Tuesday - Thursday 4:30 – 5:50 **Baker Hall 340A**

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Perhaps the most influential piece of education legislation passed in recent years is the 2002 "No Child Left Behind Act" (NCLB). One of the most widely-known consequences of the law is Its emphasis on assessment, an emphasis that has wide-spread implications for the way that American children will be taught and tested and the way that schools will be evaluated and rewarded. Associated with this issue are some politically divisive questions about who will pay for all of this testing and which groups and social strata will benefit in the long run. These issues, although extremely important, will not be addressed in this seminar. A second consequence of NCLB is its repeated call for *scientifically based education research.* Consequently, the opportunity has never been greater for basic research in cognitive science to contribute to educational practice. *That* is the topic of this seminar.

This focus on turning educational research into a rigorous scientific endeavor raises many challenging questions:

What does "scientifically based education research" mean?

- Does it mean the sort of studies that cognitive and developmental psychologists do when they are interested in how students think about math or science?
- Does it mean massive national randomized field trials on the effect of class size or teacher training?
- Does it have to include the kind of emphasis on underlying mechanisms that we (in Pittsburgh!) are so interested in discovering?
- Can it include non-experimental, qualitative, case studies and field demonstrations?
- Does it require statistical significance, or large effect sizes, or both? Must it include new technologies or traditional teacher-student interactions?

What constitutes a treatment or an independent variable: the content of a lesson, the instructional approach, the qualifications of the teacher, the attributes of the students, the philosophical and educational "approach"?

What is the appropriate grain size of the measurements and analyses: individual students, classrooms, teachers, schools, or school districts?

How can traditional academic research in cognitive science contribute to improving the science of education?

Can we point to examples that warrant the label of "scientifically based education research", and can such research inform policy and practice in ways that have substantial impact?

What happens when other stakeholders, such as practitioners, academics from other disciplines (historians, philosophers, "hard" scientists), professional groups, advocacy groups, policymakers, issue-oriented “think-tanks”, and the media begin to assess and comment on what the research enterprise is producing?

Clearly, there is enough here to fill several semesters, if not years. The approach will be "a bit of breadth and a bit of depth". We will explore these questions by (a) Looking briefly at the history of education research, (b) reading and discussing some of the broad policy statements, as well as a few of the highly contentious debates in the literature about the nature of educational research; and (c) reading and discussing several of the more "conventional" studies -- i.e., articles that appear in the scholarly journals in psychology, cognitive science, and education bearing about how children learn math and science. These

different types of papers will be interleaved throughout the course so that we get a sense of the interaction between basic research in education and "hot" policy issues.

Texts and initial readings. Scientists, historians, and philosophers of science have debated the nature of "scientific research" in education for more than 100 years, and politicians have been adding their own twists whenever it suited them. This is quite a fascinating history, and could easily comprise a course of its own. We don't have time for that, but we will get oriented to the topic by starting with readings from *An Elusive Science: The Troubling History of Educational Research* (Lagemann, 2000) Next, we will read a recent publication based on the deliberations of a "blue-ribbon panel" commissioned by the National Research Council, and published by the National Academies Press: Shavelson & Towne (2002) *Scientific Research in Education*[1]. This book is available as the text for this course in the CMU bookstore. You can also order it directly from the publisher, or, if you are really patient, you can read it on-line for free (or download it -- one PDF page at a time!).

Following that, we will jump in feet first to a timely and strongly opinionated assessment of state science standards. Then we will selectively review some of the empirical studies in cognitive psychology, cognitive science, and cognitive development whose results might be relevant to the problem of increasing the scientific basis of proposed improvements in teaching and learning in real classrooms. We will also look at studies dealing with the creation, implementation, and evaluation of new approaches to instruction. We will examine a variety of such interventions, ranging from specific topics to entire curricula. Our focus will be primarily, but not exclusively, on in the area of science and math, and primarily, but not exclusively, on elementary and middle school instruction.

