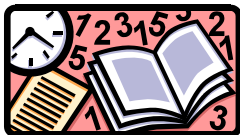


EDUCATION 56
SCIENCE, EDUCATION, AND THE SCIENTIFIC MIND
PROFESSOR KEVIN DUNBAR
SPRING 2007

Time: M, W, F: 10:00-11:05 (X Hour Thursday 12:00-12:50)
Professor: Kevin Dunbar Raven House Room 210
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Email: kevin.n.dunbar@dartmouth.edu.
Office hours: Wednesday 9:00-10:00 Thursday 1:00- 2:00 or by appointment

Course Overview. What is science? How do scientists make discoveries? Are there differences between women and men scientists and are they important? How is science learned and taught; is it just a list of facts or are there similar concepts to those learned in music, politics, art, and literature? How do children learn and how does this influence science education. What is the media's role in science and science education? We will explore these topics in a highly interactive course that covers fundamental concepts in contemporary society, education, and culture. This will be a fun course with lots of student discussion and participation

Course Structure: Two lectures and one in-class discussion per week.



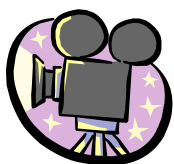
In Class Discussions: Science Fridays. Here you will discuss a specific question regarding the readings and lectures for that week. You will break up into small groups, discuss the topic among each other, and then each group will present its conclusions to the entire class and more discussion will ensue. Each person in the class will present twice.

Evaluation: (1) Midterm in-class examination consisting of short essay questions (20%). (2) final examination consisting of short essay questions covering the entire course (35%). (3) Final essay OR movie (30%). (4) In class discussion participation (15%)



Readings: All the readings for the course are (or will shortly be) available on blackboard. You can download them and print them out. All readings should be read before the class.

The essay or Movie!



You can hand in an essay, or a 4-6 minute (Max is 6 min) Quicktime movie (or windows media player) for an assignment worth 30% of the final grade.

Pick a topic that they want to write about, in consultation with the professor. Topics must be picked by Friday May 4. You must email a one page proposal for an essay topic or movie by May 4. Each essay should be 10 pages (double spaced) in length. The topics will be a topic in science education that interests you. Your goal will be to give an in-depth paper based upon research (not an opinion, nor a review). It is a summary of research in an area of science education. You must use primary sources. Instead of handing in an essay, you can hand in a movie. The movie would be similar to the essay, except here it is presenting information visually. For the movie you need to pick a science education topic and film a class, a lab, and or a teacher, a professor, students etc. You will edit everything, give a voice over, and output the final product to the computer.

Students with Disabilities

Any student with a documented disability needing academic adjustments or accommodations is requested to speak to me by the end of the second week of the term, all discussions will remain confidential, although the Student Disabilities Coordinator may be consulted to verify the documentation of the disability.

Education 56: Topics and Dates

Week 1: (March 28- March 30) Introduction & Overview of the Course
This week we will first look at the goals of the course and what you will discover when you take the course. I will give an overview of the main issues, assumptions, and controversies in understanding science, science education, and the way that the scientific mind works.



March 28: Course overview, goals of course: What is science? What is the scientific Mind?
March 30: Allocating science Fridays, History of Science Education, Making sense of Science. Popper, Kuhn, and more recent work.

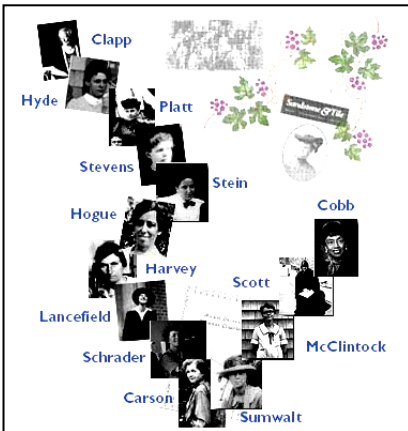
Week 2 (April 2-April 6): Science, Education, and Children
We begin with children learning science. Some have argued that children are incapable of abstract thought necessary for science, others have argued that children are really little scientists. Given these different views, how should a museum present science, schools teach it, and parents family and peers work together

April 2: The traditional view of development and science

April 4: Contemporary views of development of reasoning:

April 7: Science Friday: We evaluate of videos of science education and what should science education be doing

Week 3 (April 9- april 13). Gender and Science: The issues



Women continue to be a minority in science. What are the reasons for this and what is the role of education in issues of gender and science? This week we will examine the historical background of women in science, where women stand in science today, some recent examinations of women in science and some of the issues regarding the idea that women conduct science in a different way from men. In the following week we will look at some of the issues surrounding the enculturation of women into and out of science.

