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Learning Science for Better Learning

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Teaching Professor, Department of Psychology

$16,000$

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Like tying shoelaces

Change is hard

Relevant research can inform and guide effective innovations in teaching

- Acquainted with learning science research
- Examples that have immediate relevance
- Critical consumer of educational

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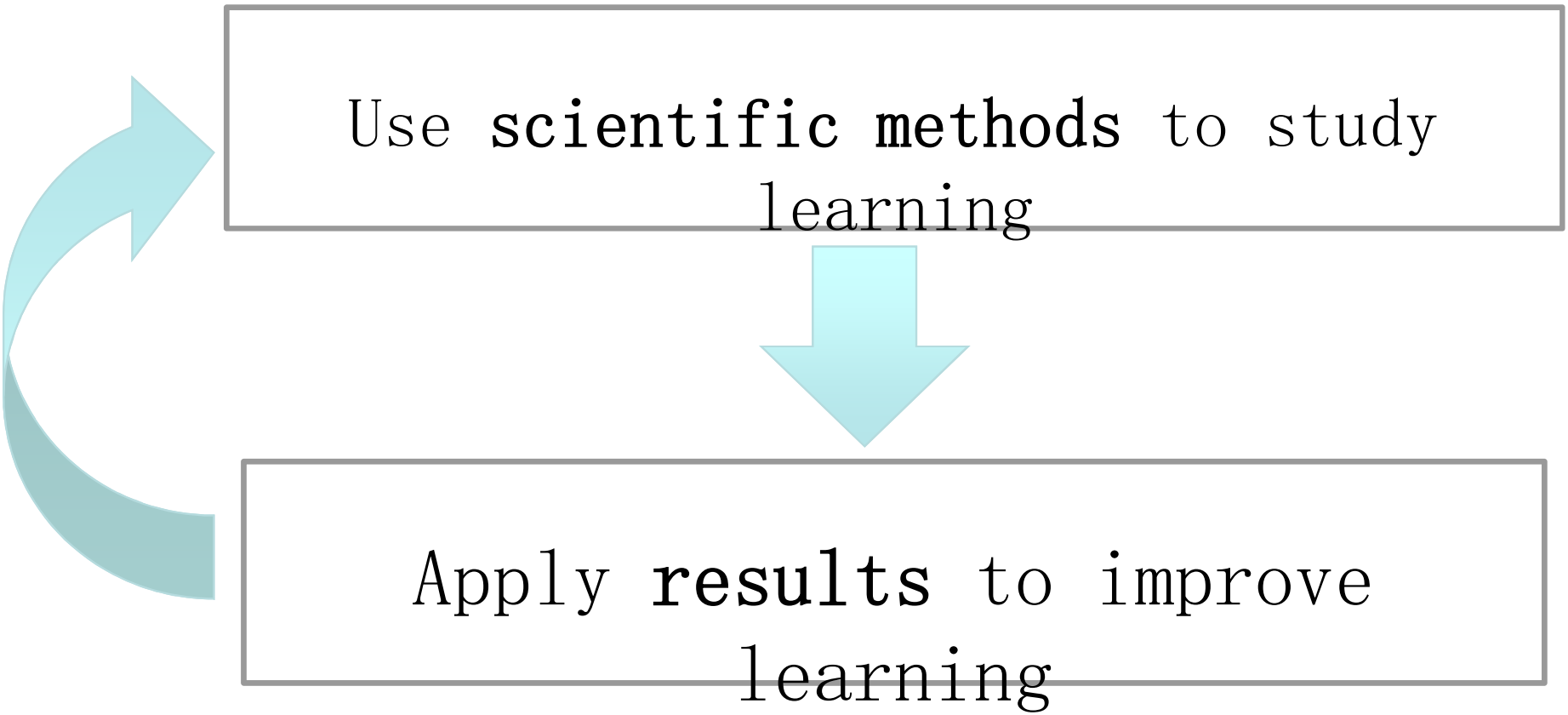
Expert Blind Spot

Occurs when expert instructors are blind to the learning needs of students

- Presume students do things the way we do
- Mis-predict what students find difficult
- Fail to see the steps students must learn
- Over-estimate what students know & can do


Use scientific methods to study learning
Apply results to improve learning

LEAP

High-Impact Educational Practices

WHAT THEY ARE,
WHO HAS ACCESS TO THEM,
AND WHY THEY MATTER

BY GEORGE D. KUH

WITH AN INTRODUCTION BY CAROL GEARY SCHNE
AND FINDINGS ON STUDENT SUCCESS FROM AAC
LEAP INITIATIVE

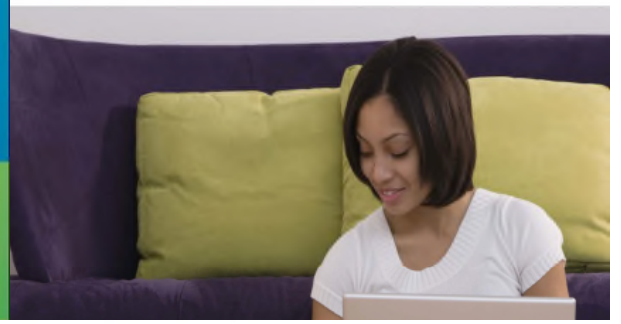
HOW LEARNING WORKS

7 Research-Based Principles *for* Smart Teaching

Susan A. Ambrose
Michael W. Bridges | Michele DiPiet
Marsha C. Lovett | Marie K. Norman

U.S. DEPARTMENT OF EDUCATION

Evaluation of Evidence-Based Practices in Online Learning
A Meta-Analysis and Review of Online Learning Studies

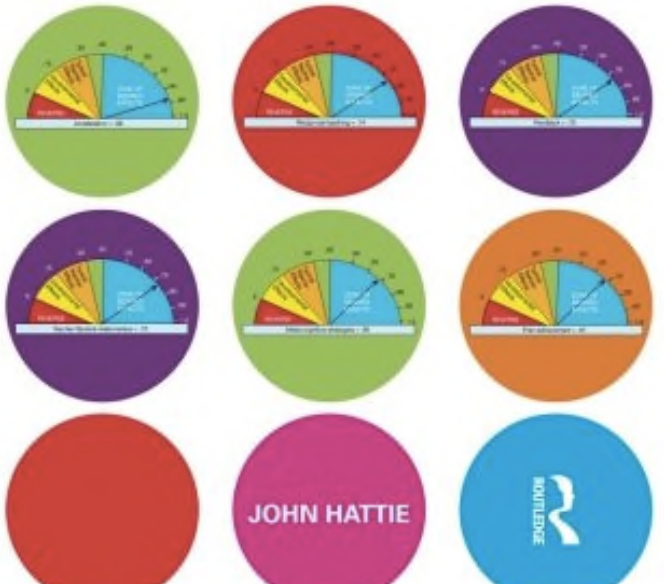


Organizing Instru
to Improve Stude
A Practice Guide

VISIBLE LEARNING

A SYNTHESIS OF OVER 800 META-ANALYSES RELATING TO ACHIEVEMENT

"Reveals teaching's Holy Grail"
The Times Educational Supplement



E-LEARNING *and the* Science of Instruction

Proven Guidelines for Consumers and Designers of Multimedia Learning

RUTH COLVIN CLARK | RICHARD E. MAYER

NCER 2007-2004
U.S. DEPARTMENT OF EDUCATION

ies NATIONAL CENTER FOR EDUCATION RESEARCH
Institute of Education Sciences

Robust Results on Learning

Spaced practice > cramming

IES *Practice Guide* (2007)