Many of the readings will come from *Educational Researcher* a publication of the American Educational Research Association (AERA). It is available, free, on-line, at: http://www.aera.net. All readings will be posted on the Blackboard system for easy downloading, and we will use the discussion board. (http://www.cmu.edu/blackboard/)

Class demographics. This is a joint graduate/advance undergraduate seminar. For most of the graduate students, this is a required "intro" course to their graduate program in educational research (PIER)[2]. The grad students come from several departments, including Psychology, Philosophy, and HCII. The undergrads are mostly psychology majors. Although some of the grads have psychology undergraduate degrees, some do not, and they may need to do a little scrambling to make up for that lack. For example, some of you might want to peruse John Bruer's (1993) *Schools for Thought.* Bruer -- the president of the McDonnell Foundation -- was one of the co-founders of its program for Cognitive Studies in Educational Practice (CSEP), which was a highly influential effort to push cognitive researchers to work on educationally relevant problems. His book, although addressed to readers without much background in psychology or education, is not superficial, and makes excellent contact with the central issues in instruction as well as with the basic cognitive psychology. Much of the work supported by the McDonnell Foundation is reported in McGilly (1994), and a sample of some more recent cognitively-oriented instructional research, you might want to look at Carver & Klahr (2001).

Format The course will be run as a participatory seminar, in which you will be responsible for leading the discussion of the readings for a few of our class sessions. (If you browse the schedule and see a topic that you are particularly interested in, and would like to lead that discussion, let me know.) Moreover, everyone will be expected to have completed the primary reading for each session *prior* to the meeting on that topic, and to post a few brief questions and/or comments about the readings on Blackboard. In addition, if you are currently engaged in research relevant to the general topic of cognitively-based instructional interventions in children's math or science you may be encouraged to present your work to the group.

Grading Grades will be based on your participation in, and leading of, class discussions and on a term paper on a topic or project relevant to the course. (Details to be provided.)

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[1] http://www.nap.edu/catalog/10236.html

[2] http://www.cmu.edu/pier/

The following schedule is provisional because, as the semester develops, we may discover that we want to skip some topics or explore others in more depth, or someone might suggest a more appropriate reading for a specific topic.

Week 1 Tu 1/15		**Seminar goals & procedures** PIER background Students' interests and experience. Assertions about education: "scientific" and other types.	
Th 1/17		**Educational research: current examples and current directions** Discuss: The state of educational research: (intro)	Lagemann: ix-xvii, 1-22; 159-183 Miller (1999)
Week 2 Tu 1/22		Continued discussion of Lagemann	Lagemann 184-230
Th 1/24		**NO CLASS (but do reading!)**	**Read:** Shavelson & Towne (2000), **SRE Chaps 1 - 3**
Week 3 Tu 1/29		**A Framework for "Scientific Research in Education"**	Read SRE, Chaps 4 - 6
Th.1/31		**Reactions to SRE**	Feuer, Towne, Shavelson, 2002; Pellegrino & Goldman, 2002; Berliner,2002;Erickson & Gutierrez, 2002; St. Pierre, 2002
Week 4 Tu 2/5	Rich Lehrer visit	**Reality tests:** State science standards	a. Fordham Institute (2005) thru p26, then: Alabama, California, and Pennsylvania reports. b. Education Week (2006) "Quality counts at 10" c. Woolf (2007)..
Th 2/7			**NO CLASS**
Week 5 Tu 2/12		**Why not more use of Random Assignment in Ed Research?**	Cook (2003)
Thu 2/14		**Cognitive Science: relevant or not? Some examples**	Strauss (1998); (first half)
Week 6 Tu 2/19		**From Lab to Classroom and Back**	Klahr & Li, 2005
Th 2/21		**What is "scientific thinking", and how can it be taught?**	Lehrer, R., & Schauble, L. (2007).
Week 7 Tu 2/26		**tba**	**tba**
Th 2/28		**More examples of cognitive science approaches to instructional issues** Self explanation as a learning process	Chi (2000)
Week 8 Tu 3/4		Extended classroom instructional interventions	Leherer & Schauble (2004)
Th 3/6		Complex interventions based on cognitive psychology	Brown (1992) Cognition & Technology group at Vanderbilt (2000)
March 11 & 13			**No CLASS: CMU SPRING BREAK**
Week 9 Tu 3/18		Intelligent Tutoring	Koedinger, Anderson, et al 1997
Th 3/20		High school Physics knowledge diagnosis	Clement (1993)
Week 10		**"Official" criteria for "Scientific" Educational Research**	"Official" WWC documents and critiques (TBA)

