University of Massachusetts at Boston
Graduate College of Education, Critical and Creative Thinking Program

---

CHILDREN AND SCIENCE
Critical and Creative Thinking 652
Spring 2005

Instructor: Dr. Carol Smith
Office: McCormack Bldg, 4th floor, Rm 265
Office Hours: Tues/Thurs, 12-1:30 & by Appointment
Telephone & email: 617-287-6359 (with answering machine) Carol.Smith@umb.edu
Course website: http://psych.umb.edu/faculty/smith/652syll.html

Class Times: Wednesday 4 - 6:30 PM
Class Meeting Place: W/2/056
Vacation Dates: Spring Vacation: March 12-20

Course Description:

The goal of this course is to understand the interpretive frameworks students of various ages bring to science class and how those frameworks influence their learning of scientific frameworks. We will explore student frameworks for a variety of science domains (e.g., the nature of earth and the movement of heavenly bodies, the human body, the nature of matter, force and motion, groundwater) as well as their more general conceptions of how they learn and do science. In addition, we will explore the teaching conditions which help students (a) bridge between their initial conceptions and scientists' conceptions and (b) deepen their understanding of scientific inquiry. Through the course, you should gain skill (a) in devising, giving, and analyzing clinical interviews designed to uncover student ideas and (b) in planning lesson sequences to promote conceptual understanding, critical thinking, and conceptual change.

Course relationship to the Professional Education Unit's (PEU) conceptual framework:

The course will help you develop a commitment to pursuing life-long learning about science education pedagogy through making you aware of the journals, websites, and professional associations that are forums for exchange of ideas about the nature of students' initial conceptions in science and the pedagogical practices that enable students to transform those conceptions. This course will also help you develop deeper understandings of science content, conceptual change teaching and assessment strategies, and innovative educational software that is designed to help students difficult science topics. This course will help you understand and value student ideas and realize that students can master key ideas in science if they are given the time and space to "reason" their way through to new understanding. Finally, this course will help you develop the knowledge, skills, and dispositions that are required to be a "reflective practioner": one who continually studies the thinking of students in your classroom, experiments with different teaching approaches, and uses this information to improve instructional practice.

Objectives of the Course:

1. Become aware of the literature on student preconceptions in science (and of the journals and professional meetings where such research is discussed) and acquire knowledge of the important findings of this literature.
2. Develop skill in devising, giving, and analyzing an individual interview that is designed to probe student conceptions about a particular science topic.
3. Become aware of the teaching strategies that allow you to engage students' initial ideas, help them clarify and extend their ideas, help them construct an understanding of new ideas (that were initially unintelligible to them), help them evaluate competing ideas in light of their capacity to explain patterns of evidence, help them revise ideas in light of their ability to account for evidence.
4. Become aware of the research findings about the effectiveness of the above teaching strategies and of the ways that reflective practioners and science education researchers have studied and assessed the effectiveness of teaching practices.
5. Analyze the discourse practices of exemplary teachers who engage their students in "reflective discourse".
6. Examine innovative educational software and reflect on the ways it can be used as a tool to promote student understanding of inquiry as well as difficult science topics
7. Develop skill in evaluating existing curricular materials in terms of the extent to which they promote inquiry, understanding of inquiry, and conceptual change, as well as devising new lessons (or modifying existing materials) so that they accomplish these goals
8. Develop your own skill at first-hand inquiry: making observations, representing observations, finding patterns of data, creating models to explain the data, using models to make new predictions, revising models in light of further data, etc.

Course Readings:

1. Osborne, R. and Freyberg, P. (1985) Learning in Science: The implications of children's science. New Zealand: Heinemann. (available for purchase in the bookstore)
2. Primary readings: Articles by leading researchers in the field (available on Electronic Reserves for UMB). These articles will be the central readings for the course that are closely discussed in class. You may access and print them from home (on the internet) or from one of the Computer Labs on campus. (see attached handout with password and instructions for how to access these articles).
3. Independent reading for papers. Note: Healey Library has the main journals that have research about student preconceptions (I will provide you will a list of key journals). In addition, you may find articles by searching the ERIC database (http://www.eduref.org) or by looking through the files of articles that I keep on student preconceptions. The Curriculum Resource Center (Healey Library 5th floor) has some curriculum materials, including 2 volumes of Tik Liem's book Invitations to Science Inquiry kept on reserve. I also keep of file of innovative curriculum materials and websites of researchers who are developing new curricular materials. Finally, three online links to science lessons are: (a) the ScienceNetlinks website (run by the AAAS) http://www.scienelinks.org; (b) the Eisenhower National Clearinghouse (www.enc.org); and the AskEric website (www.eduref.org).

