CS7697: Cognitive Models of Science and Technology

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DESCRIPTION

The focus of this course is on creativity and innovation in science and engineering. We will examine to what extent models of human cognition can provide the basis for an enriched, more nuanced understanding of the practices used in science and engineering research, and technology development. The course will examine analyses of scientific cognition developed in philosophy of science, cognitive psychology, and AI. We will address such questions as: By drawing from the cognitive sciences, can we better understand how scientists devise and execute real world and thought experiments, develop and use models, construct arguments, create concepts, invent and use mathematical tools, communicate ideas and practices, and train practitioners? Can theories and methods in the cognitive sciences provide a means for reconstruction of historical "discovery processes"? What does the recent move to ethnographic studies of “science in the wild” offer? What is the relation between cognitive and socio-cultural models of these practices? Can examining the cognitive practices of scientists and engineers inform us about mundane cognition? About learning in science and engineering education? There will also be a section devoted to thinking about “interdisciplinarity” and its role in contemporary practices.

REQUIREMENTS

There will be a significant amount of reading. All students, including those registered for “p/f” and "audit" credit, will make joint presentations and propose problems for discussion. Those students requiring a letter grade will do a research paper on a topic of their design related to the theme of the course. All students will make presentations of their proposed research.

REQUIRED TEXTS

These books are in the **Engineers Bookstore**:

L. Laudan, *Progress and its Problems*, U. Of California Press, 1977

N. J. Nersessian, *Creating Scientific Concepts*, MIT Press, 2008

Papers are on t-square site in folders for each week

SCHEDULE

Week 1 - 8/20

Introduction: the problem situation in contemporary cognitive studies of science & technology

Science as a problem solving practice: Background in Philosophy of Science

Week 2 – 8/29 – NO CLASS

Reading: Laudan, 1-69

Week 3 - 9/3 (discussion of Laudan Part I)

Laudan, 70-151

Mental Models

Week 4 - 9/10

N. J. Nersessian, *Creating Scientific Concepts*, Chapts 1 & 4

R. Giere, "The cognitive structure of scientific theories," *Philosophy of Science* 61:276-296, 1994

S. Trickett & J. Trafton, "'What if...' The use of conceptual simulations in scientific reasoning," *Cognitive Science* 31:843-875, 2007

Analogy and Visualization

Week 5 - 9/17

D. Gentner, et al., "Analogical reasoning and conceptual change: A case study of Johannes Kepler." *Journal of the Learning Sciences* 6: 3-40, 1997

D. Craig, et al. "Perceptual simulation in analogical problem solving." In: *Model-Based Reasoning: Science, Technology, & Values*. 167--191. Kluwer Academic / Plenum Publishers, New York, 2002.

D. Gooding, "Cognition, construction, and culture: Visual theories in the sciences," *Journal of Cognition and Culture* 4:552-593, 2004

Representational Innovation

Week 6 - 9/24

N. J. Nersessian, *Creating Scientific Concepts*, Chapts. 3, 5, 6

Integrating Culture and Cognition in S&T practices

Week 7 – 10/1

N. J. Nersessian, "Interpreting scientific practices" in *Scientific and Technological Thinking*, Gorman et al, Lawrence Erlbaum, 2005

E. Hutchins, "Learning to navigate," in *Understanding Practice*, Chaiklin & Lave, Cambridge U. Press, 1993

N. J. Nersessian, "How do engineering scientists think?" *Topics* 1:730-757, 2009

Week 8 – 10/8

R. Giere, "The problem of agency in distributed cognitive systems," *Journal of Cognition and Culture* 4, 2004

R. Hall et al. "Disrupting Representational Infrastructure in Conversations across Disciplines", *Mind, Culture, and Activity* 9: 179–210 2002

N. J. Nersessian, "Engineering Concepts: The Interplay between Concept Formation and Modeling Practices in Bioengineering Sciences." *Mind, Culture, and Activity*, 19:3, 222-239, 2012

Week 9 - 10/15 – FALL BREAK – NO CLASS

Interdisciplinarity

Week 10 - 10/22

J. Klein, *Crossing Boundaries: Knowledge, Disciplinarities, and Interdisciplinarities*, U. of Virginia Press, 1996, Part I

J. Klein, "Interdisciplinary teamwork: the dynamics of collaboration and integration," in *Interdisciplinary Collaboration: An emerging cognitive science*, Derry et al., Lawrence Erlbaum, 2005, Chapt. 2

Trading zones and boundary objects

Week 11 – 10/29

S. L. Star & J. Griesemer, "Institutional ecology, translations, and boundary objects," *Social Studies of Science*, 19:387-420, 1989

P. Galison, "The trading zone: coordinating action and belief," in *Image and Logic*, Cambridge U. Press, 1997

K. Henderson, "Flexible sketches and inflexible data bases: visual communication, conscription devices, and boundary objects in design engineering," *Science, Technology, & Human Values*, 16:448-473, 1991

Interdisciplinarity in S&T: case studies "in the wild"

Week 12 - 11/05

In *Interdisciplinary Collaboration: An emerging cognitive science*, Derry et al., Lawrence Erlbaum, 2005:
Chapt. 3: A. O'Donnell & S. Derry, "Cognitive processes in interdisciplinary groups"
Chapt. 4: C. Goodwin, "Seeing in depth"

L. Osbeck & N.J. Nersessian Forms of Positioning in Interdisciplinary Science
Practice and Their Epistemic Effects Journal for the Theory of Social Behaviour 40:2, 2010

Student research presentations

Week 13 - 11/12

Week 14 - 11/ 19

Week 15 – 11/26

Week 15 – 12/3 paper writing week – no class

*****papers due by noon, Monday 12/9*****