EDUC56:
STEM and Education

Winter Term, 2013	Prof. David J.M. Kraemer, PhD
Tuesdays, Thursdays 2:00 – 3:50	*david.kraemer@dartmouth.edu*
Xhr: Wednesday 4:15 – 5:05	Office: Raven 205
Moore 110	*Office hrs: Tue, Thu 4:00-5:00; Wed 3:00-4:00*

COURSE DESCRIPTION

How do we learn, understand, and teach science, technology, engineering, and math (the STEM disciplines)? In this class, we will explore the nature and development of the scientific mind; how we formulate theories, design experiments, and understand scientific, technological, and mathematical concepts; and how we learn and teach related skills in the classroom, addressing the debate about the effectiveness of direct instruction and hands-on approaches.

COURSE GOALS

This course challenges students to think critically about the relationship between what we know about the mind from experimental research and how we teach students to learn in actual classroom settings. In-class discussion of assigned readings is a critical component of this course. We will discuss such topics as how people learn mathematical and scientific reasoning, how knowledge is stored and organized in the mind, and how schools have used and could use the findings of psychological research to improve student learning. Developing the skills of critically reading empirical research articles, writing a research paper for a scientific audience, and using knowledge of the scientific literature to argue for a specific position are central to achieving these course goals.

GRADING OVERVIEW

15% Class Participation
10% Short Opinion Paper
25% Pop Quizzes (5)
25% Debate Presentation and Position Paper
25% Final Examination

GENERAL POLICIES

1. **Read all materials and prepare for class.** You are expected to read the materials posted on Blackboard *before* each class. Be prepared to discuss that material *in class*. Everyone is expected to come to every class and to arrive on time. You are also expected to contribute to class discussion. You will learn the material better and others will learn from you. The success of this course depends on everyone coming to class prepared and ready to discuss the material. Both attendance (on-time) and preparation for class will determine a portion of your grade (see "Assignments and Assessments" below).
2. **Tell me sooner rather than later.** If you know ahead of time that you will be missing a class, e.g., for sports or religious observance, please let me know in advance in order to avoid losing course credit.
3. ***ASSUME THAT I WILL NOT ACCEPT LATE ASSIGNMENTS.***
4. **Cell phones are not to be used in class.** If an emergency arises that requires the use of a phone, please quietly excuse yourself from the room to respond.
5. **Accommodations.** Students with learning, physical, or psychiatric disabilities enrolled in this course who may need disability-related classroom accommodations are encouraged to make an office appointment to see me early in the semester (i.e., within the first two weeks). If you have not done so already, students requiring disability-related accommodations should register with the Student Accessibility Services office regarding Dartmouth's policies and available resources: http://www.dartmouth.edu/~accessibility/
6. **Plagiarism is unacceptable.** All work submitted as your own must be written by you and not previously submitted for any other class. It is important to attribute material that is the work of others to the original source. If you are unsure how to properly cite a source, please consult with me prior to handing in an assignment. You should be familiar with Dartmouth's Academic Honor Principle, which applies to all courses at Dartmouth (available here: www.**dartmouth**.edu/~uja/**honor**/). I do not expect any violations of this code, but if any concerns do arise I will forward all related materials to Dartmouth's Committee on Standards.
7. **Before you turn in your papers…** make sure that you use 12-point Times New Roman font, that you double-space the whole document, that your print margins are 1-inch on all sides (not the default in *Word)*, that all your pages are numbered, and that your document is stapled together (if printed). For citations in all papers, you must use APA Style formatting (refer to the APA Style Manual or online guides, such as: http://owl.english.purdue.edu/owl/resource/560/01/)

ASSIGNMENTS and ASSESSMENTS

Class Participation & Attendance (15%)

- Arrive on time for each class
- Prepare for class discussions (read the assigned materials, stay awake during class, stay off internet, etc.)
- Demonstrate that you are familiar with the assigned readings. Complete understanding of the readings prior to class discussion is not expected – questions about the readings are always encouraged. Hopefully discussion will help elucidate any confusing aspects of the articles. In this way, your comments and questions will help everyone understand the material in greater depth.