Required Assignments:

1. **Moon Journal & Reflection paper** (Weekly journal entries; final reflection paper due April 27th, about 7-8 typed pages)**:** Throughout this course you will be engaged in first-hand inquiry about the moon in which you will raise questions and gather information about the patterns of the moon's appearances and disappearances and develop and test models to explain your data. As part of this inquiry you are expected to keep a moon journal in which you record your daily observations about the moon and respond to particular homework assignments on any given week. You are NOT allowed to consult any "expert" sources about the moon during this project. Rather your theorizing should develop in light of your initial knowledge about the moon, the daily observations that you make, and the exchange of ideas that occurs with classmates. At the end of the project you will be asked to write a moon journal reflection paper (approximately 7-8 pages), submitted along with a complete copy of your journal entries, in which you describe the evolution of your thinking during this inquiry and any things that you learned from this experience that would affect your views about inquiry teaching in science. In describing the evolution of your thinking, you should discuss your initial ideas, questions asked, predictions made based on those initial ideas, observations gathered to test predictions, modifications made to initial ideas in light of observations, new rounds of prediction/observation and testing, general patterns noted in observations, explanations of those patterns, etc. Your moon journal papers will be evaluated based on thoughtfulness and engagement with the inquiry process (strength of observations, willingness to consider deeper conjectures, strength of reasoning and argument about conjectures) rather than on the "correctness" of your answers per se.

2. **Rationale and design of an interview paper** (due on March 2nd, about 5 pages, plus interview script appended). In this paper, you will identify a science topic about which you want to probe a student's conceptions, identify and read 2-3 prior research articles that have probed student conceptions in this area, develop some hypotheses about what you expect your students' conceptions will be like based on this prior research, and then devise a script for your student interview that will allow you to probe their understanding in an imaginative and thorough manner. Your paper will be evaluated based on your understanding of the prior literature, your ability to formulate some specific hypotheses about how students may think about the topic and to contrast that way of thinking with the current expert conception, and the appropriateness and richness of your interview design. (Note: it is OK to build on, or use portions of interviews that prior researchers have used. Your interview does not have to be completely original.) Prior to undertaking you interview, I will give you detailed feedback on your proposed interview and you may revise the interview script in light of my feedback.

3. **Analysis of a student interview paper** (due on March 22nd, about 7 pages typed, plus an appended interview transcript). The purpose of this paper is for you to present your analysis of your student interview (after you have conducted the interview), along with a typed transcript of the interview. That way, I can look at the interview myself and offer comments about the extent to which I agree with your analysis. In presenting your analysis, you need to consider what you think students' underlying concepts are in this area, how they are organized, the evidence in your interview that supports your analysis, and the way students' conceptions appear to be similar to/different from an experts'. You should also reflect on the strengths/limitations of your interview and ways that it could be improved. Your paper will be evaluated based on the thoroughness and insightfulness of your interview and analysis as well as on your capacity to constructively criticize yourself as an interviewer

and to suggest improvements.

4. **Teaching project paper** (due on May 11th, about 12 pages typed, with appropriate appendices). The purpose of this final project is for you to demonstrate understanding of the teaching strategies that promote student inquiry, understanding of inquiry, and conceptual change. You may approach this assignment in one of two ways, either (a) describing how you would approach designing a series of lessons that take a conceptual change approach to teaching a topic and that also involve students in inquiry and deepening their understanding of inquiry; or (b) evaluating an existing series of lessons in terms of their ability to promote an understanding of inquiry and conceptual change, and then suggesting ways these lessons can be modified or improved. Note, as part of doing this project you will need to identify interesting curriculum materials that address a science topic that interests you. Your paper will be evaluated based on what it shows about your understanding of teaching strategies that promote inquiry, understanding of inquiry, and conceptual change.

Summary of Course Requirements and Methods of Evaluation:

Requirement	Relevant Objective	Due Date	Percent of Grade
Design of interview paper	1,2	March 2nd	15%
Interview analysis paper	1,2	March 23rd	15%
Moon journal	8	April 27th but kept daily	10%
Moon journal reflection paper	8	April 27th	15%
Teaching project paper	3,4,7	May 11h	20%
Attendance, participation, and completion of in-class exercises[1]	1,2,3,4,5,6,7,8	All classes	25%

[1]It is expected that students will attend class regularly and come to class prepared to take part in discussion. At most, only two classes should be missed if students expect to earn a grade of B or better in Attendance/participation.