- Evidence
- Instructional strategies
- Roadblocks
- Solutions

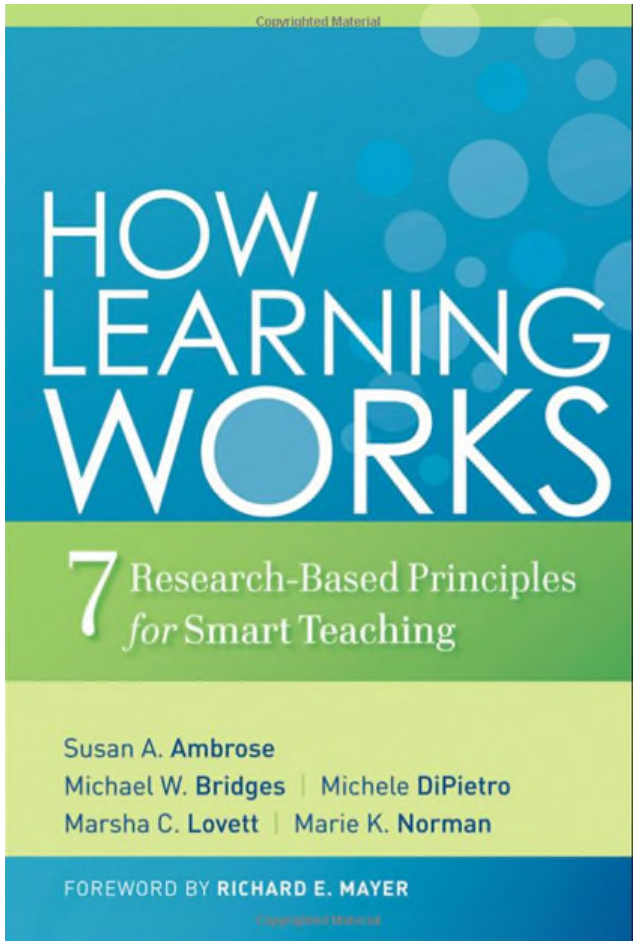
Active learning > lecture

PNAS (2014) meta-analysis

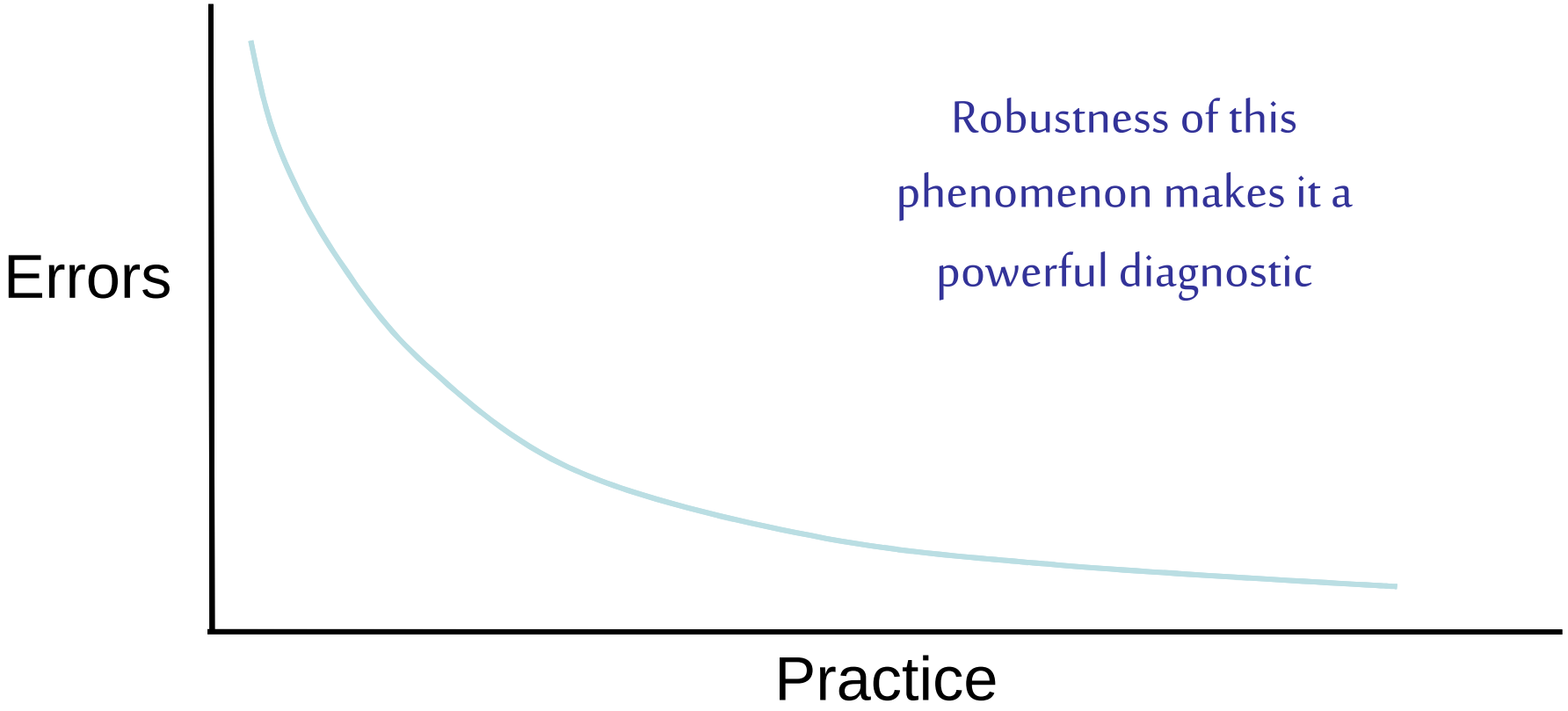
- 225 studies of active learning vs. lecture
- With active learning, **exam scores up** and **failure rates down**

Principles of Learning

1. Prior knowledge
2. Organization of knowledge
3. Motivation
4. **Practice and feedback**
5. Development of mastery
6. The "whole" student
7. Self-directed learning

