

85-122 A Freshman Seminar: The psychology of scientific thinking

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Office hours: Tues. 4:00-5:00; (or by appt.)

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Goal: The goal of this course is to help you answer four questions:

The first question is: “What does it mean to “do science”? You will discover that the answer depends on being able to define “science”, “the scientific method” and “scientific knowledge?” We will sample – a very tiny part of -- the vast literature on Science. This will involve reading selected papers on general issues relating to scientific reasoning, creativity, invention, and discovery and the practice of science. You will learn something about what philosophers, historians, sociologists have written about how science is done, and you will also see what scientists themselves have to say about the matter.

The second question is “How do people think, solve problems, reason, and make decisions?” Here too, there is vast literature, so we will look at only a small, but important part of what is known about this area of cognitive psychology. We will read selected topics from a standard textbook on thinking and problem solving. You will learn what cognitive psychologists have discovered about how people think, solve problems, reason, and make decisions. We will start by learning about psychological studies of how the mind processes relatively abstract and simple materials, and then move on to learn about very complex types of problem solving – with the aim of being able to better understand scientific problem solving.

The third question combines the first two, and asks: “How do scientists think when they are doing science?” In this part of the course, we will look at studies and papers about the cognitive psychology of science, and you will read several “primary sources”: articles from journals in cognitive psychology that deal with the psychology of scientific reasoning.

The fourth question builds on all of this and asks: “What are some of the more effective ways to teach science?” Here we will focus on early science education, and examine some of the current controversies about science education.

Participation: One of the main goals of the Freshman Seminars is to “jump start” your college experience by giving you the opportunity to express yourself actively on a regular basis, rather than just listening to what a professor tells you. Our class sessions will be a mixture of lecture and discussion. Many of the classes will be student-led. So what you (and your classmates) get out of this class will depend quite heavily on what you (and they) put into it. Thus, it is particularly important that you attend all classes and actively participate in the class discussions. In a small seminar like this one, your absence would be disruptive both to your own learning and to the sense of continuity that is important in a small seminar. Class participation will account for 25% of your grade, and if you are not here, you can’t very well participate. Of course there are unavoidable exceptions (illness, crises, personal demands) but they should be kept to a minimum.

Preparation: All of the assigned material should be read before coming to class. Before each class, you will be expected to post a few questions or comments about the reading on Blackboard (a web site containing course information More about Blackboard later) . These postings should run between 150 to 200 words, and they should indicate that you really have read the paper being discussed. It is ok to ask questions about things that are confusing, or to express your reasons for disagreeing with something in the reading. But your comments must stay on topic!! Flames and blogs belong elsewhere. For many of the classes, a pair of students

will be responsible for leading the discussion by first summarizing the main reading(s) and then responding to the questions and comments posted on Blackboard.

Postings must be completed by 9:00 PM 2 days preceding the class (so that the class discussants get a chance to prepare their presentation. *That is, comments for Tuesday's class should be posted by Sunday evening, and for Thursday's class, by Tuesday evening. Once you get into this routine, you will find it easy to keep up.*

Cheating & Plagiarism: The rules are simple: I expect your work to be your own. See the Student Handbook for the CMU's description of the consequences of cheating and plagiarism.

Grading:

Quiz 1 20%

Quiz 2 20%

Class participation 25%

- Blackboard posts 10%
- Discussion, etc. 15%

Term paper 35% (The term paper requirements will be described in a separate document.)

- Proposal 5%
- Outline 5%
- Final paper 25%

Class protocol: (1) Don't be late: Classes will start promptly. Late arrival is disruptive to your classmates, and it puts you at a disadvantage if you miss the opening context of each class. (2) Cell phones, iPods, Blackberries, etc. As a courtesy to your classmates and your instructor, please turn off your cell phones in class! (3) Laptops: Feel free to use a laptop (if you have one) for taking notes in class. Do *not* feel free to use it for e-mail, chatting, blogging, or surfing the net during class. (Even if you are surfing out of curiosity about issues and topics that arise in class, it is really quite rude to be doing that in the middle of class meetings.)

Effort: At CMU, a 9-unit course is supposed to take approximately 9 hours each week. Class time will take about 3 hours each week. The other 6 hours should be allocated approximately evenly to (a) weekly class readings and your written summaries, and (b) work on your term project. If you really put in this much time, you will be able to handle both the regular reading assignments, as well as the rest of the reading, organizing, searching, drafting and writing that will be required for your paper. However, if you simply do the class readings, and let the project slip until the end of the semester, you will have great difficulty getting your work done.

Readings: The required readings are listed on the class schedule on the next few pages of this document. All readings will be posted on Blackboard (an internet based system that allows you to access readings, check on assignments, and post your answers to class assignments and discussions.) I will describe more about Blackboard in class. For complete instructions on how to use it, go to: <http://www.cmu.edu/blackboard/> (be sure to have your Andrew password handy!)