Accommodations: Section 504 and the Americans with Disabilities Act of 1990 offer guidelines for curriculum modifications and adaptations for students with documented disabilities. If applicable, students may obtain adaptation recommendations from the Ross Center (287-7430). The student must present these recommendations to and discuss them with each professor within a reasonable period, preferably by the end of the Drop/Add period.

Academic honesty: Students are required to adhere to the Code of Student Conduct, including requirements for academic honesty, delineated in the University of Massachusetts Boston Graduate Student Bulletin, Undergraduate catalog, and relevant program student handbook(s).

Policy on Incompletes: Incompletes can only be if you have an emergency or exceptional circumstances toward the end of the semester, if only a small portion of the work remains to be completed, and if you meet with me prior to the end of the semester to fill out an incomplete contract.

Students are advised to retain a copy of this syllabus in personal files for use when applying for certification, or transfer credit.

TENTATIVE SCHEDULE OF TOPICS AND READINGS
(Readings are to be completed prior to coming to class)

Part 1: Student Conceptions and Models

Week 1 (Jan. 26). Introduction (Classes Cancelled: Snow Day)

Week 2 (Feb. 2). Exploring children's science: models of the earth and heavenly bodies

- Osborne & Freyberg, chap 1 (Children's Science) & 2 (Science Teaching and Science Learning), pp. 1-27.
- Nussbaum, J. (1985). The Earth as a cosmic body. In R. Driver, E. Guesne, & A. Tiberghien, Children's ideas in science (pp. 170-192). Philadelphia, PA: Open University Press.

Week 3 (Feb. 9). Exploring children's science: what's alive?

- Osborne & Feyberg, chap. 3 (Language in the Science Classroom), pp. 29-40.
- Carey, S. (1988) Conceptual differences between children and adults. Mind and Language, 3, 167-181.
- Kuhn, T. (1957). "The heavens in primitive cosmology" and "The apparent motion of the sun" (pp. 4-12) In The Copernican Revolution. Cambridge, MA: Harvard University Press.

Week 4 (Feb. 16): Exploring children's science: models of the human body

- Carey, S. (1985) Chapter 2 "The Human Body" (pp. 41-71). In Conceptual change in childhood. Cambridge: MIT Press.
- Kuhn, T. (1957). "The birth of cosmology--the two-sphere universe" (pp. 25-41). In The Copernican Revolution. Cambridge, MA: Harvard University Press.

Week 5 (Feb. 23): Exploring children's science: models of matter

- Osborne, R. & Freyberg, P. (1985) Appendix A "Finding out what children think", 151-165.
- Carey, S. (1991) Knowledge acquisition: Enrichment or Conceptual Change (read part starting with "The Evidence", pp. 269-287). In S. Carey and R. Gelman, (Eds.) Epigenesis of Mind. Hillsdalell, NJ: Lawrence Erlbaum Associates.
- Novick, S. and Nussbaum, J. (1981) Pupils' understanding of the particulate nature of matter: A cross age study. Science Education, 65 (2), 273-281.

Week 6 (March 2): Metacognition: student's conceptions of science and learning

- Carey, S. & Smith, C. (1993). On understanding the nature of scientific knowledge, Educational Psychologist, 28, 235-243, plus Appendix A-C.
- Driver, R. et al. (1995). A framework for characterizing features of students epistemological reasoning in science. In Young people's images of science.
- Rigden, J.S. & Tobias, S. (Jan, 1991). Tune in, turn off, drop out. Sciences, 16-20.

- **Paper 1 (Rationale and Design of Interview) is due**

Part 2: Teaching for Conceptual Change and Understanding

Week 7. (Mar. 9): Teaching for Conceptual Change: Overview of a Framework for Science Teaching

- Roth, K. (1984) Using classroom observations to improve science teaching and curriculum materials (pp. 1-20)
- Strike, K. & Posner, G. (1985). A conceptual change view of learning and understanding. In L. West and A. Pines (Eds.), Cognitive structure and conceptual change (pp. 211-231). New York: Academic Press.
- Osborne, R. & Freyberg, P. (1985) Chapter 7 "Assumptions about teaching and learning" & Chapter 8 "The role of the teacher", pp. 82 - 99.