April 9: The background: History of women and science

April 11: Perspectives on women in science

April 13: The Summers (2005) controversy and its impact. Possible guest speaker.

Week 4 (April 16-April 20): Gender issues in learning science



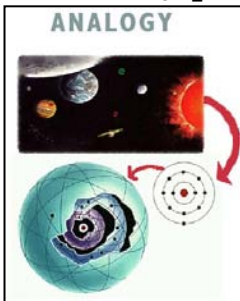
Here we see that parents, both mothers and fathers treat girls differently from boys when discussing science both at the dinner table and in science museums. Clearly this has many ramifications for girls and their interest in science. We will discuss ways that have been used to get girls and women involved in science and how to keep them as key participants.

April 16: Gender and science implications for education

April 18: In class discussion keeping minorities in science. How?

April 20: In Class Midterm Examination

Week 5 (April 23-April 27): Analogy in science and science education



How do we communicate new ideas to someone in science? We use analogies. Analogies are used at all levels of science education from the basic to Nobel prize winning labs. How is it used? When do analogies really help educate and when do analogies get in the way? We will explore the use of analogy generation and the provision of many analogs as tools for scientific understanding..

April 23: Analogy as a key educational tool

April 25: Analogy in and out of the scientific laboratory

April 27: In class discussion analogy, the good, bad and the ugly

Week 6 (April 30- May 4): Learning the basic skills: Causality, Induction, & Deduction



What types of skills do we teach in science education? Causal reasoning, deduction, induction and abduction are key skills that are components of all science education and that scientists use in their research. We will unravel the mechanics of these skills and see how these they are taught.

We will take a look at some of the problems that people have, including scientists, in using these skills and how being taught to deal with the unexpected is a key thing that scientists learn,

particularly in postgraduate science education.

April 30: Inductive reasoning in science

May 2: Causality & Deduction

May 4: Science Friday: Learning about complex causes AIDS, SARS and Avian flu.

Week 7 (May 7- May 11) What are Experiments and how is experimentation taught?



How, and why, do some scientists design experiments without hypotheses? Given the potentially infinite number of experiments that scientists could conduct, how do they decide to conduct an experiment in a particular way? We will look at designing experiments as a form of problem solving. We will look at the teaching of the use of controls and control conditions. We will also look at children and the design of experiments. Can children design an experiment? We will explore this important dimension of the child as scientist controversy.

May 7: Designing an Experiment: What is done?

May 9: The High school science Lab .

May 11: In Class Discussion The lab class at Dartmouth

Week 8: Conceptual Change as the goal of science education (May 14-May 18)



Many science educators have argued that the key goal of science education and the key goal of learning is large-scale changes in concepts. One area of science education where conceptual change has proved very difficult is physics. We all possess many basic concepts of motion and momentum that that must be overcome in physics education. We will look at ways that educators have used to overcome our Naïve physics and whether they have succeeded or not

- May 14: Conceptual change what is it and why is it so hard
- May 16: How Naïve theories that we all have interfere with learning
- May 18: In class Discussion: Do we ever achieve Conceptual Change

Weeks 9 & 10: Science & Evolution(May 21-May 30)



Science, science education, and the media are inter-related domains for changing our conceptions of key issues in science. The media influence scientists, the funders of scientists, educators, and the lay public. This week we will explore the roles of the media (from blogs, podcasts, and the internet to the more traditional print, radio, TV, and movies) on a key scientific concept: Evolution. We will explore the multiple strands and conclusions that drive our understanding of evolution from media to the technologies used in education.

- May 21: The media & Science
 - May 23: Evolution and education the issues
 - May 24: Evolution and education the consequences
 - May 25: Last formal class. Has science education changed our understanding of Science?
 - May 30: I will be in the classroom to answer questions and collect movies or essays.
- Essay or Movie due by beginning of class on May 30th**

Readings Education 56 2007 Science, Education, and the Scientific Mind

Week 1 Introduction & Overview

Capaldi, E.J. & Proctor, R. (2005). Why Science matters. Chapters 1, 3, & 6.