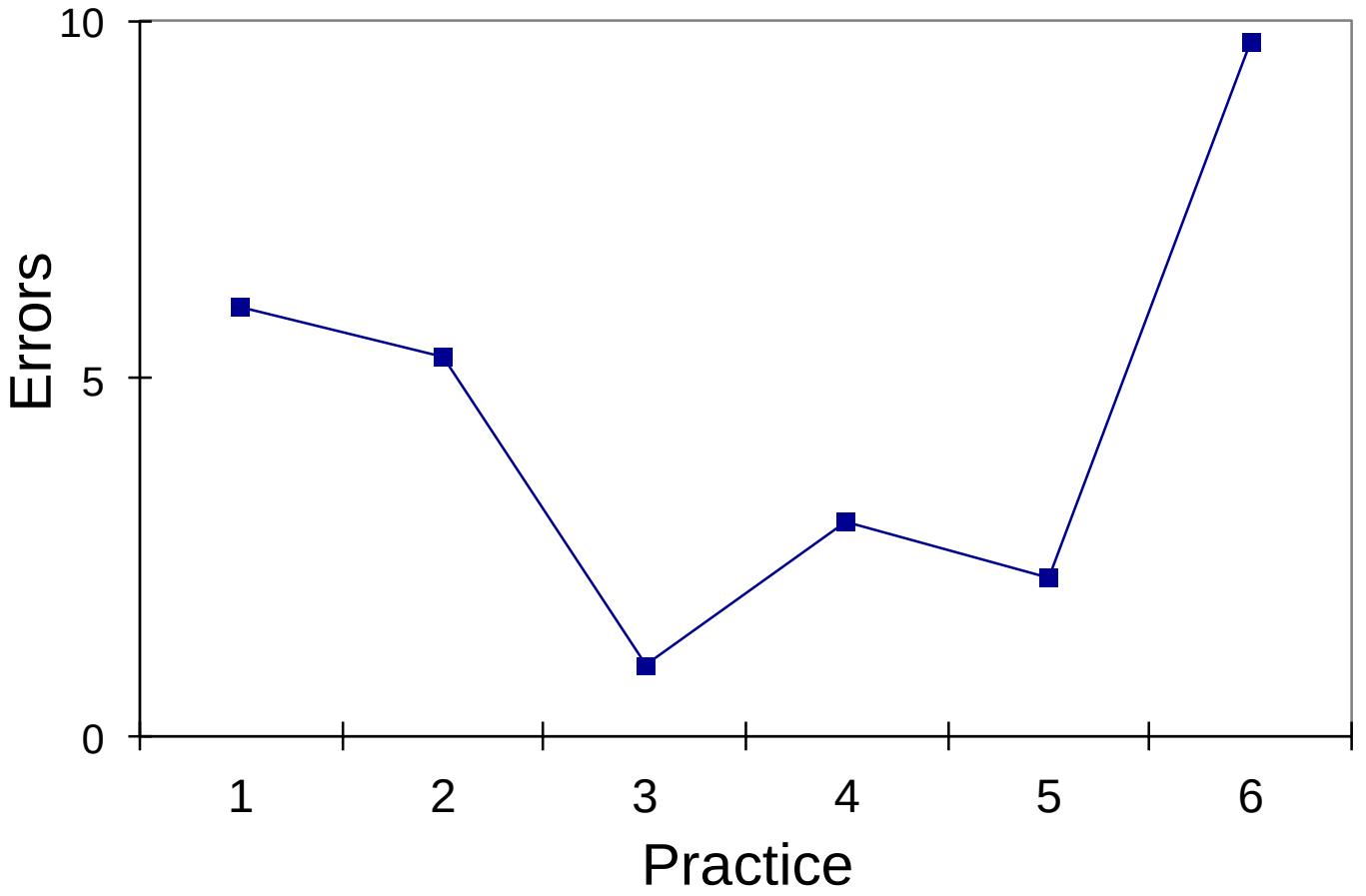


The Power Law of Learning

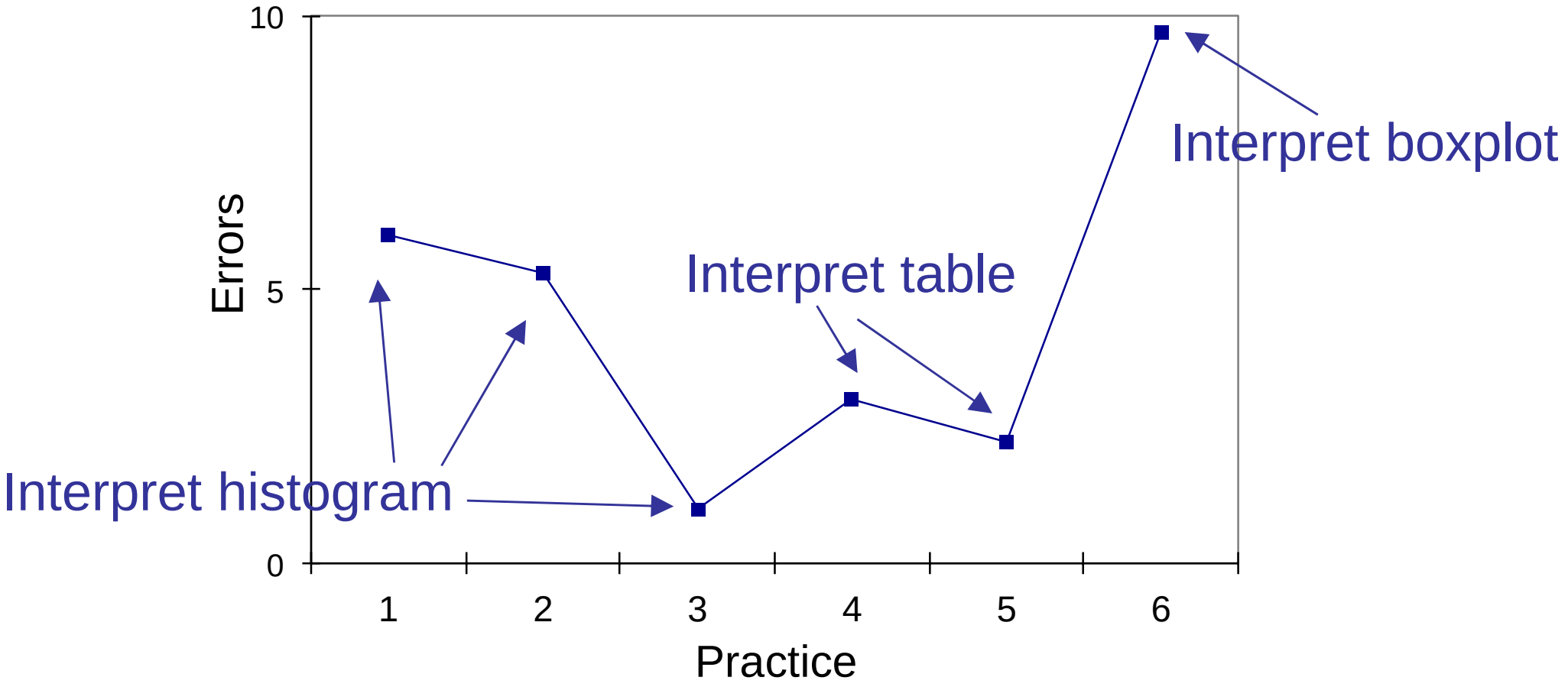


As students practice, performance improves with marginally decreasing returns

The Performance We Observe



The Underlying Skills



Performance Re-indexed

If you're not paying attention to the skills students are supposed to learn, you're missing something fundamental.

The Power Law of Learning revealed

A few key results regarding practice

Practicing a given skill

improves performance ***on that skill***

Practice activities are effective to the degree that they

1. Align with the skills students need to learn
2. Offer opportunities for repeated practice
3. Provide targeted and timely feedback

Align practice with desired skills

Skill – Select and apply appropriate statistical tests

✗ Apply statistical tests from the current chapter

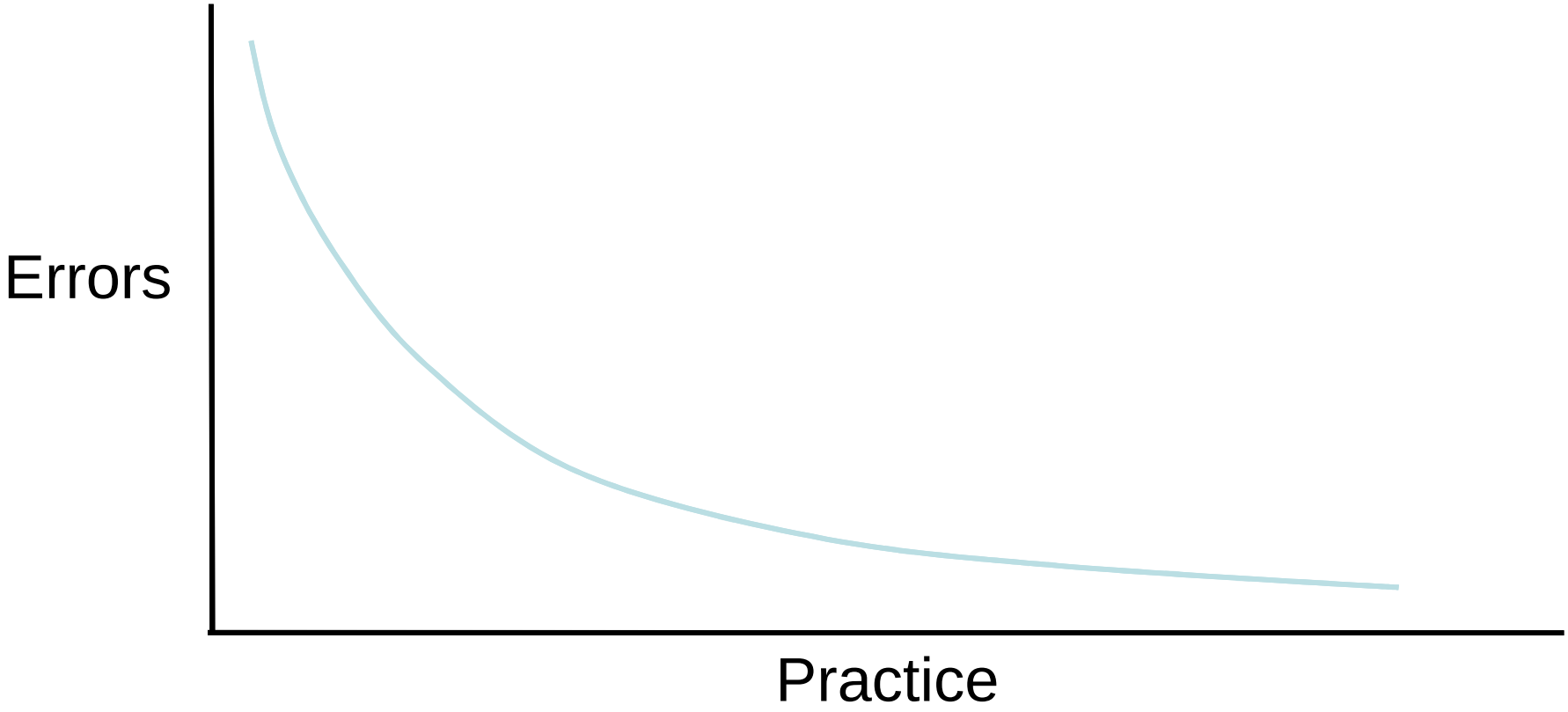
✔ Analyze data, drawing on variety of statistical tests