Debate Presentation and Position Paper (25%)

- On two separate occasions, two groups will debate a given motion (see schedule for the motions) – one group will argue for the motion and one against.
- Each team will research the given topic and, as a group, decide on the best evidentiary and logical support for their assigned position.
- The groups will divide the relevant aspects of their argument amongst their members such that each team member (except one) will make an opening statement reflecting a different aspect of their team's overall argument.
- Following the opening statements, class members who are not debating (i.e., the audience), will each ask a question directed at one or both teams.
- Finally, the team member on each team who did not make an opening statement will make a closing statement summarizing his or her team's position and incorporating points that were raised during the debate.
- At the start of the debate, I will poll the audience to determine what percentage agrees with the motion prior to the debate. I will poll again afterwards to see if anyone was persuaded by the debate to change his or her mind. The team who persuades the most audience members to choose their side wins the debate.
- Prior to the debate, each team will post 1 reading to Blackboard that they deem the most pertinent for the audience to read in advance. Each debate will take place on a Thursday and these readings are to be posted on Blackboard no later than the preceding Tuesday.
- Each team will meet with me during the X-hour on the day prior to the debate to outline their arguments and get my feedback. At this time, a draft position paper is due from each team member that summarizes your team's position, emphasizing your unique contribution to the team's literature research. The draft can be in mostly outline format, but must contain at least 4 relevant scientific references. At least one of these must not be used by any other team member.
- The final version of the position paper will be roughly 7 pages in length (before References), will follow APA Style guidelines for a research paper (see Policies), and is **due on the Tuesday** following your team's debate. It should incorporate key points from the debate and have no fewer than 8 references.

Short Opinion Paper (10%) – *DUE: JANUARY 24th*

- A 2-3 page paper responding to a topic related to those discussed in class (TBA)
- Paper must cite at least 2 new sources (≥ 1 peer-reviewed scientific article)
- Full credit will be given for the above criteria and submitting the paper on time.
- This is meant as a low-stakes opportunity for me to provide feedback on writing for a scientific audience.

Pop Quizzes (5 @ 5% each)

- Will consist of short answer and fill-in-the-blank questions
- Covers recently assigned class readings
- These are intended to be low-stakes opportunities for me to track your understanding of the material.

Final examination (25%) – *WEDNESDAY, MARCH 13th @ 3pm*

- Mix of short answer and fill-in-the-blank questions

SCHEDULE OF TOPICS AND READINGS

COURSE INTRODUCTION

Tuesday, January 8

Course overview, review syllabus, choose debate topics

MAGNITUDE AND THE APPROXIMATE NUMBER SENSE (ANS)

Thursday, January 10

Readings:

1) Cantlon, J. F., & Brannon, E. M. (2006). Shared system for ordering small and large numbers in monkeys and humans. Psychological Science, 17(5), 401–406.
2) Berger, A., Tzur, G., & Posner, M. I. (2006). Infant brains detect arithmetic errors. Proceedings of the National Academy of Sciences, 103(33), 12649–12653.

CORRELATES OF THE ANS; BOOTSTRAPPING

Tuesday, January 15

Discuss upcoming short paper assignment

Readings:

1) Halberda, J., Mazzocco, M. & Feigenson, L. (2008). Individual differences in nonverbal number acuity predict maths achievement. Nature, 455, 665-668.
2) Carey S. (2004). Bootstrapping and the origin of concepts. *Daedalus*, Winter, 59-68.

X-Period *(optional)*: BRAIN BASICS

Wednesday, January 16

Discuss basics of brain anatomy, understanding fMRI results

ROLE OF LANGUAGE IN MATH; TRIPLE CODE MODEL

Thursday, January 17

Readings:

1) Dehaene, S. (1992). Varieties of numerical abilities. Cognition, 44(1), 1–42.
2) Schmithorst, V. J., & Brown, R. D. (2004). Empirical validation of the triple-code model of numerical processing for complex math operations using functional MRI and group Independent Component Analysis of the mental addition and subtraction of fractions. NeuroImage, 22(3), 1414–1420.