Week 2. Development

Kuhn, D. (2002) What is Scientific Thinking and how does it develop. In U Goswami (Ed.) Blackwell handbook of Child development. PP 371-393.

Harris, P. (2002). What do Children learn from testimony. In P. Carruthers, M. Siegal, & S. Stich (Eds.) Cognitive bases of Science. Cambridge: Cambridge University Press.

Gopnik, A. Meltzoff, A. & Kuhl, P. (1999). What children learn about things. Chapter 3 of the scientist in the crib. Morrow.

Carey, S. (2001). Concepts. From the journal of Cognition and development

Week 3 Gender 1

Fox-Keller, E. (1985). Gender and Science. Chapter 4 of Reflections on Gender and Science. Yale University Press.

Schiebinger, L. (1999). The Clash of Cultures. Chapter 4 of "Has feminism changed science?" Harvard University Press. Cambridge, MA.

Summers, L. H. (2005). Remarks at NBER Conference on Diversifying the Science & Engineering Workforce. The office of the President. Harvard University.

Hyde, J.S. (2005). The gender similarity hypothesis. American Psychologist. 60, 581-592.

Ivie, K. & Ray, R. (2005). Women in physics and Astronomy. American Institute of Physics, Number R430-02

Week 4 Gender 2

Crowley, K. Callanan, M.A., Tenenbaum, H. R., & Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. Psychological Science, 258-261.

Tenenbaum, H.R., & Leaper, C. (2003). Parent-Child conversations about science: The socialization of gender inequities? Developmental Psychology

Various authors (1993). Gender and the culture of science: Women in science '93. Science, 260, 383-429.

Week 5 Analogy as a tool for teaching science

Holyoak, K.J. & Thagard, P (1994). The Analogical Scientist. In K.J. Holyoak, and P. Thagard. Mental Leaps. MIT Press, Cambridge:MA pp 185-209.

Wong, D.E. (1993). Understanding the generative capacity of analogies as a tool for explanation. Journal of research in science Teaching, 30 1259-1272.

Blanchette, I., & Dunbar, K. (2000). How Analogies are Generated: The Roles of Structural and Superficial Similarity. *Memory & Cognition*, 28, 108-124.

Week 6: Scientific Reasoning skills as the focus of science education

Dunbar, K., & Fugelsang (2006) Scientific Thinking in Holyoak, K. J. & Morrison, R. H. Cambridge Handbook of Thinking and reasoning Thagard, P. (2005). Induction, from Mind an introduction to Cognitive science

Gallo, R. (1991). About the causes of Disease (and in particular, Why HIV is the cause of AIDS). In R. Gallo: Virus Hunting, Aids, Cancer, and the human retrovirus. A Story of scientific discovery. New York: NY. Basic Books.pp 276-297.

Week 7: Designing Experiments

Kuhn, D. Integrating theory and data in Experimental design

Baker, L.M. & Dunbar, K. (2000). Experimental design heuristics for scientific discovery: The use of baseline and Known Standard Controls. International Journal of human Computer studies.

National Academy of Sciences (2005). Laboratory experiences and student learning. Chapter 3 of the nations lab report. National Academy Press. Pp 116-137.

Week 8: Conceptual Change in science and science education

Rolands, Graham, Berry, Mc William (2007). Conceptual change through the lens of Newtonian Mechanics. Science & Education (2007) 16: 21-42

Chi, M.T.H., & Roscoe, R.D. (2002). The processes and challenges of conceptual change. In M. Limon and L. Mason (Eds). Reconsidering Conceptual change: Issues in Theory and Practice. Kluwer Academic Publishers, The Netherlands, pp 3-27.

Zirbel, E.L. (2004). Framework for conceptual change. Astronomy Education Review. 3, 62-76.

Weeks 9 & 10 : Evolution, the media, technology and science!

Evolution 2006 @ Berkeley: <http://evolution.berkeley.edu/evosite/nature/index.shtml>

AAAS 2006. Special event Evolution <http://www.aaas.org/programs/centers/pe/evoline/index.shtml>