Week	Date	Topic	Schedule	Readings
Part I: What is Science?				
1	8/28 T	<u>Introduction, Orientation</u>	BBC Science News Reports	<ul style="list-style-type: none"> • Dark fruits and Cancer • Global Warming • Einstein's gravitational theory • Scientists support union
	8/30 Th	<u>What is "Science"</u>		<ul style="list-style-type: none"> • Chap. 2 from: Duschl, R. A., Schweingruber, H. A., & Shouse, A. W. (Eds.) (2007) <i>Taking Science to School: Learning and Teaching Science in Grades K-8</i>. Washington, DC.: National Academies Press
2	9/4 T	<u>The "Scientific Method"?</u>	McComas: "Myths of Science"	
	9/6 Th	<u>From resistance to acceptance: examples of how scientific knowledge advances Continental Drift</u>		<ul style="list-style-type: none"> • Wagner, L. V W. The Great Continental Drift Mystery (1991)
3	9/11 T	Ulcers and Bacteria		<ul style="list-style-type: none"> • Thagard, P. (1998). Ulcers and bacteria I: Discovery and acceptance. <i>Studies in History and Philosophy of Science. Part C: Studies in History and Philosophy of Biology and Biomedical Sciences</i>, 29: 107-136
	9/13 Th	NO CLASS THIS THURSDAY (read ahead: note, 2 articles for Tuesday)		
4	9/18 T	<u>Relation between Science and Technology</u>		<ul style="list-style-type: none"> • Tierney, W. G. (2005) Pasteur's Quadrant and Chaos of Disciplines. (Book reviews) • Basalla, G. (1988). Diversity, Necessity, & Evolution, from: <i>The evolution of technology</i>. New York: Cambridge University Press. pp. 1-25
	9/20 Th	<u>Controversy in Science</u>		<ul style="list-style-type: none"> • Silverman, M. P. (1992) Raising questions: Philosophical significance of controversy in science. <i>Science & Education</i>, 1, 163-179
5	9/25 T	<u>Why experiment?</u>		<ul style="list-style-type: none"> • Harré, R. (1983) <i>Great Scientific Experiments: Twenty experiments that changed our view of the world</i>. New York: Cambridge U. Press, (Introduction) pp. 1-22
	9/27 Th	<u>Discovery and the Philosophy of Science</u>		<ul style="list-style-type: none"> • Kantorovich, A. (1993). <i>Scientific discovery: logic and tinkering</i>. Albany, NY: SUNY Press. pp. 1-48
6	10/2 T	<u>Term Paper assignment & Quiz Review Session</u>		<ul style="list-style-type: none"> • Distribute and document describing term paper • Quiz review session
	10/4 Th	<u>Library Session</u>		<ul style="list-style-type: none"> • How to use CMU Libraries, How to search Databases, etc.

7 10/9 T **QUIZ 1**

10/11 Th Discuss your proposals for projects

DUE in class: Brief descriptions of at least 2 possible term paper topics: Who?, When?, What discovery or invention? or 2 references (complete citation).**Part II: Brief Introduction to the Psychology of Human Problem Solving**8 10/16 T Gestalt psychology

- Mayer, Chap 1: "Beginnings" (skim) &
- Chap 3: "Gestalt: Thinking as restructuring" (main reading)

10/18 Th Induction

- Mayer, Chap 4: "Inductive reasoning: Thinking as Hypothesis testing"

9 10/23 T Rule induction & Falsification
Analogy

- TDM, pp. 92-99 (Popper), 129-144 (2-4-6-task)
- Holyoak & Thagard (1995) *Mental Leaps*. Chps 1&2

10/25 Th NO CLASS MEETING: BUT do reading & BBoard Assignment!

- Mayer, Chap 14: "Analogical Reasoning"

Part III: The Cognitive Psychology of Scientific Thinking10 10/30 T Problem solving as Search

- Mayer, Chapter 6: "Computer Simulation"

11/1 Th Scientific Discovery as Problem Solving

- Klahr (2000) Chap 2 excerpt pp 21-30.
- Mayer, 103-108 Reread

11/2 (FRIDAY, by 5:00 PM)

Proposal for term paper due11 11/6 T What do Scientists REALLY do?

- TDM, pp. 170-175
- Medawar (1990): "Is the scientific paper a fraud?"
- Medawar (1990): "The Philosophy of Karl Popper"
- Dunbar (1994): "How Scientists Really Reason"

11/8 Th

12 11/13 T **QUIZ 2**11/15 Th Do children know what they know and don't know"?

- Fay & Klahr (1995) Knowing about Guessing and Guessing About Knowing *Child Development*

11/16 FRIDAY, by 5:00

First draft of Term paper due**Part IV: Early Science Education**13 11/20 T What should be taught?

Science k-8 excerpt

11/22 Th **NO CLASS: Thanksgiving break**14 11/27 T How should it be taught?

tba

11/29 Th tba

tba

15 12/4 T

Student presentations: summaries of term papers.

12/6 Th

Student presentations: summaries of their papers.

12/9

TERM PAPER DUE**by 5:00 PM on Sunday Eve****References:**

The full citations for the readings are included in the Blackboard postings. As you will discover, many of them come from the books listed below. These books are on reserve in the Hunt Library, in case you want to read more than the few chapters that have been assigned in the course (e.g., for your term paper). The source books are:

Harré, R. (1983) *Great Scientific Experiments: Twenty experiments that changed our view of the world*. NY: Cambridge University Press

Holyoak, K.J. & Thagard, P. (1995). *Mental leaps : Analogy in creative thought*. Cambridge, Mass.: MIT Press.

Mayer, R. E. (1992). *Thinking, problem solving, cognition* (2nd Ed.). New York: W.H. Freeman and Co.

Although the book is out of print, it is quite a good introduction to cognitive psychology, so you might want to purchase it, both for the convenience of use in this course, and for future reference. You can find used copies on Amazon.com, at very reasonable prices.

(see: http://www.amazon.com/gp/offer-listing/0716722151/ref=dp_olp_2/103-5978431-2840604)

Tweney, R.D., Doherty, M.E., & Mynatt, C.R. (Eds.) (1981). *On scientific thinking*. New York: Columbia University Press. (This book is listed as **TDM** in the schedule)