Skill – Compare and critique authors' arguments

✔ Class discussion eval-uating relative merits of different arguments

✗ Paper summarizing individual authors' arguments

Repeated Practice Opportunities



As students practice, performance improves with marginally decreasing returns

Targeted and timely feedback

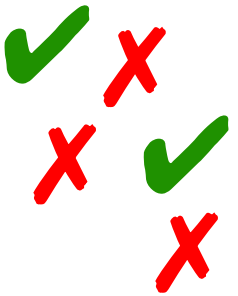
Current situation:

- Students do their homework and turn it in
- Days later, they receive graded papers

Class has moved on to next topic

No incentive to remediate

What we want:



Give students feedback in a timely manner so they can learn from it

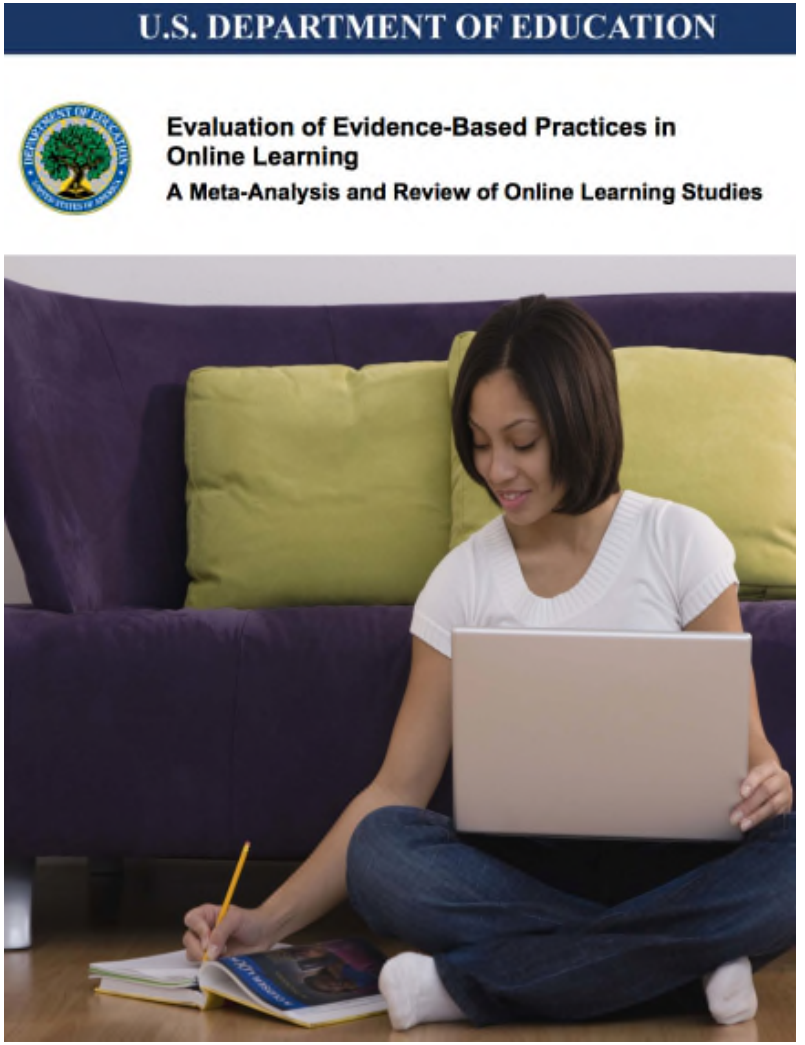
Can technology help?

Review of Online Learning Studies

Current state of the art:

1000+ studies

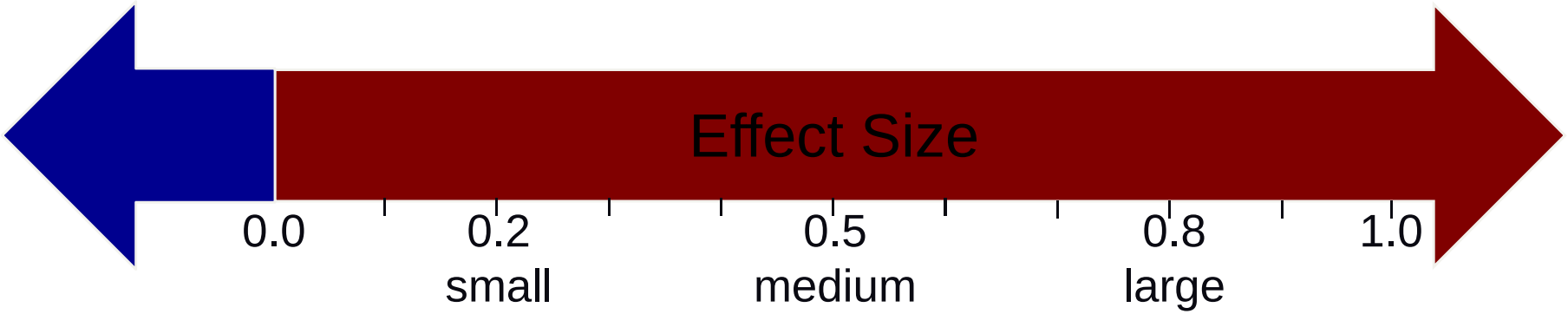
What do they tell us about the effectiveness of online learning?



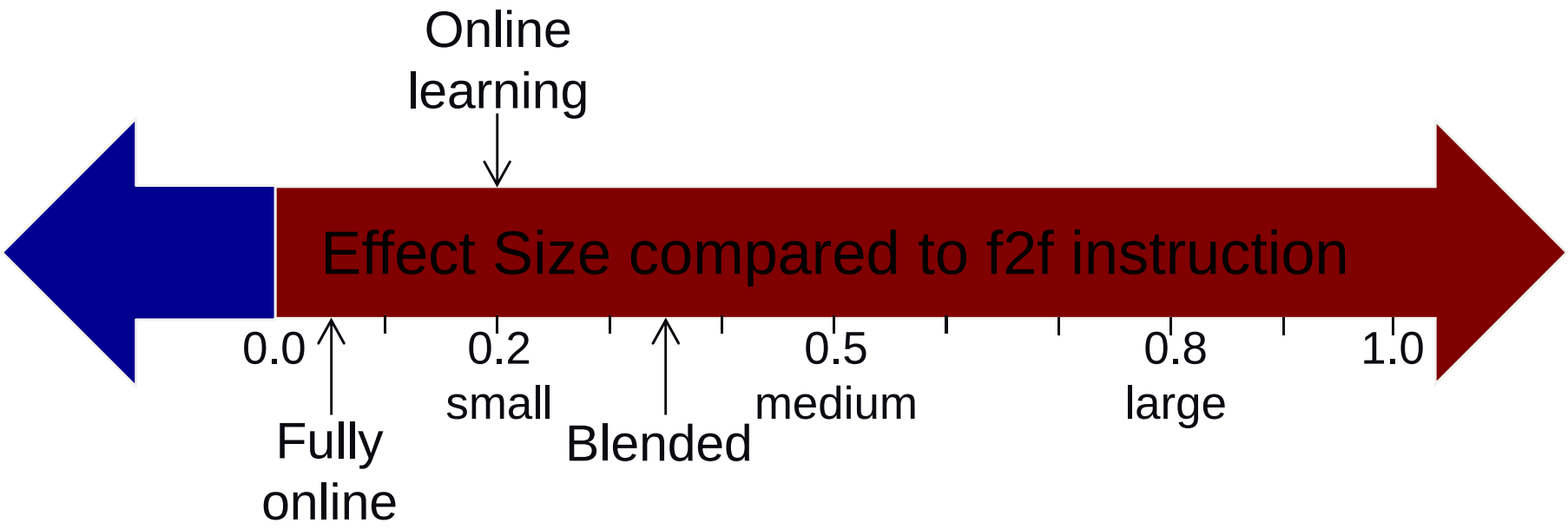
U.S. Department of Education (2010).

