Enhancement

Introduction: Working at the Nano Scale

Nanotechnology refers to a variety of scientific and technological developments that involve the very precise manipulation of matter at the *nanoscale*. One nanometer (nm) equals one-billionth of a meter. Nanoparticles are typically between 1 and 100 nanometers in length or width. As illustrated in Figure 1, DNA and silver nanoparticles are examples of "nano"-sized materials, red blood cells are bigger and considered to be "micro"-sized, and objects we can see easily are "macro"-sized. Powerful microscopes are needed to visualize objects at the nanoscale.

Figure 1. From the Macro-scale to the Nano-scale, the Natural and the Manufactured

	Natural	Manufactured
Macro 0.1mm and up (millimeters) or 100 µm and up; 1 mm = one thousandth of a meter	*Most people can easily see objects at the **macro** level.* Ant 4-5 mm long	Head of a pin 1-2 mm wide
Micro 0.1-100 µm (micrometers); 1 µm = one millionth of a meter	*We start to need to magnify objects to see them well at the **micro** level.* Red blood cells 2-6 µm wide	MicroElectroMechanical (MEM) Devices 10-100 µm wide
Nano 2-100 nm (nanometers); 1nm= one billionth of a meter	*Very powerful microscopes are needed to see objects at the **nano** level.* DNA 2-12 nm wide	Carbon nanostructures 1-100 nm

- A background document was provided to the students that explained nanotechnology and its applications.
- Students were in different conditions; e.g., asking them to take notes or prompting critical thinking.
- The goal was to provide a knowledge base.

Assignment 2: Reading

SCENARIO 1: "Assume that scientists have developed a way to improve human memory. This discovery has the potential to cure Alzheimer's. It may also enable some people to develop a super-human memory. Under what circumstances, if any, should this technology be restricted?"

SCNEARIO 2:"Now assume that, sometime in the future, Mr. and Mrs. Vanderbilt decide they would like to have a baby. Both parents have the genetic markers for Cystic Fibrosis. Their doctor informs them that for $250,000 he can, through the use of nanogentics, ensure that their baby is born without Cystic Fibrosis. The Vanderbilts can afford this, but can't agree on whether they should. Mrs. Vanderbilt favors any kind of intervention that may keep their future children healthy. 'Protecting our children from suffering is a moral obligation,' she argues. Mr. Vanderbilt, however, opposes any technology that can manipulate human genetics. He worries that while this technology might help his child, it will eventually be misused so that parents can engineer their children for superficial reasons. What do you think about this scenario? How should the law treat this technology?"

Please use all of your discussion time. Do not continue to the final question until your TA given you permission. If you are having trouble finding things to discuss and debate, consider these:

BRAINSTORMING QUESTIONS

- What would someone who disagrees with me say?
- What are some of the pros and cons of this technology?
- What are some potential second-order effects of this technology?
- What if I were personally involved in these issues? How might my perspective change?
- Are there any trade-offs we need to consider? If we do [insert suggestion from the group here], will that prevent us from doing something else that we might consider desirable later on?

- Usually, half the students worked alone and the other half worked in groups
- Moderators guided discussions of small groups of students
- In one study, moderators were active vs. passive
- The goal was to evoke deliberation

Assignment 3: ELSI Scenarios

Future development:
What *developments* should be prioritized or avoided?

Regulation of Nanotechnology:
What *regulations* should be in place or are needed?

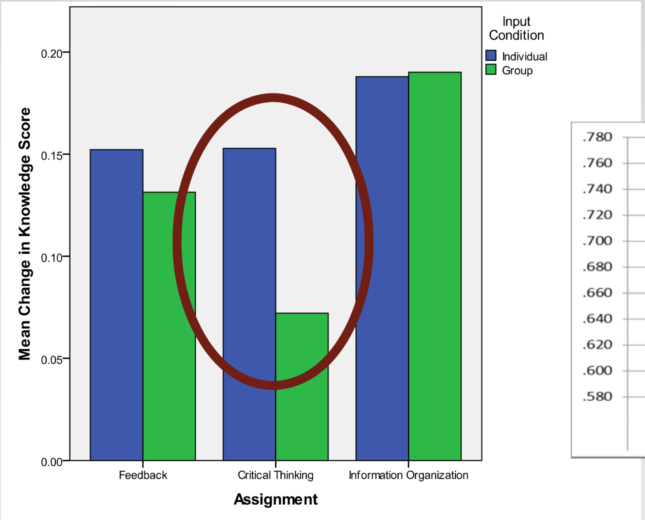
- Students gave their final input in regards to
  - the risks and benefits of nanotechnology
  - Regulation of nanotechnology
- The goal was to get students to practice citizen input
- In addition, they were able to give feedback on the activities