MATH INSTRUCTION STRATEGIES; ARITHMETIC

Tuesday, January 22

Readings:

1) Slavin, R. E., & Lake, C. (2008). Effective programs in elementary mathematics: A best-evidence synthesis. Review of Educational Research, 78(3), 427–515.
2) Carpenter, T. P., Fennema, E., & Franke, M. L. (1996). Cognitively guided instruction: A knowledge base for reform in primary mathematics instruction. The Elementary School Journal, 3–20.

X-Period *(optional)*: WRITING A RESEARCH PAPER

Wednesday, January 23

Formatting APA style, using reference databases (ERIC, PsycInfo, PubMed), using a reference manager (Zotero)

ALGEBRA AND FRACTIONS; GEOMETRY AND CALCULUS

Thursday, January 24

SHORT OPINION PAPER DUE

Readings:

1) Ritter, S., Anderson, J. R., Koedinger, K. R., & Corbett, A. (2007). Cognitive Tutor: Applied research in mathematics education. Psychonomic bulletin & review, 14(2), 249–255.
2) Krueger, F., Spampinato, M. V., Pardini, M., Pajevic, S., Wood, J. N., Weiss, G. H., … Grafman, J. (2008). Integral calculus problem solving: an fMRI investigation. Neuroreport, 19(11), 1095.

MATH ANXIETY AND STEREOTYPE THREAT; INDIVIDUAL DIFFERENCES

Tuesday, January 29

Readings:

1) Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math performance, and math anxiety. Psychonomic Bulletin & Review, 14(2), 243–248.
2) Krendl, A. C., Richeson, J. A., Kelley, W. M., & Heatherton, T. F. (2008). The Negative Consequences of Threat A Functional Magnetic Resonance Imaging Investigation of the Neural Mechanisms Underlying Women's Underperformance in Math. Psychological Science, 19(2), 168–175.

X-Period *(required for Debate 1 teams)*: DEBATE PREP

Wednesday, January 30

DRAFT POSITION PAPER DUE

Meet with each team to outline their positions

DEBATE #1

MOTION: *"'Singapore Math' is the most effective instructional approach."*

Thursday, January 31

Readings:

1) TBA by Debate Group 1
2) TBA by Debate Group 2

MATH AS A BASIS FOR UNDERSTANDING SCIENCE; NAÏVE SCIENCE CONCEPTS

Tuesday, February 5

*****FINAL POSITION PAPER DUE FOR DEBATE 1 GROUPS*** **

Readings:

1) Reiner, M., Slotta, J. D., Chi, M. T. H., & Resnick, L. B. (2000). Naive physics reasoning: A commitment to substance-based conceptions. Cognition and Instruction, 18(1), 1–34.
2) Goldberg, R. F., & Thompson-Schill, S. L. (2009). Developmental "roots" in mature biological knowledge. Psychological science, 20(4), 480–487.

LEARNING TO THINK AS A SCIENTIST: OBSERVING, QUANTIFYING, TESTING

Thursday, February 7

Readings:

1) Kuhn, D., & Pearsall, S. (2000). Developmental origins of scientific thinking. Journal of cognition and Development, 1(1), 113–129.
2) Chen, Z., & Klahr, D. (1999). All other things being equal: Acquisition and transfer of the control of variables strategy. Child development, 70(5), 1098–1120.

CONCEPTUAL MENTAL MODELS; ANALOGY IN SCIENTIFIC DISCOURSE

Tuesday, February 12

Readings:

1) Kastens, K., & Rivet, A. (2010). Using analogical mapping to assess the affordances of scale models used in Earth and environmental science education. Spatial Cognition VII, 112–124.
2) Chan, J., Paletz, S. B. F., & Schunn, C. D. (2012). Analogy as a strategy for supporting complex problem solving under uncertainty. Memory & Cognition, 1–14.