SPRING VACATION WEEK: March 12-20

Week 8. (Mar. 23): Classroom dialogues

- Osborne, R. & Freyberg, P. (1985) Chap. 6 "Facing the mismatches in the classroom", 66-80.
- Minstrell, J. (1982) Explaining the 'at rest' condition of an object, Physics Teacher, 20, 10-14.
- Minstrell, J. (1984) Teaching for the development of understanding of ideas: Forces on moving objects. AETS Yearbook.
- Swift, J. Nathan, Gooding, C. Thomas, & Swift, Patricia R. Using Wait Time to Improve the Quality of Classroom Discussion. In Research Matters...To the Science Teacher.
- Sadker, M. & Sadker, D. (March, 1986). Sexism in the classroom: From grade school to graduate school. Phi Delta Kappan, 512-515.

- **Paper 2 (Analysis of Interview) is due**

Week 9. (March 30): Using metacognition to enhance classroom dialogues and student learning.

- Hennessey, M. & Beeth, M. (1993) Students' reflective thoughts about science content: A relationship to conceptual change learning. Paper presented at the annual meeting of the American Educational Research Association, Atlanta, GA. (pp. 1-32)
- Beeth, M. and Hewson, P. (1999) Facilitating learning of science content and scientific epistemology: Key elements in teaching for conceptual change. Paper presented at the meeting of the National Association for Research in Science Teaching, Boston, MA.

Week 10. (April 6): Pathways to learning: Using bridging analogies and models to enhance understanding

- Osborne, R. & Freyberg, P. (1985) Chapter 5 "Relating the new to the familiar", pp. 51 - 65.
- Brown, D. (1992) Using examples and analogies to remediate misconceptions in physics: Factors influencing conceptual change. Journal of Research in Science Teaching, 29, 17-34.
- Smith, C., Maclin, D., Grosslight, L., and Davis (1997) "Part 2: Comparison of the Effectiveness of Two Approaches to Teaching About Matter and Density", pp. 357-369, Cognition & Instruction.
- Waters, B. (1994). The groundwater curriculum. (Introductory excerpts).

Week 11. (April 13). Pathways to learning: Cycles of model evaluation and revision.

- Lehrer, R., Schauble, L., Strom, D., & Pligge, M. (2001). Similarity of form and substance: Modeling material kind. In S. Carver & D. Klahr (Eds.), Cognition and instruction: Twenty-five years of progress. Mahwah, NJ: Erlbaum.
- Passmore, C. and Stewart, J. (2002) A Modeling Approach to Teaching Evolutionary Biology in High Schools, Journal of Research in Science Teaching, 39 (3), 185-204. (Section 1 and 2 of the Natural Selection Curricular Materials at the website: http://www.wcer.wisc.edu/ncisla/muse)

Week 12. (April 20) Using technology to enhance science learning

- Perkins, D. & Unger, C. (1994). A new look in representations for mathematics and science learning, Instructional Science, 22, 1-37.

Week 13 (April 27). Moon model presentations/Improving Assessment

- Atkin, J., Black, P. & Coffey, J. (2001). The case for strengthening assessment in the science classroom, pp. 11-22. Washington, D.C.: National Academy Press.
- Donovan, J. (1989) Chapter 4 "Writing in science" in Process writing: A comprehensive methodology for teaching thinking and learning science, (pp. 89-110) Master's thesis, Critical and Creative Thinking Program, University of Massachusetts/Boston

- **Moon Journals and Reflection Paper Due**

Week 14 (May 4) Assessing the adequacy of current science curricula and assessments

- Kesidou, S. and Roseman, J. (2002) How well do middle school science programs measure up? Findings from Project 2061's Curricular Review, Journal of Research in Science Teaching 39 (6), 522-549.
- Stern, L. and Ahlgren, A. (2002) Analysis of Students' Assessments in Middle School Curriculum Materials: Aiming Precisely at Benchmarks and Standards, Journal of Research in Science Teaching, 39 (9), 889-910.
- Massachusetts Department of Education, Science & Technology Exam Questions for Grades 4, 8, and 10. Massachusetts Comprehensive Assessment System.

Week 15 (May 11) Conclusions and course evaluations

- Brief presentations of individual projects
- **Teaching Project Paper is due**

.