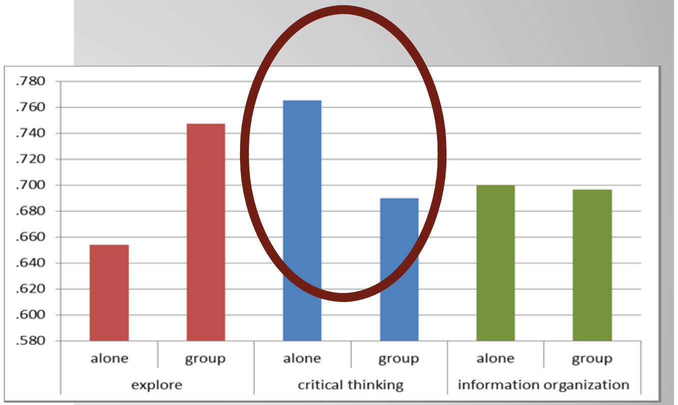
Assignment 4: Final Input

Findings

A Sampling of our Effects

- **Semester 1 & 2**
  - All conditions show knowledge gains
  - When we've asked students to think critically, they've appeared to learn more if they were in the 'alone' scenarios condition





Learning

During the Engagement I…

1=Not at all, 2 =Just a little, 3 = Some, 4 = Quite a bit, 5 = A great deal

Conscientious (Cronbach's α = .82+)
Gave careful consideration to all of the options presented.
Thought it was important to be thorough in my consideration of the issues.
Was concentrating hard.
Felt focused.
Carefully evaluated the relevance of various arguments.

Active Learning/Metacognitive (Cronbach's α = .77+)
Explored topics related to the issues in order to satisfy my own curiosity.
Checked myself to see how well I understood the issues related to the topics I was learning about.
Identified questions that I still had about the topics.
Thought about how the topics related to other things I know.
Tried to find answers to my questions about the topics.

Creative (Cronbach's α = .85+)
Felt creative.
Used my imagination.
Felt inspired.
Worked to think of novel or inventive issues related to the topic.
Tried to be innovative in my ideas.

Open-minded (Cronbach's α = .70+)
Felt open to hearing new ideas about the topics.
Tried hard to understand perspectives that were different from mine.
Felt open-minded.

Closed-minded (Cronbach's α = .72+)
Felt like my mind was already made up.
Knew how I would feel about the topic even before doing the task.
Felt like new information would not change my opinions.

Social (Cronbach's α = .88+)
Discussed my ideas about the topics with others.
Talked to others about the topics to get their opinions.
Asked others what they thought about the topics and issues.
Listened to what others thought about the issues.

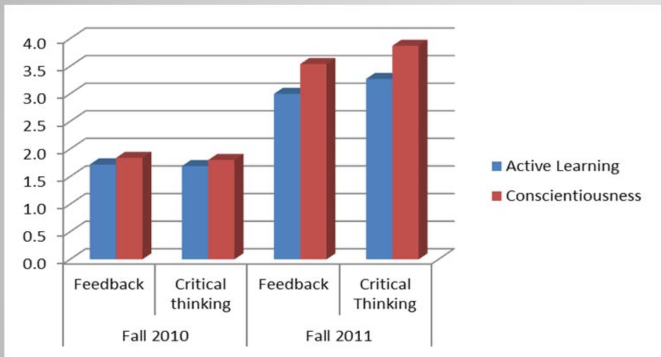
Disinterested (Cronbach's α = .89+)
Was impatient to get this over.
Wished I were doing something else.
Felt bored.
Felt distracted.
Was uninterested in the task I was asked to do.
Thought this process was not worth my time.
Didn't care at all about the activities and tasks.

Student Engagement

- **Semesters 1 & 2:** Students in the critical thinking condition were *dis*engaged compared to control or other students

- **Subsequently:** Moved to the use of "prompts."
  - Critical thinking students were *more actively* engaged (and a bit higher on most positive engagement factors),
  - but also more *disinterested*.

- Effortful cognitive engagement may not be fun.