Tu 3/25		What Works Clearing House & It's Discontents	
Th 3/27			***NO CLASS – PIER to AERA***
Week 11 Tu 4/1	Lindlsy Richland	**Course Project Introduction**: IES Request for Proposals *("RFPs"): Course projects: Preliminary discussions*	http://ies.ed.gov/funding/pdf/2007305.pdf Brief student proposal possibilities
Th 4/3		**Assessment Issues** Large scale assessment of a cognitive tutor (Guest lecture by John Pane, RAND Corp)	a. RAND proposal on Geometry Tutor b. Aleven, & Koedinger (2002)
Week 12 Tu 4/8		**Teacher Certifcation Wars: science or politics??**	Walsh (2001a)
Th 4/10			Walsh (2001b) Darling-Hammond & Youngs (2002)
Week 13 Tu. 4/15		A Blast at "Constructivist approaches" **Project proposal drafts due by Friday**	Kirschner, Sweller, & Clark (2006)
Th. 4/17		NO CLASS	Spring Carnival
Week 14 Tu 4/22		… and a response on constructivism"	Hmelo-Silver, Duncan, & Chinn,2007; Kuhn, 2007; Schmidt, Loyens, van Gog, & Paas, 2007 Sweller, Kirschner, & Clark, 2007
Th 4/24			Whitehurst, G. (2003)
Week 15 Tu 4/29		**Research proposals for IES**	Project presentations
Th 5/1			Project presentations continued

Tentative Reading list

Adams St. Pierre, E. (2002). "Science" rejects Postmodernism. *Educational Researcher*, 31(8), 25-27.

Aleven, A.W.M.M. & Koedinger, K. R. (2002) An effective metacognitive strategy: learning by doing and explaining with a computer-based Cognitive Tutor. *Cognitive Science* 26, 147-179.

Berliner, D.C. (2002). Educational Research: The Hardest Science of All. *Educational Researcher*, 31(8), 18-20.

Brown, A. & Campione, J. C. (1994) Guided discovery in a community of learners. In K. McGilly (Ed.) *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 229-272), Cambridge, MA MIT Press.

Brown, A. (1992) Design Experiments: Theoretical and Methodological Challenges in Creating Complex Interventions in Classroom Settings. *The Journal of the Learning Sciences*, 2, 141-178.

Bruer, J.T. (1993). *Schools for thought: a science of learning in the classroom*. Cambridge, MA: MIT Press.

Carver, S. M. and Klahr D. (Eds.) (2001) *Cognition and Instruction: 25 years of progress*. Mahwah, NJ: Erlbaum

Chi, M.T.H., de Leeuw, N., Chiu, M.H., LaVancher, C. (1994). Eliciting self-explanations improves understanding. *Cognitive Science*, 18, 439-477.

Chi, M.T.H (2000) Self explaining expository tests: The dual process of generating inferences and repairing mental models. In Glaser, R. (Ed.) *Advances in Instructional Psychology*, Mahwah, HNJ: Erlbaum, pp 161-238

Clement, J. (1993). Using bridging analogies and anchoring intuitions to deal with students' preconceptions in physics. *Journal of Research in Science Teaching, 30*(10), 1241-1257.

Cognition and Tech Group at Vanderbilt (2000). Adventures in anchored instruction: Lessons from beyond the ivory tower. In R. Glaser (ed). *Advances in instructional psychology: Vol 5. Educational design and cognitive science* (pp. 35-99) Mahwah, New Jersey, Lawrence Erlbaum.

Darling-Hammond & Youngs (2002). Defining "highly qualified teachers": What does "scientifically-based research" actually tell us? *Educational Researcher, 31*(9),13-25.

Education Week (2006) http://www.edweek.org/ew/toc/2006/01/05/index.html

Erickson, R. & Gutierrez, K. (2002). Culture, rigor and science in educational research. *Educational Researcher*, 31(8), 21-24.

Feuer, M.J., Towne, L. & Shavelson, R.J. (2002). Scientific Culture and Educational Research. *Educational Researcher*, 31(8), 4-14.

Fordham Institute (2005) *The State of State Science Standards 2005*. Paul R. Gross, Ursula Goodenough, Lawrence S. Lerner, Susan Haack, Martha Schwartz, Richard Schwartz, Chester E. Finn, Jr.

http://www.edexcellence.net/institute/publication/publication.cfm?id=352

Gage, N.L. (1991). The obviousness of social and educational research results. *Educational Researcher, 20* (1), 10-16.

