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

---

CHILDREN AND SCIENCE
Critical and Creative Thinking 652
Spring 2002

Instructor: Dr. Carol Smith
Office: McCormack Bldg 4th floor, Rm 265
Office Hours: Monday, 9-10 , Wednesday & Friday 12:00-1, & by Appointment
Telephone & email: 617-287-6359 (with answering machine) Carol.Smith@umb.edu

Class Times: Wednesday 4 - 6:30 PM
Class Meeting Place: Science Bldg 4th floor, Rm 064
Vacation Dates: Spring Vacation: March 16-24

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. Reading packet (available from instructor): a collection of articles that will be discussed each week in class.
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 data base (http://ericir.syr.edu/Eric/) or by looking through the files of articles that I keep on student preconceptions. The Curriculum Library (Healey 5th floor) is a good source for curriculum materials. I also keep of file of innovative curriculum materials and websites of researchers who are developing new curricular materials.

Required Assignments:

1. **Moon Journal papers: Two papers reflecting on and describing your moon journal** (one due on March 6th, and the other on May 1st; each about 7 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. 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. Your moon journal papers will be evaluated in light of what they show about your engagement with the inquiry process (strength of observations, willingness to consider deeper conjectures, strength of reasoning and argument about conjectures) and not on how knowledgeable you are about "expert" answers.

2. **Rationale and design of an interview paper** (due on February 27th, about 5 pages, with 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 his/her 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 27th, 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 your student's underlying concepts are in this area, how they are organized, the evidence in your interview that supports your analysis, and the way your student's 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. **Curriculum project paper** (due on May 15th, 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 (ideally it is the same topic for which you researched student conceptions in assignments 2 and 3 listed above). 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. A brief presentation (20 minutes) based on this project will be made to class members in the final two weeks of the course. The presentation will be evaluated based on your ability to communicate clearly, effectively, and in an interesting manner with class members about your project and to provide them with an informative 1-page handout about your project.

Summary of Course Requirements and Methods of Evaluation:

Requirement	Relevant Objective	Due Date	Percent of Grade
Moon journal paper: I	8	March 6th	10%
Moon journal paper: II	8	May 1st	10%
Design of interview paper	1,2	February 27th	15%
Analysis of interview paper	1,2	March 27th	15%
Curriculum project paper	3,4,7	May 15th	25%
Class Presentation	3,4,7	May 8th or May 15th	5%
Attendance, participation, and completion of in-class exercises[1]	1,2,3,4,5,6,7,8	All classes	20%

[1]It is expected that students will attend class regularly and come to class prepared to take part in discussion (i.e., having read the required reading carefully before coming to class and having made moon observations they are prepared to share and discuss). It is also expected that students will help create a positive learning environment by arriving promptly, listening respectfully, and participating constructively. If students must miss a class, they should contact me ahead of time (if possible) and make arrangements to make up any missed in-class activities and to obtain course readings and handouts. At most, only two classes should be missed if students expect to earn a grade of B or better in Attendance/participation.

Accomodations:

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).

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

(The readings for a given week will be distributed at the previous class along with a reading guide. Readings listed for a given week are to be read PRIOR to coming to class for that week, as they will form the basis for class discussion.)

PART 1: STUDENT CONCEPTIONS AND MODELS

Week 1 (Jan. 30). Introduction

Week 2 (Feb. 6). 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.
- Kuhn, T. (1957). "The heavens in primitive cosmology" (pp. 4-8) and "The apparent motion of the sun" (pp. 8-12). In The Copernican Revolution. Cambridge, MA: Harvard University Press.

Week 3 (Feb. 13). Exploring children's science: models of the human body and biological processes

- Osborne & Feyberg, chap. 3 (Language in the Science Classroom), pp. 29-40.
- Carey, S. (1985) Chapter 2 "The Human Body" (pp. 41-71). In Conceptual change in childhood. Cambridge: MIT Press.
- Wood-Robinson, C. (1995) Children's biological ideas: Knowledge about ecology, inheritance, and evolution. In: S. Glynn and R. Duit (Eds.) Learning Science in the Schools: Research Reforming Practice. Mahway, NJ: Lawrence Erlbaum Associates.
- Kuhn, T. (1957). "The birth of cosomology—The two-sphere universe", "The sun in the two-sphere universe", & "The functions of a conceptual scheme" (pp. 25-41) In The Copernican revolution. Cambridge, MA: Harvard University Press.

