Images of Science and Becoming an Engineer

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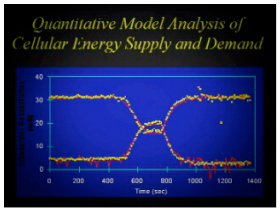
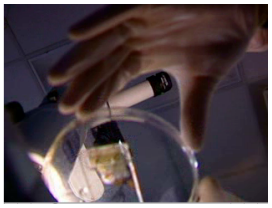
Images of Bioengineering

Bioengineering is an emerging field that crosses the disciplinary boundaries of the life sciences to promote technological advances, primarily in bio-medical applications.



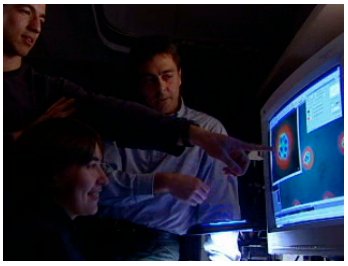


Images of science portray science as *endeavor*, *product* and the *nature of scientific knowledge*.

Range of Images Students Encounter

- Classroom
  - Instruction
  - Peers
  - Visual images
  - Prior educational experiences
- Out of school
  - Media
  - Everyday discourse
- Artifacts
  - Textbooks
  - Form and voice of scientific writing
  - Scientific equipment

What is the influence of the images that students encounter?



Images of Science and Epistemology

- Images of Science (Driver et al., 1996)
  - The purposes of scientific work
  - The nature and status of scientific knowledge
  - Science as a social enterprise
- Images of Disciplines
  - Students encounter disciplinary images in the classroom, in everyday settings and through artifacts.
  - Students come to understand the nature of knowledge as contextualized within a discipline.

Driver et al. (1996). *Young people's images of science*. Buckinghan, UK: Open University Press.

Trading Zones

• "In science, the fundamental unit of accomplishment remains the discovery; in engineering, the fundamental unit of accomplishment is problem solving." (Williams, R.)

• Trading zones- an intermediate domain where procedures are coordinated locally despite conflict in broad meanings. (Galison 1997)

–The vitality of trading zones lie in breaking down boundaries

Williams, R. Education for the profession formerly known as engineering, 2003

Galison, P., Image and Logic: a material culture of microphysics. Univeristy of Chicago Press. 1997

Engineering education today: Unsettled terrain

- Reshaping the epistemological relationship between science and engineering
  - Technoscience- process of interaction in interdisciplinary projects where the projects, not the disciplines define the terms of engagement. (Williams R, 2003)
  - "…the relationship between science and engineering is no longer summarized in a set of reliable equations: it now includes all the complexities of evolving life forms. "

Images of Science and Becoming an Engineer—Research Questions

- What images of life science do engineering students encounter while in the introductory phase of engineering education?
- How do student come to understand the nature of knowledge in the life sciences through engineering education?

Study Design & Methods

- 75+ hours of ongoing classroom observations
  - Biology for engineering students
  - Biology in biology department
  - Introductory bioengineering course
- Student interviews, 11 students in first research cohort
  - 20 plus hours of interview data
  - Over-sampled for diversity
  - Range of level of commitment to bioengineering
- Methods
  - Interviews cataloged and transcribed
  - Identified segments in data related to "image of disciplines" (IoD)
  - Analyzed thematically

Emergent Themes

Themes regarding disciplinary epistemologies emerged from the data.

- Images of biology
- Images of engineering

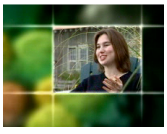
Sources of Data—Images of Discipline in…

- …in departmental recruitment materials
- …in instruction
- …in student talk

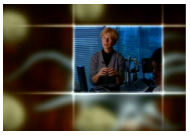
Images of Bioengineering in Departmental Recruitment Materials

"bioengineering is defined differently by everyone that you ask…"

"Its still sort of developing and people are still trying to figure out exactly what bioengineering means."



"…I have to explain that its more encompassing than genetically modified corn or cloning dolly"



"it's the integration of the sciences in general for the improvement of and the development of novel technologies"

Biology Taught through the Engineering Department

- Intended curriculum uses familiar engineering topics and structures to convey biological information
  - Chemical engineering
  - Electrical engineering
  - Mechanical engineering
- Image of Discipline
  - Does this curricular approach maintain a dichotomized view of bioengineering in terms of engineers solving biological problems rather than promoting techno-science?

Images of Discipline in Classroom Observations from Faculty

- Jane: "When you're working with DNA its kind of unsatisfying because its not so tangible. It's a lot of pipetting clear fluids…we are going to do a lot more of that kind of thing…It's a lot of hit or miss."
- Biology is characterizing (figuring out the rules) where as engineering has already figured out it's rules (implicit)
  - "If we want to engineer biology all we have to do is change the DNA, its relatively easy to change traits, but that's where biology is, figuring out the rules."

Stacy and Allen

- Seniors, expecting to graduate in 2006
- Involved in extracurricular programs
- Doing research in addition to course load
- Both in a biology for engineers class

- These two cases were chosen because they express views that are shared across the first research cohort.

Student images of biology

Stacy

- " biology is more like searching the cell, and I think that its labor intensive, a lot of pipettes is what I see it to be, a lot of lab work and just I see engineering as a way to automate that, as a way to make it faster, better, less human intensive so that people can focus on other things"

Student images of biology

Allen

- "(biology) seemed more of like constructing…a really big catalog. Now that we have that though we can start analyzing it from an engineering perspective and develop and start to implement certain uses and certain functions from what we know so that its using it instead of just gathering all the information."

Student images of engineering

Allen

- "in engineering course work we've learned more about basic components of a system and how we can do something with that."

Stacy

- "I think that engineering is more like problem solving, like you're given some sort of task, a goal, and your … goal is to design something to a certain specification."

Summary

- Students view biology as…
  - Not usable
  - Not related to theory
  - Unprincipled
- Students view engineering as…
  - Engineering as readily applicable
  - Problem solving
  - A rhetoric of conclusions (Schwab)
    - Principles, evidence, theory, law (settled knowledge)
- Students view biology and engineering as separate endeavors with divergent epistemologies

Conclusions and Implications

- There is a profound gap between engineering curriculum and engineering practice.

- Future Research:
  - Is it productive for students to make this strong distinction?
  - What role do images of disciplines play in how students identify with a particular discipline and come to find a place for themselves within it?
  - How are students prepared for technoscience and the shifting boundaries in disciplinary science?

Acknowledgements

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everyday science & technology group
everydaycognition.org

Members

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- Suzanne Reeve
- Heather Toomey Zimmerman

Please let us know if you would like to stay informed about ESTG or the LIFE Center.

Upcoming Presentations

- NARST Session 8G: families learning in a science museum (today, 2:30, Zimmerman)
- AERA
  - Session 34.025: The LIFE Center (Tues)
  - Session 58.052: Teens & instant messaging (Thurs, Zimmerman)
- EARLI: Historical argumentation (August; Bell)
- ISCAR: Argumentation in everyday contexts (September; Bell, Bricker, Zimmerman)