

When is Educational Technology Educational?

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Interesting & puzzling!

- ◆ Though correlation is not cause, these results demand an explanation
 - Must not jump to conclusions
 - Nor discount these results as non-causal, so not important
- ◆ Hard to describe associations in a neutral way:
 - “Students who use computers most frequently under specific situations tend to have lower achievement in mathematics”

Same words in reverse order:

- Students who have lower achievement in mathematics to use computers most frequently under specific situations

What's the right question to ask to make sense of these results?

- ◆ Why does technology use hurt learning?
- ◆ Why do poor learners use technology more?
- ◆ Why do poor learners *report* using technology more?
- ◆ Is there something about students who report using technology more that causes them to learn less?

- ◆ Why is there no overall relationship between technology & math learning?
- ◆ ...

But, my favorite is:

- ◆ When and how may technology best help or hinder learning?

Many Studies of Ed Tech Effectiveness

- ◆ And many meta-analyses of these many studies:
- ◆ Niemiec, R. and Walberg, H.J. (1987). Comparative effects of computer-assisted instruction: A synthesis of reviews. *Journal of Educational Computing Research*, 3, 19-37.
 - 13 literature reviews, 0.42 sd average effect size
- ◆ Kulik, C. C. & Kulik, J. A. (1991). Effectiveness of Computer-Based Instruction: An Updated Analysis. *Computers in Human Behavior*, 7, 75-95.
 - 254 controlled evaluation studies, 0.30 sd average effect size
- ◆ Kulik, J. A. (1994). Meta-analytic studies of findings on computer-based instruction. In E. Baker and H. O'Neil eds. *Technology assessment in education and training*. Hillsdale, NJ: Lawrence Erlbaum.
 - 11 meta-analyses of > 500 studies, ~0.30 effect size
- ◆ As Elena noted: “we are all aware of the positive effects of educational technology”

TABLE 1.1
Findings From 12 Meta-Analyses on Computer-Based Instruction

<i>Meta-Analysis</i>	<i>Instructional level</i>	<i>Type of Application</i>	<i>Number of Studies Analyzed</i>	<i>Average Effect Size</i>
Bangert-Drowns, J. Kulik, & C. Kulik (1985) ^a	Secondary	CAI, CMI, CEI	51	.25
Burns & Bozeman (1981)	Elementary & secondary school	Drill & Tutorial	44	.36
Cohen & Dacanay (1991)	Health professions education	CAI, CMI, CEI	38	.46
Hartley (1978)	Elementary & secondary math	Drill & tutorial	33	.41
Fletcher (1990)	Higher education & adult training	Computer-based interactive video	28	.50
C. Kulik & J. Kulik (1986) ^a	College	CAI, CMI, CEI	119	.29
C. Kulik, J. Kulik, & Shwalb (1986) ^a	Adult education	CAI, CMI, CEI	30	.38
J. Kulik, C. Kulik, & Bangert-Drowns (1985) ^a	Elementary	CAI, CMI, CEI	44	.40
Niemiec & Walbert (1985)	Elementary	Drill, tutorial, CMI, problem solving	48	.37
Robtlyer (1988)	Elementary to adult education	CAI, CMI, CEI	82	.31
Schmidt, Weinstein, Niemiec, & Walberg (1985)	Special education	Drill, tutorial, & CMI	18	.57
Willett, Yamashita, & Anderson (1983)	Precollege science	CAT, CMI, CSI	11	.22

Note. CAI = computer-assisted instruction; CEI = computer-enriched instruction; CMI = computer-managed instruction; CSI = computer-simulation in instruction.

^aBased on updated analysis in C. Kulik and J. Kulik (1981).

Some kinds of tech are more educational than others ...

Effect Sizes for Six Categories of Computer-Based Instruction

Tutoring	0.38
Managing	0.14
Simulation	0.10
Enrichment	0.14
Programming	0.09
Logo	0.58

Might the survey questions be tapping use of less effective kinds of technology?