Week 4 (Feb. 20): Exploring children's science: models of matter

- Osborne, R. & Freyberg, P. (1985) Appendix A "Finding out what children think", 151-165.
- Smith, C, Maclin, D., Grosslight, L., & Davis, H. (1997). Starting conceptions—Commonsense matter theories, Cognition and Instruction, 15, pp. 321-327.
- Nussbaum, J. (1985). The particulate nature of matter in the gaseous phase. In R. Driver, E. Guesne, & A. Tiberghien, Children's ideas in science (pp. 124-144). Philadelphia, PA: Open University Press.

Week 5 (Feb. 27): 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.
- Grosslight, L., Unger, C., Jay, E., and Smith, C. (1991) Understanding models and their use in science. Conceptions of middle and high school students and experts. Journal of Research in Science Teaching, 28, 799-822.
- Rigden, J.S. & Tobias, S. (Jan, 1991). Tune in, turn off, drop out. Sciences, 16-20.

Rationale and Design of Interview paper is due

PART 2: TEACHING FOR CONCEPTUAL CHANGE AND UNDERSTANDING

Week 6. (Mar. 6). The Framework: Teaching for Conceptual Change

- Osborne, R. & Freyberg, P. (1985) Chapter 7 "Assumptions about teaching and learning" & Chapter 8 "The role of the teacher", pp. 82 - 99.
- 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.
- Smith, C. (in press) Conceptual Change. In J. Guthrie (Ed.), Encyclopedia of Education, 2nd Edition.
- Roth, K. (1984) Using classroom observations to improve science teaching and curriculum materials (pp. 1-20)

First Moon Journal paper is due

Week 7. (Mar. 13): Classroom dialogues

- Osborne, R. & Freyberg, P. (1985) Chapter 6 "Facing the mismatches in the classroom", pp. 66-80.
- Minstrell, J. (1982) Explaining the 'at rest' condition of an object, Physics Teacher, 20, 10-14.
- Simpson, D. (2000). Collaborative conversations: Strategies for engaging students in productive dialogue. In J. Minstrell and E. van Zee (Eds.) Inquiring into Inquiry Learning and Teaching in Science. Washington, DC: AAAS.
- 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.

SPRING VACATION WEEK: March 16-24

Week 8. (Mar. 27): 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)
- Gunstone, R.F. & Mitchell, I.J. (1997) Metacognition and conceptual change. In J.J. Mintzes, J.H. Wandersee, & J.D. Novak (Eds.) Teaching Science for Understanding. San Diego: Academic Press.

Analysis of a Student Interview paper is due

Week 9. (April 3): 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. and Clement, J. (April, 1987) Overcoming misconceptions in mechanics: A comparison of two example-based teaching strategies. Paper presented at the American Educational Research Association Meetings, pp.1-33.
- Smith, C, Maclin, D., Grosslight, L., & Davis, H. (1997) A comparison of the effectiveness of two approaches to teaching about matter and density, Cognition and Instruction, 15, 357-369.
- Waters, B. (1994). The groundwater curriculum. (Introductory excerpts).

Week 10. (April 10): Using technology to enhance science education

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

Week 11. (April 17). Writing to learn

- 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

Week 12 (April 24). Putting it all together: Model-based approaches to teaching science & inquiry

- Cartier, J., Passmore, C., & Stewart, J. (2001). Balancing generality and authenticity: A framework for science inquiry in education. Paper presented at the International History, Philosophy, and Science Teaching Organization 6th international conference. Denver, Colorado.
- Passmore, C. and Stewart, J. (in press) A modeling approach to teaching evolutionary biology in high schools. Journal of research in science teaching.

Weeks 13. (May 1). Thinking critically and creatively about standards and assessment: Discussion

of the Massachusetts Science & Technology Curriculum Frameworks and related MCAS Exam in light of issues raised in course

- Massachusetts Department of Education, Science & Technology/Engineering Curriculum Framework (Malden, 2001)
- Massachusetts Department of Education, Science & Technology Exam Questions for Grades 4, 8, and 10. Massachusetts Comprehensive Assessment System.

Second Moon journal paper is due

Week 14. (May 8) Student presentations

Week 15. (May 15). Student presentations and course evaluations

Curriculum Project paper is due

Policy on Incompletes:

I follow the University guidelines for granting 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.