Huntley, M. A., Rasmussen, C. L., Villarubi, R. S., Sangtong, J., & Fey, J. T. (2000) Effects of *Standards*-Based Mathematics Education: A Study of the Core-Plus Mathematics Project Algebra and Functions Strand. *Journal for Research in Mathematics Education*,

31, 328–361

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist, 42*, 99– 107.

Kirschner, P. A., Sweller, J., & Clark, R. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential and inquiry-based teaching. *Educational Psychologist, 41*, 75–86.

Klahr, D. & Nigam, M. (2004) The equivalence of learning paths in early science instruction: effects of direct instruction and discovery learning. *Psychological Science. 15*, 661-667.

Klahr, D & Li, J. (2005) Cognitive Research and Elementary Science Instruction: From the Laboratory, to the Classroom, and Back, *Journal of Science Education and Technology, Vol. 14, No. 2,*

Klahr, D., Chen, Z., and Toth, E. E. (2001). Cognitive development and science education: Ships passing in the night or beacons of mutual illumination? In Carver, S. M. and Klahr D. (Eds.) *Cognition and Instruction: 25 years of progress*. Mahwah, NJ: Erlbaum

Koedinger, K. R., Anderson, J.R., Hadley, W.H., & Mark, M . A. (1997). Intelligent tutoring goes to school in the big city. *International Journal of Artificial Intelligence in Education,* 8, 30-43..

Kuhn, D. (2007). Is direct instruction the answer to the right question? *Educational Psychologist, 42*, 109–113.

Lagemann, E. C. (2000). *An Elusive Science: The Troubling History of Educational Research*. Chicago: University of Chicago Press.

Lehrer, R. & Schauble, L. (2004) Modeling Natural Variation Through Distribution, *American Educational Research Journal*, 41, 635-679

Lehrer, R., & Schauble, L. (2007). Scientific thinking and science literacy. In W. Damon, R. Lerner, K. Anne Renninger, & I. E. Sigel, (Eds,), *Handbook of Child Psychology, Sixth Edition, Volume Four: Child Psychology in Practice*. Hoboken, NJ: John Wiley & Sons.

Linn, R.L. (2000). Assessments and accountability. *Educational Researcher,* 29(2), 4-16.

McGilly, K. (Ed.) (1994). *Classroom lessons: integrating cognitive theory and classroom practice*. Cambridge, MA: MIT Press.

Miller, D. W. (1999) The Black Hole of Education Research: Why do academics play such a minimal role in efforts to improve the schools. *The Chronicle of Higher Education*, 8/6/1999, 45, 58.

Mosteller, F., Nave, B., & J. Miech, E. J. (2004) Why We Need a Structured Abstract in Education Research, *Educational Researcher*, 29-34

National Science Education Standards: http://www.nap.edu/readingroom/books/nses/

Pellegrino, Chudowsky, & Glaser (2001) Knowing What Students Know: The Science and Design of Educational Assessment http://www.nap.edu/catalog/10019.html

Pelligrino, J.W. & Goldman, S.R. (2002). Be Careful What You Wish For--You May Get It: Educational Research in the Spotlight. Educational Researcher, 31(8), 15-17.

Raudenbush, S. W. (2004) Learning from attempts to improve schooling: The contribution of Methodological Diversity (working paper, NRC).

Ruiz-Primo, M. A. & Furtak, E. M. (2004) *Informal formative assessment of Students' Understanding of Scientific Inquiry*. Paper presented at the AERA Annual Meeting Symposium, Assessment for Reform-Based Science Teaching & Learning. April 16, 2004

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Schmidt, H. G., Loyens, S. M. M., van Gog, T., & Paas, F. (2007). Problem based learning *is* compatible with human cognitive architecture: Commentary on Kirschner, Sweller, and Clark (2006). *Educational Psychologist*, *42*, 91–97.

Sweller, J., Kirschner, P. A., & Clark, R. (2007). Why Minimally Guided Teaching Techniques Do Not Work: A Reply to Commentaries. EDUCATIONAL PSYCHOLOGIST, *42*(2), 115–121

Strauss, S. (1998) Cognitive Development and Science Education: Toward a Middle Level Model. In I. Sigel & K. A. Renninger (Eds. (W. Damon, Series Editor) *Handbook of Child Psychology*, V4: Child Psychology in Practice. 357-400.

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L. Woolf l. (2007) California Political Science Education Article <http://units.aps.org/units/fed/newsletters/summer2005/woolf.html>

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