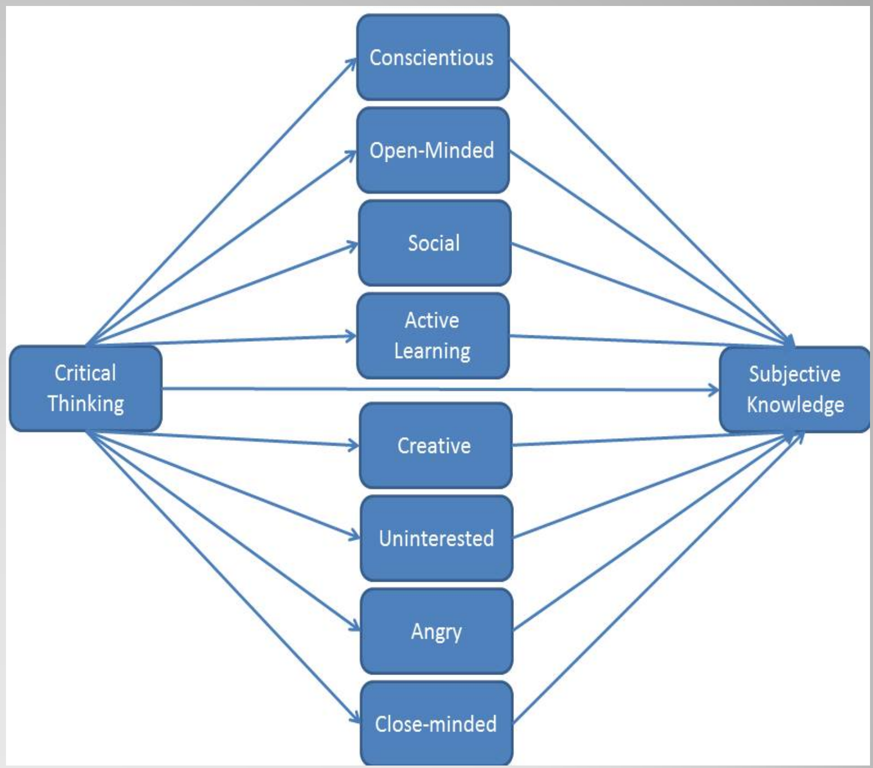
Engagement Scale	Fall 2010				Fall 2011			
	Feedback		CT		Feedback		CT	
	Mean	***SD***	***Mean***	***SD***	***Mean***	***SD***	***Mean***	***SD***
Active Learning	1.72	.54	1.69	.53	3.00*	.71	3.27*	.78
Conscientiousness	1.84	.55	1.80	.52	3.54*	.69	3.87*	.65

Note: * indicates significant differences.

Student Engagement

Semester 3, 4, 5

- Critical thinking condition is associated with more **subjective knowledge** gains
- Effect appears to be best mediated by
  - Conscientious engagement (2 of 3 studies) (also often related to objective learning gains)
  - Lower closed-mindedness (1 of 3 studies)
  - Active learning engagement (1 of 3 studies)



Learning & Engagement

- Qualitative coding of “final input” for “quality”

Breadth/ Depth	Variable Name	Correlation with NFC
Breadth	**Count** of topics (sum of 17 dummy variables) Also: Number of new topics at post (not at pre)	Pearson Correlation = .43
		Sig (2-tailed) = .07
Depth	**Meta-Oppos** scale from 0-4 measuring with 0=no mention of alternative viewpoints, 1=mentions at least one alternative viewpoint, 2=mentions numerous viewpoints or describes one in some detail, 3=evaluates one view or describes more than one view, 4=evaluates more than one view) Also: Consideration of Evidence	Pearson Correlation = .12
		Sig (2-tailed) = .636

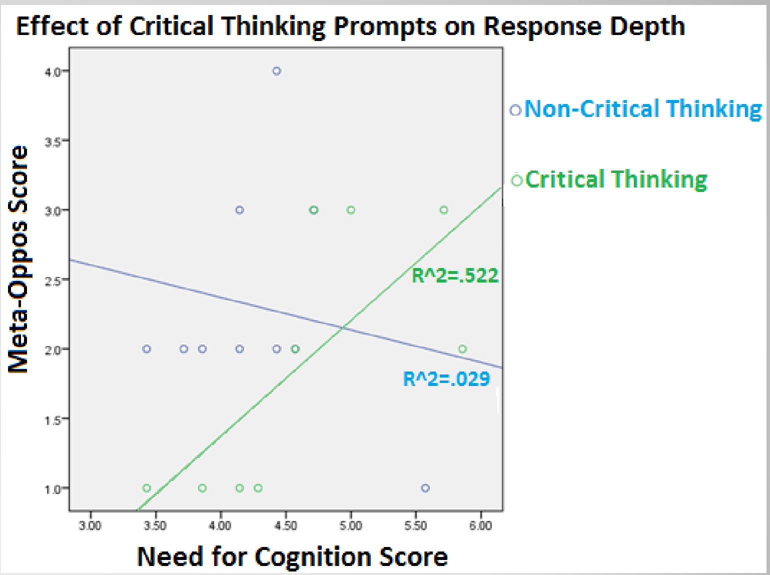
Critical Thinking

Critical Thinking

- Critical thinking may benefit depth over breadth
  - Students who **did not** receive CT prompts were more likely to mention additional topics than those who **did receive prompts**.

- Critical thinking condition may benefit high NFC students, harm low NFC

- When receiving CT prompts
  - Students with a high NFC were likely to more deeply consider opposing arguments (than controls)
  - Students with a low NFC were actually less likely to consider opposing arguments (than controls)



- Not all students will embrace infusion of ELSI topics into their basic science course
  - Some things help:
    - Timing of content, asking them about the importance first
- Try not to have the "research" aspect be salient (undermines credibility)
- Group moderators appear to be helpful
- There is a difference between positive cognitive and positive affective engagement
- Things that "should" work may not (or may not for everyone)

Challenges & Lessons Learned

Thank You!

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