Meta-analysis combines across results

Draw on multiple studies to quantitatively estimate the overall effect of treatment vs. control



Results look favorable, but…

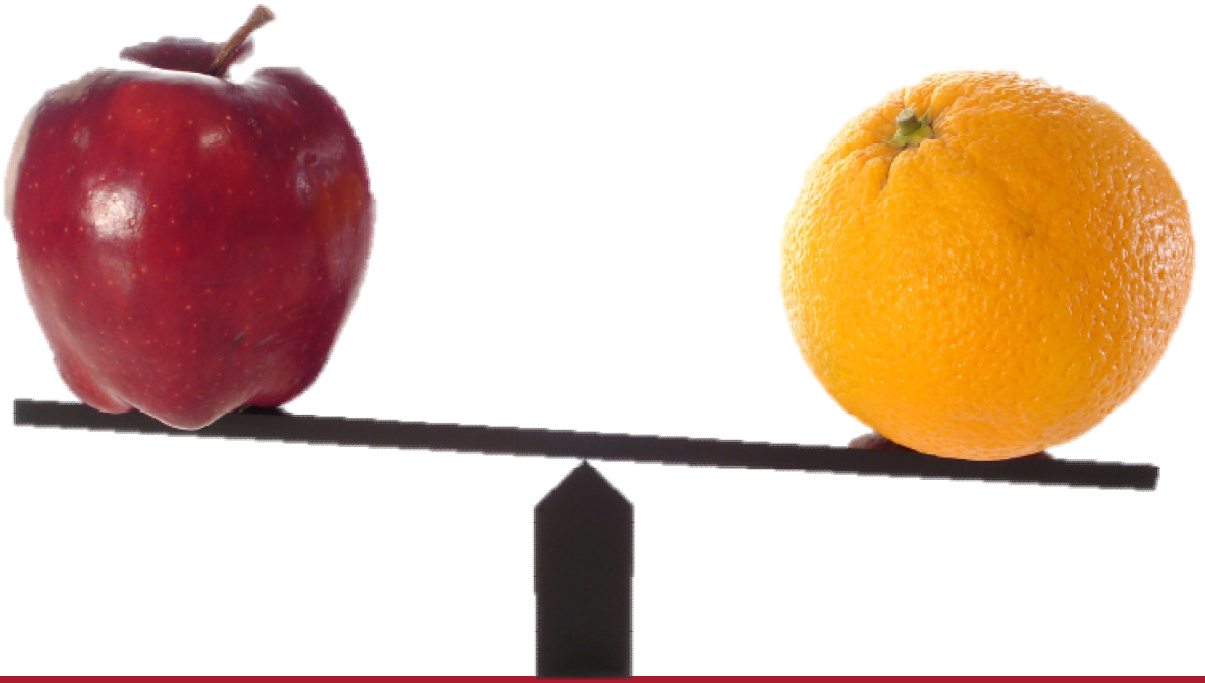


Online (fully/blended) conditions often had more time

Online (fully/blended) vs. face-to-face often differed in content and pedagogy

So, it's not about the technology…

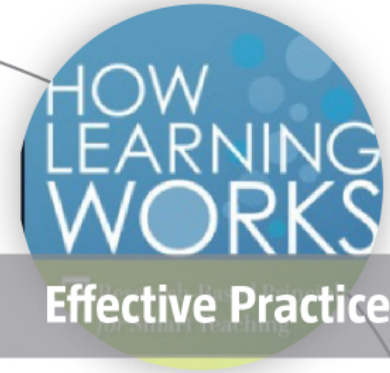
"The observed advantage for blended learning conditions is not necessarily rooted in the media used per se and may reflect differences in content, pedagogy and learning time."



Positive results for online learning stem from how you design it

Empowered Faculty

Global Learning Council



Effective Practice

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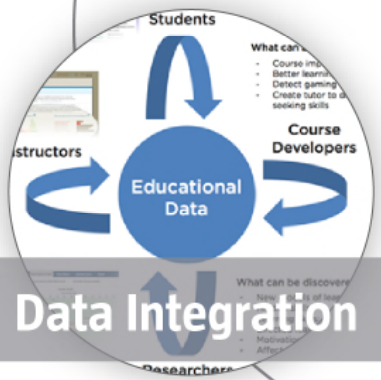
The Simon Initiative



Data Integration

Engaged Learners

Innovative Research

Spin Outs & Spin Ins

A few key results regarding practice

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improves performance *on that skill*

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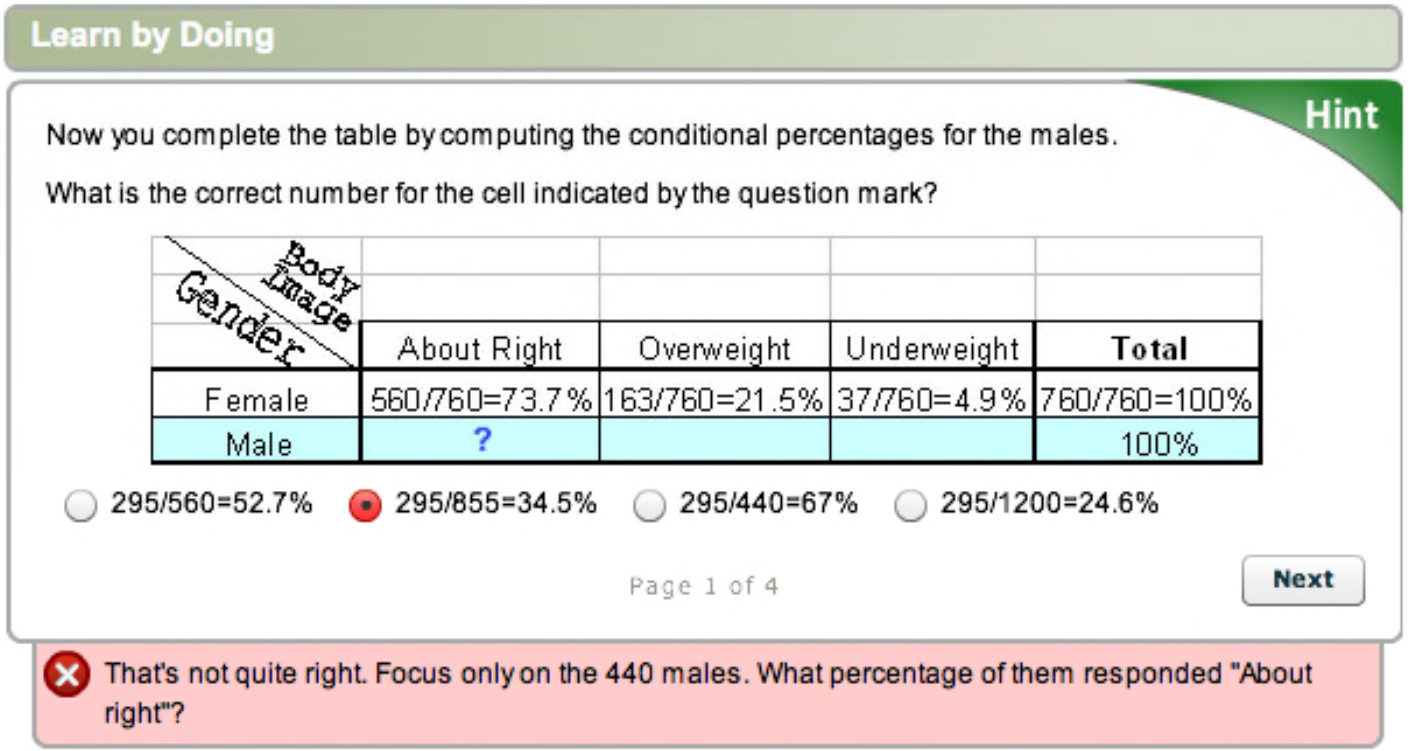
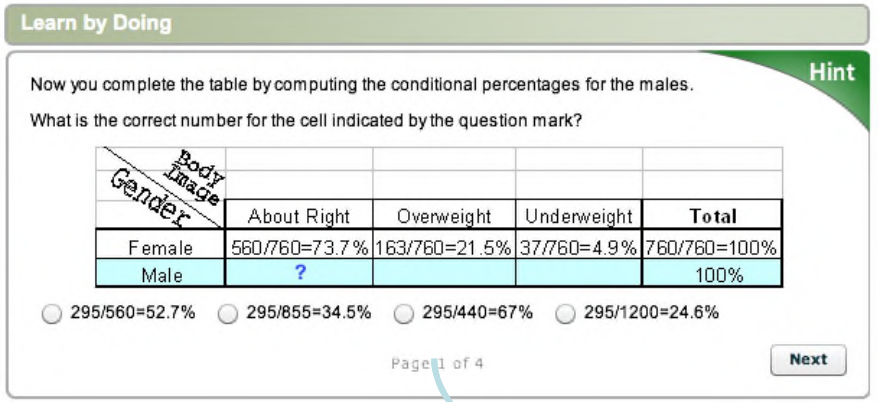
Research-based online instruction