LEARNING THE VOCABULARY OF SCIENCE; LEARNING VIA OBSERVATION

Thursday, February 14

Readings:

1) Nehm, R. H., Ha, M., & Mayfield, E. (2012). Transforming biology assessment with machine learning: automated scoring of written evolutionary explanations. Journal of Science Education and Technology, 21(1), 183–196.
2) Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. Annu. Rev. Neurosci., 27, 169–192.

****Last Day To Drop 4th Class Without Receiving a 'W': Monday, February 18th****

LEARNING THROUGH LAB EXPERIENCE; EMBODIED LEARNING

Tuesday, February 19

Readings:

1) Hickok, G. (2009). Eight problems for the mirror neuron theory of action understanding in monkeys and humans. Journal of cognitive neuroscience, 21(7), 1229–1243.
2) Klahr, D., & Nigam, M. (2004). The equivalence of learning paths in early science instruction Effects of direct instruction and discovery learning. Psychological Science, 15(10), 661–667.

X-Period *(required for Debate 2 teams)*: DEBATE PREP

Wednesday, February 20

DRAFT POSITION PAPER DUE

Meet with each team to outline their positions

DEBATE #2

MOTION: *"Performance activities are more effective than the alternatives."*

Thursday, February 21

Readings:

1) TBA by Debate Group 3
2) TBA by Debate Group 4

****Last Day To Withdraw (Without A Petition): Tuesday, February 26th****

SMART BOARDS AND CLASSROOM TECH; VIDEO GAMES, ED SOFTWARE

Tuesday, February 26

FINAL POSITION PAPER DUE FOR DEBATE 2 GROUPS

Readings:

1) Preston, C., & Mowbray, L. (2008). Use of SMART Boards for teaching, learning and assessment in kindergarten science. Teaching Science, 54(2), 50–53.
2) Chase, C. C., Chin, D. B., Oppezzo, M. A., & Schwartz, D. L. (2009). Teachable agents and the protégé effect: Increasing the effort towards learning. Journal of Science Education and Technology, 18(4), 334–352.

ONLINE INSTRUCTION; ONLINE MATH AND SCIENCE TUTORING

Thursday, February 28

Readings:

1) Yeh, Y. C. (2009). Integrating e-learning into the Direct-instruction Model to enhance the effectiveness of critical-thinking instruction. Instructional Science, 37(2), 185–203.

2) Sitzmann, T., Kraiger, K., Stewart, D., & Wisher, R. (2006). The comparative effectiveness of web-based and classroom instruction: A meta-analysis. Personnel Psychology, 59(3), 623–664.

ADVANCED SCIENCE AND ENGINEERING INSTRUCTION

Tuesday, March 5

Readings:

1) Thompson, M. E., Ford, R., & Webster, A. (2011). Effectiveness of Interactive, Online Games in Learning Neuroscience and Students' Perception of the Games as Learning Tools A Pre-experimental Study. Journal of allied health, 40(3), 150–155.
2) Prince, M. (2004). Does active learning work? A review of the research. JOURNAL OF ENGINEERING EDUCATION-WASHINGTON-, 93, 223–232.

ENGINEERING INSTRUCTION: COMPUTER PROGRAMMING; COURSE WRAP-UP

Thursday, March 7

Readings:

1) Emurian, H. H., Holden, H. K., & Abarbanel, R. A. (2008). Managing programmed instruction and collaborative peer tutoring in the classroom: Applications in teaching Java™. Computers in Human Behavior, 24(2), 576–614.
2) Kazimoglu, C., Kiernan, M., Bacon, L., & Mackinnon, L. (2012). A Serious Game for Developing Computational Thinking and Learning Introductory Computer Programming. Procedia-Social and Behavioral Sciences, 47, 1991–1999.

FINAL EXAM

Wednesday, March 13 @ 3pm