Recall questions:

Do you use a computer to:

Look up ideas and information for math

Write reports for school

Process and analyze data

Kulik, J. A. (1994). Meta-analytic studies of findings on computer-based instruction. In E. Baker and H. O'Neil eds. *Technology assessment in education and training*. Hillsdale, NJ: Lawrence Erlbaum.

Success of intelligent tutoring systems

- ◆ Bloom: one-on-one human tutoring yields a 2 sd gain over classroom instruction
- ◆ Computer-aided instruction provides some of individualized benefits of human tutoring
- ◆ Intelligent tutoring systems increase the nature & extent of individualization
 - Numerous evaluation studies getting closer to Bloom's challenge (~ 1 sd)
 - Andes Physics tutor, LISP programming tutor, ...
 - "Cognitive Tutors" for mathematics

Cognitive Tutor Algebra

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TIFF (LZW) decompressor
are needed to see this picture.

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Cognitive Tutor Algebra *Course*

- ◆ *Blended* course
 - Classroom 3 days/week,
Computer lab 2 days
 - Integrated textbook,
software tutor,
teacher training

- ◆ Reform elements
 - Project-based
 - Less whole-group lecture
 - Cooperative learning
 - Teacher as facilitator

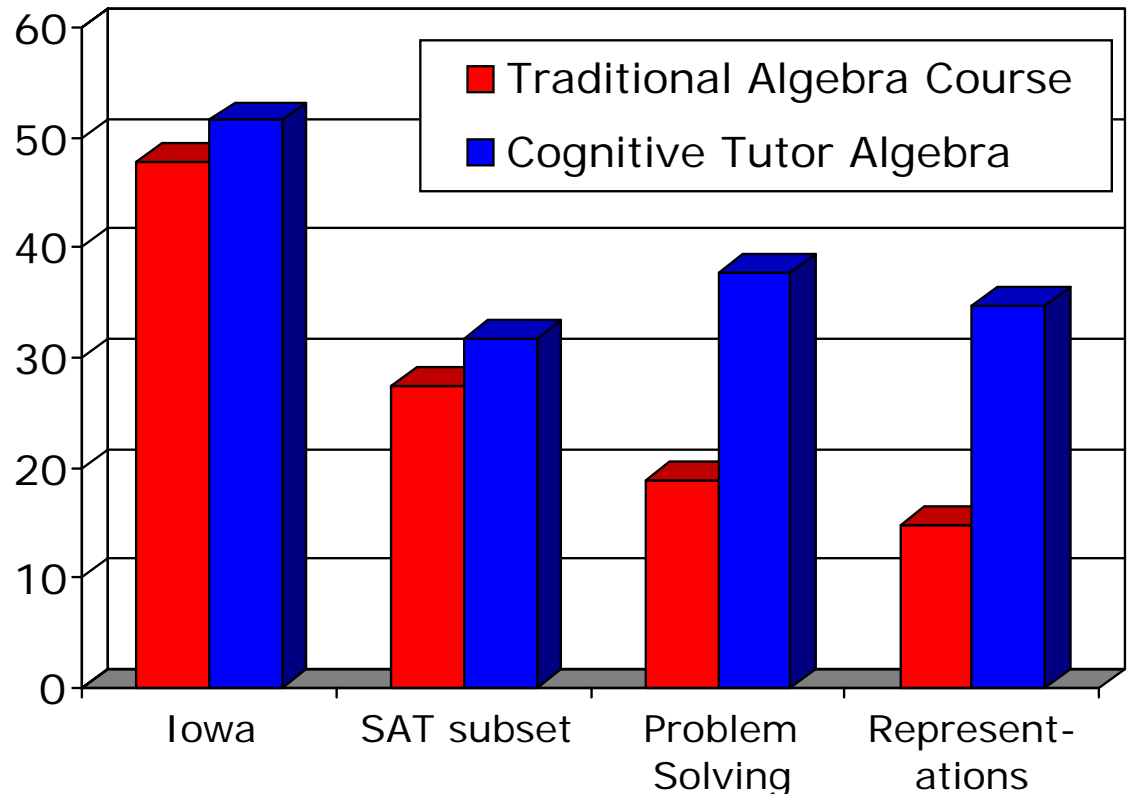


Early Cognitive Tutor Studies

- ◆ Quasi-experimental studies in 2 urban districts across two years

- ◆ Typical results:
50-100% better on problem solving & representations

15-25% better on standardized tests



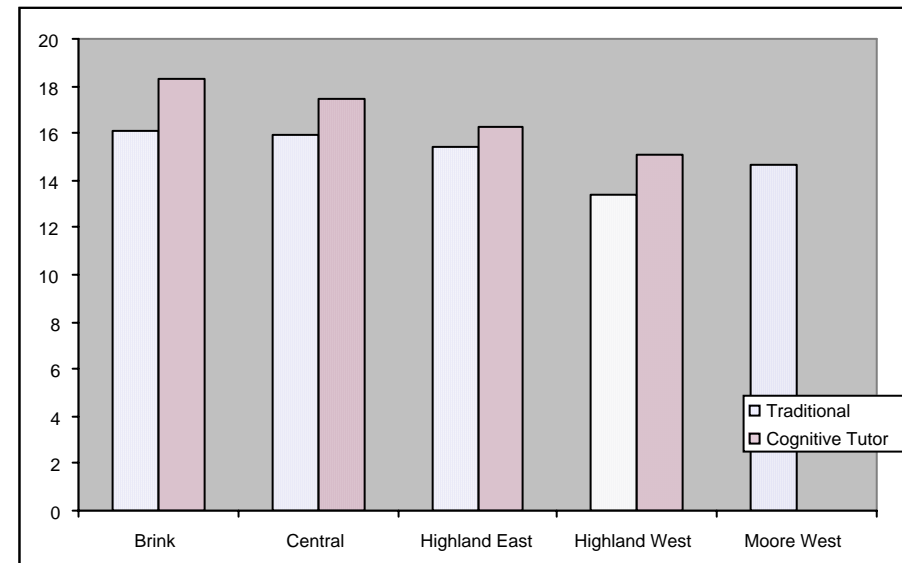
Koedinger, Anderson, Hadley, & Mark (1997). Intelligent tutoring goes to school in the big city.

Many other studies of Cognitive Tutor Algebra

- ◆ Dr. Steve Ritter has collected these:
 - www.carnegielearning.com/results/reports
- ◆ 11 study reports available
 - From 1994 to present
 - More than 8000 students
 - Most run independently of Carnegie
- ◆ Significant positive results in all but 1 study which found no difference

Independent study in Moore, Oklahoma, 2000-01

- ◆ Study run by district at 5 junior highs
 - 1,035 students, urban public schools, mixed ethnicity
- ◆ Study design
 - *Sections* randomly assigned Cognitive Tutor (N = 224) or comparison (N = 220)
 - ETS end-of-course Algebra test
- ◆ Cognitive Tutor significantly better
 - $p < .01$, 0.3 sd effect
- ◆ Students were more confident & likely to feel math is useful



1 of first 2 in *What Works Clearinghouse*:
Meets high quality study standards!

Cognitive Tutor Algebra Adoption

- ◆ In use in more than 2000 schools
 - More urban and rural schools
- ◆ In some schools, more so in suburban schools, it is adopted in lower tracked or remedial classes
 - Less use for high achieving students
 - Adoption of innovations is driven not just by good science, but where the pain is being felt

Which way does the causal arrow go? Low math -> seek innovation?