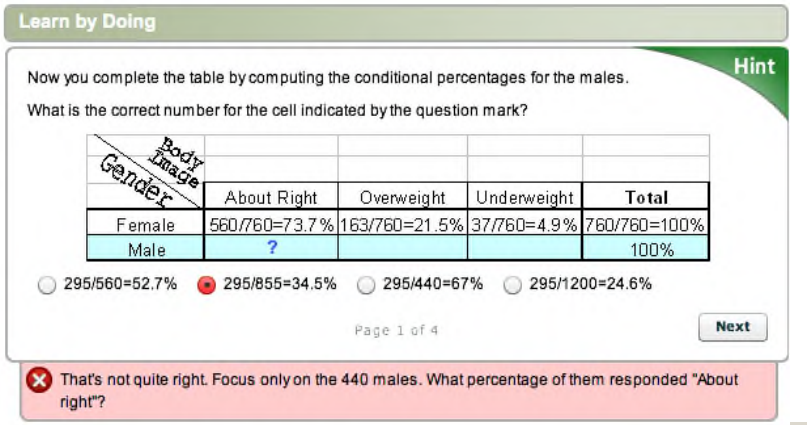
Online course in introductory statistics built within the Open Learning Initiative platf



Learning activities are instrumented to *continuously* assess student learning

Feedback to Student





Feedback to Instructor

The *Learning Dashboard* provides an accurate and evolving picture of how well students have learned particular skills

by analyzing rich interaction data *in terms of* established cognitive theory & computational models of learning

Cognitively informed learning analytics

Most learning analytics barely tap this potential:

Track what students do

Record which questions students get right or wrong

Summarize student progress and performance

Predict some future behavior

The *Learning Dashboard* gets more out of the data:

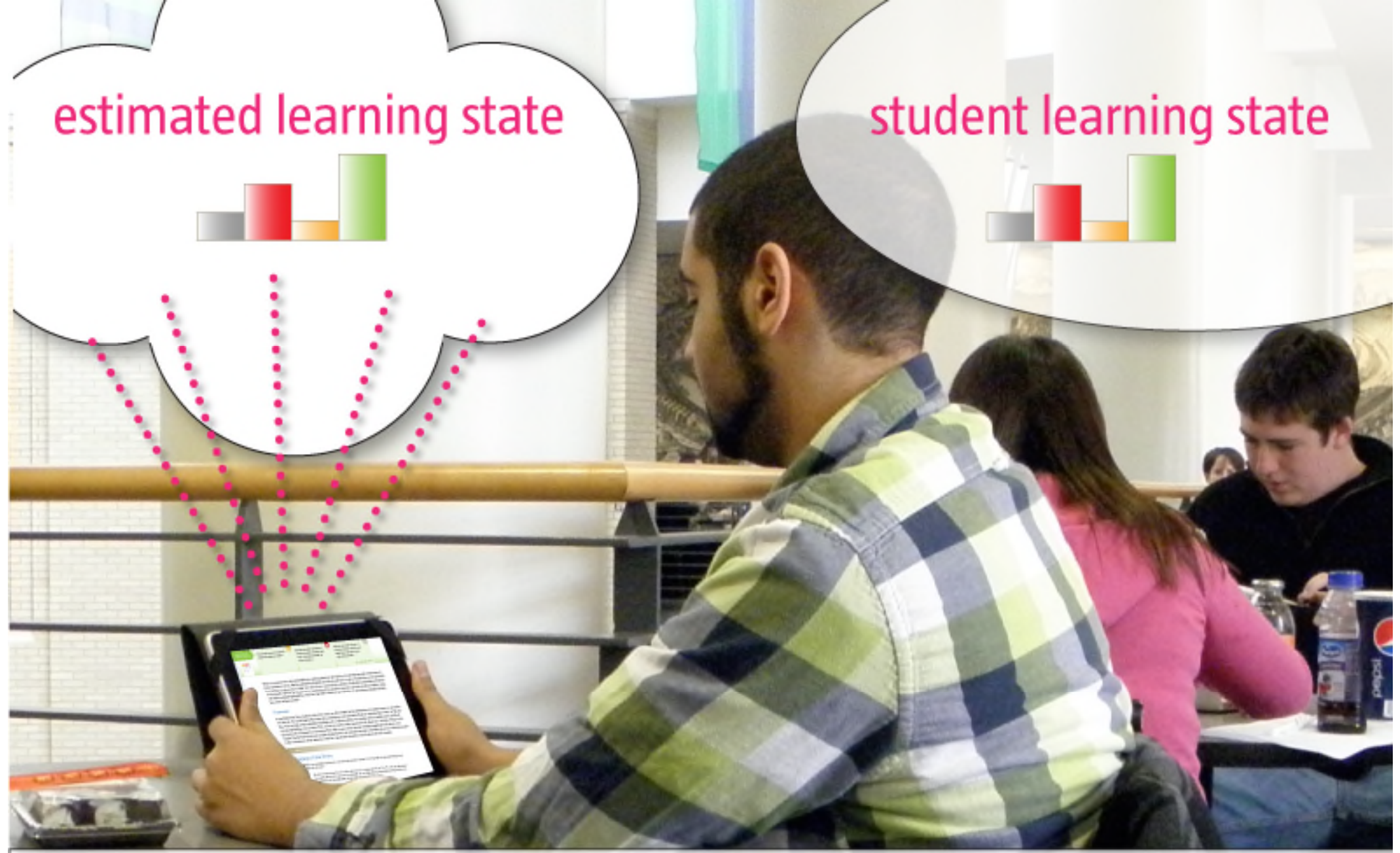
Reveals what students did/not learn

Quantifies how well students have learned each skill

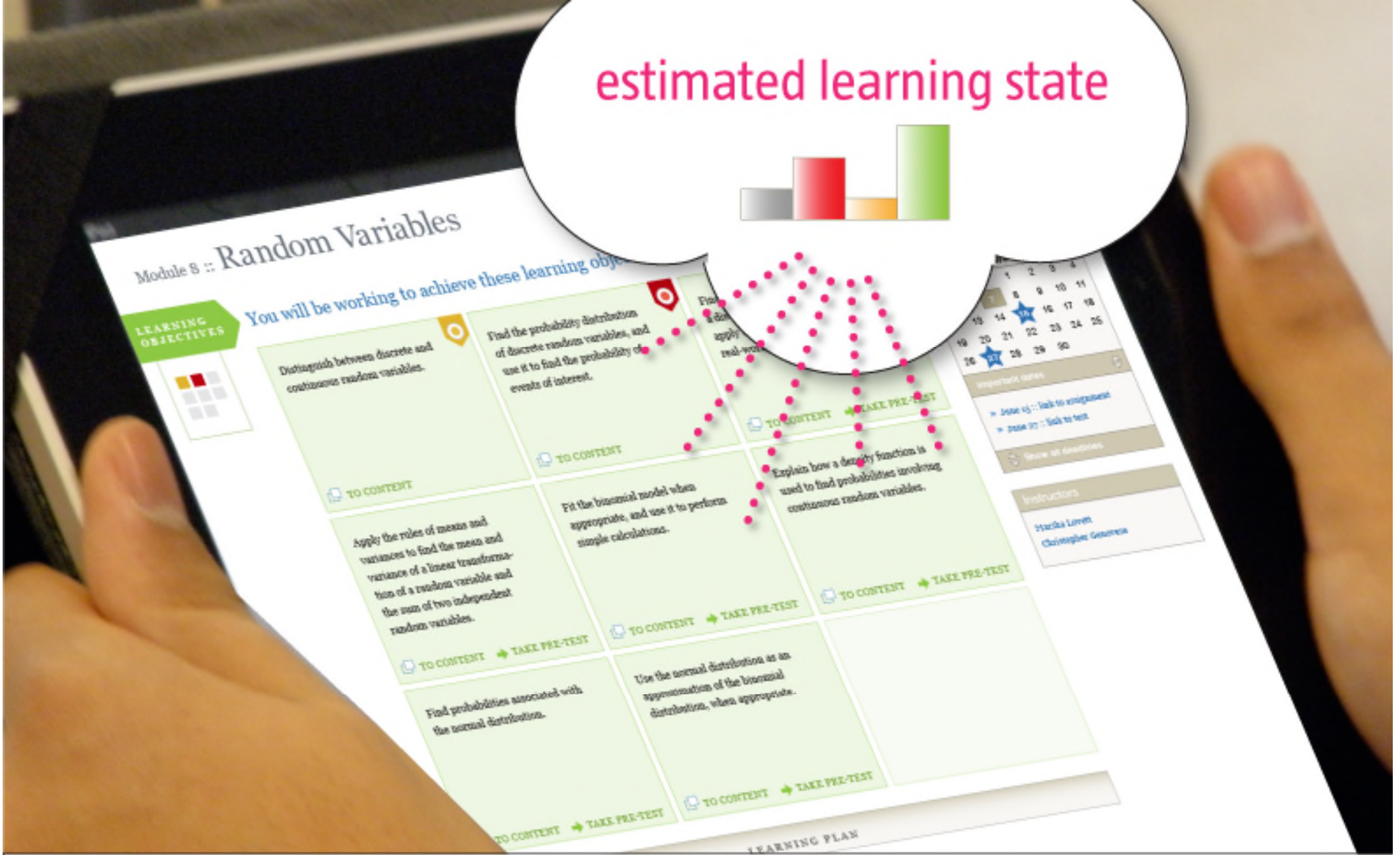
Identifies consequential patterns in students' learning behaviors

Measures effectiveness of instructional and design choices

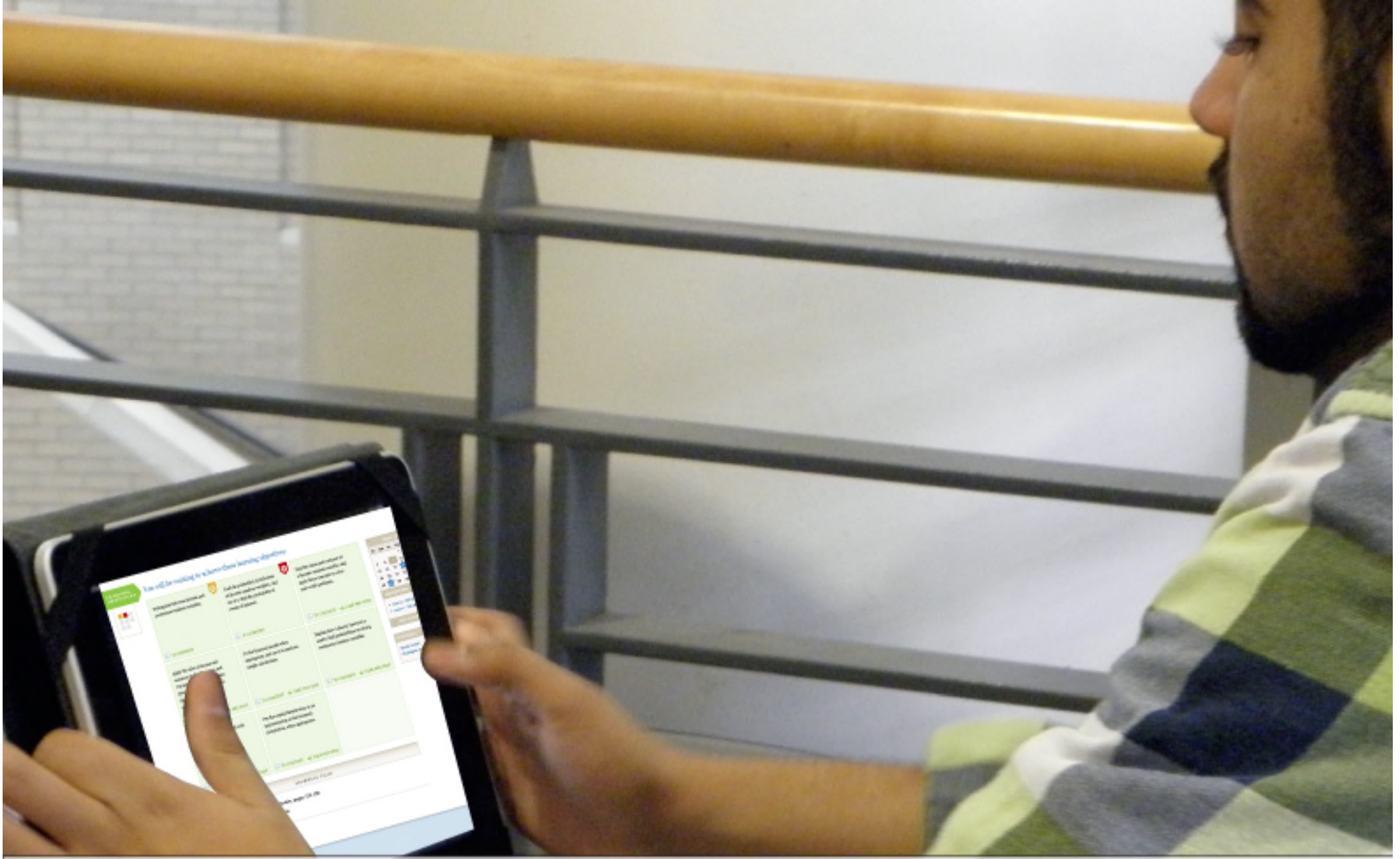
When working on an instructional activity, a student is drawing on particular knowledge and skills, some of which may be correct or incorrect, some of which may be strong or weak.