◆ Given:

- Preponderance of positive results of use of educational technology
- Known school adoption patterns of innovative

◆ *Perhaps* most likely explanation

- Schools or teachers with lower performing students are more likely to seek credible alternatives to existing approaches
- Ed tech is a likely choice given its track record
- Schools may be using a “compensatory educational strategy” (Jan-Eric Gustafsson)

Effect of educational background

- ◆ Important side observation from Elena's paper:
- ◆ "The results of this study are a bit disappointing
 - Educational variables are still unable to surpass the effects of SES and educational background"

Making a difference in the home

- ◆ Children are learning all the time, in school and out
- ◆ **80%** of their time is out of school
- ◆ So, perhaps we should not be too surprised that home factors are so strong
- ◆ But, indeed such analyses help us think about where we might best focus our energies

- ◆ My speculation:
Serious educational games (with database ties to schools) have great potential to effectively tap into that 80%

Summary so far

- ◆ Cross-sectional data analyses are informative
 - Surprising findings deserve explanation
 - Inspire follow-up studies
- ◆ Multiple possible explanations
 - Technology hurts learning
 - Better students don't inflate or confound computer use in their self-reports
 - Survey is not addressing effective kinds of computer use
 - Struggling schools and teachers more likely to adopt innovative approaches
- ◆ Need to integrate results from experimental studies ...

The classroom as an educational laboratory

Past Success:

- ◆ Cognitive Tutors as delivery vehicle
 - Bring *existing* Learning Science to classroom

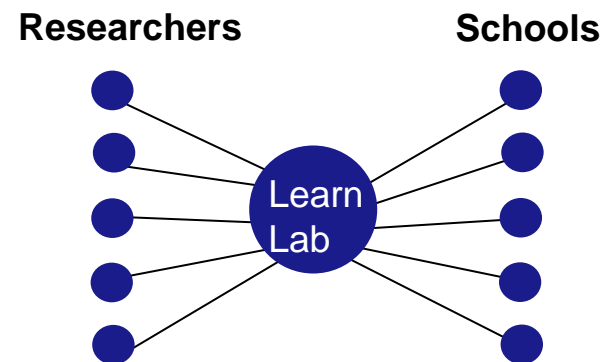
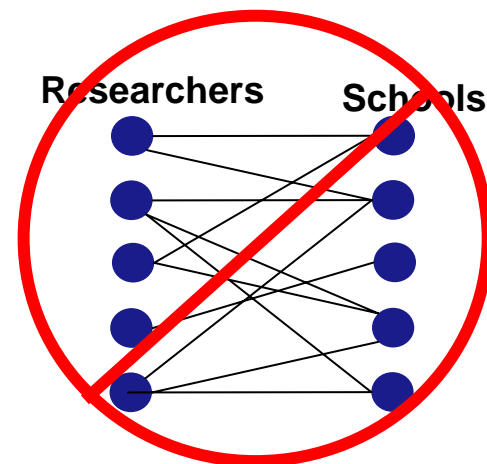
New Goal:

- ◆ Cognitive Tutors as research platform
 - Create *new* Learning Science & Technology
- ◆ Pittsburgh Science of Learning Center



PSLC's LearnLab

- ◆ Like a research hospital for educational research
- ◆ Helps researchers run controlled experiments as “replacement units” in any of our 7 courses
 - Math: Algebra, Geometry
 - Science: Physics, Chemistry
 - 2nd Language: Chinese, French, English
- ◆ Technology-enhanced with on-line & tutor pieces
 - Instrumented to collect process & achievement data
 - DataShop: Web-based repository of data open for secondary analysis
- ◆ See LearnLab.org



Future Work Suggestions

- ◆ If ed tech is pulling students away from math content, might expect lower reporting of opportunity to learn
- ◆ Perhaps employ Gustafsson's analysis of within-country differences over time
 - Is increased computer use associated with decreased achievement?
 - Or is decreased achievement associated with increased computer use?
 - Answer cannot be yes to both!?

Related Research Efforts

- ◆ Pittsburgh Science of Learning Center

learnlab.org

- ◆ Tools for authoring Cognitive Tutors
 - Variety of new domains: sciences, languages

ctat.pact.cs.cmu.edu

- ◆ “Assistments” for on-line dynamic assessment

assistment.org