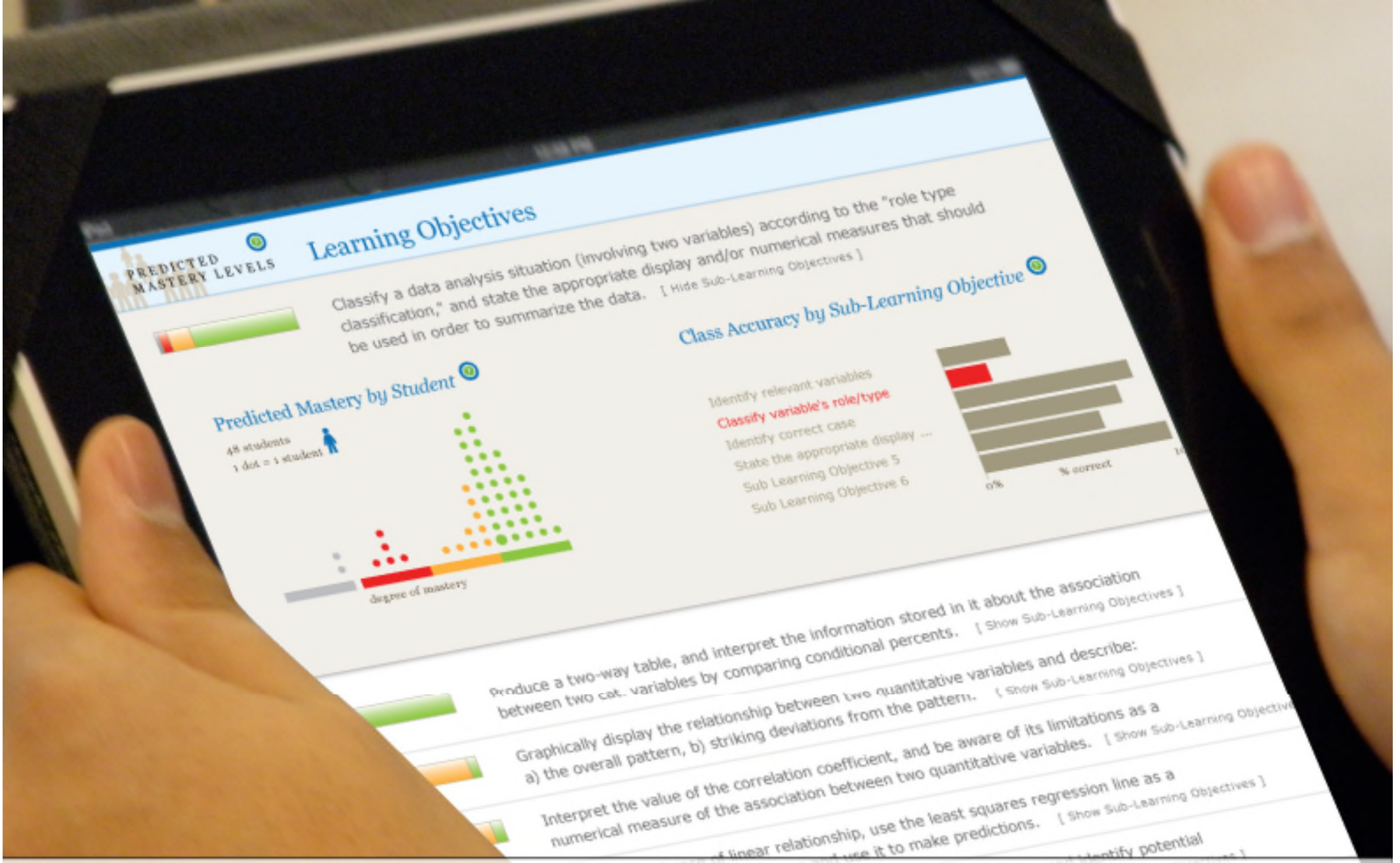
The student's interactions are transmitted to the *Learning Dashboard* where state-of-the-art statistical and cognitive models make inferences about the student's current learning state.



The *Learning Dashboard* creates interactive displays to communicate key aspects of the learning state to the **student**, instructor, and administrator.



Student clicks on a recommendation from the *Learning Dashboard* and goes back into content.



The *Learning Dashboard* creates interactive displays to communicate key aspects of the learning state to the student, **instructor**, and administrator.

Accelerated Learning Hypothesis

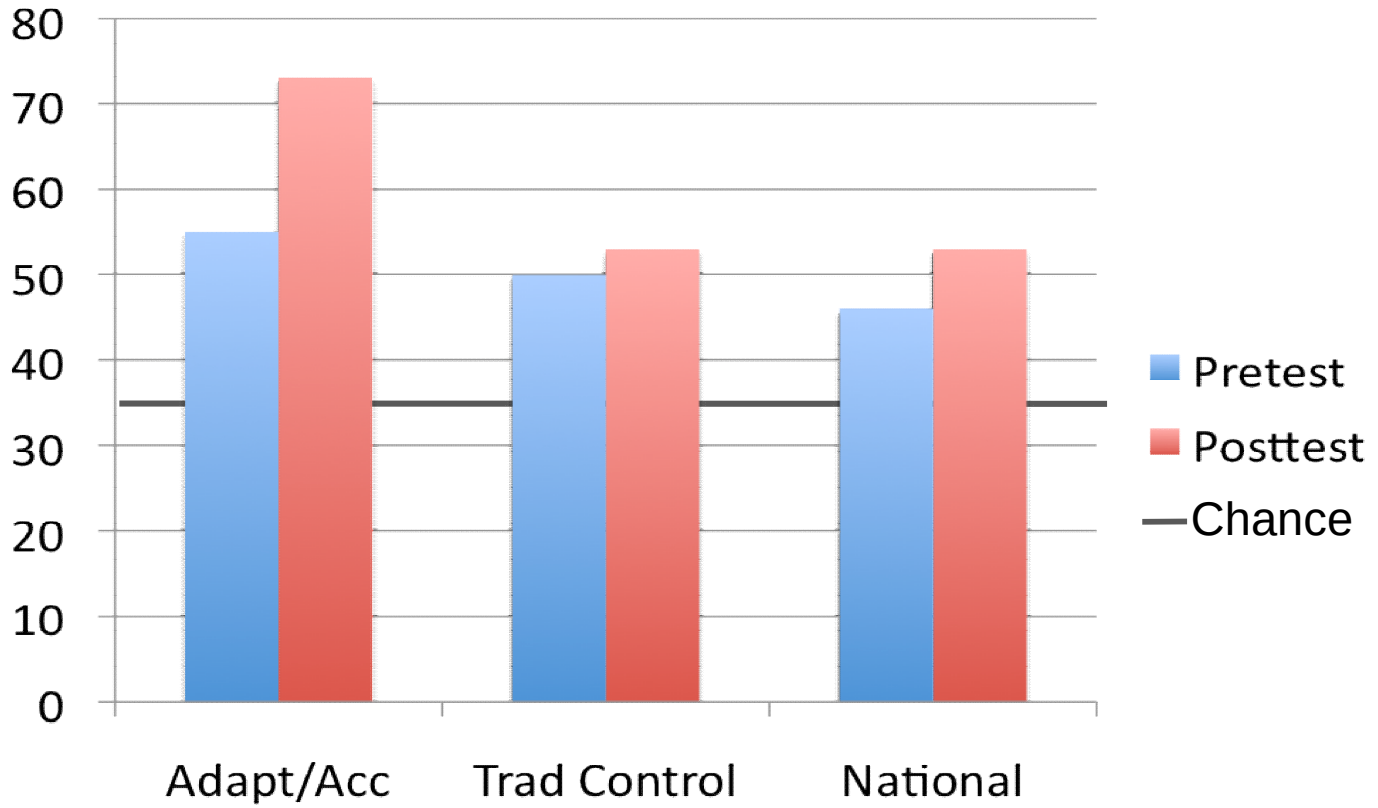
Hypothesis: With this kind of adaptive teaching and learning, students can learn the **same material** as they would in a traditional course in **shorter time** and still show **equal or better learning**.

Adaptive/Accelerated vs. Traditional

Two 50-minute classes/wk	<	Four 50-minute classes/wk
Eight weeks of instruction	<	Fifteen weeks of instruction
Homework: complete OLI activities on a schedule	<	Homework: read textbook & complete problem sets
Tests: Three in-class exams, final exam, and CAOS test	=	Tests: Three in-class exams, final exam, and CAOS test

Same content but different *kind* of instruction

Standardized Test Results

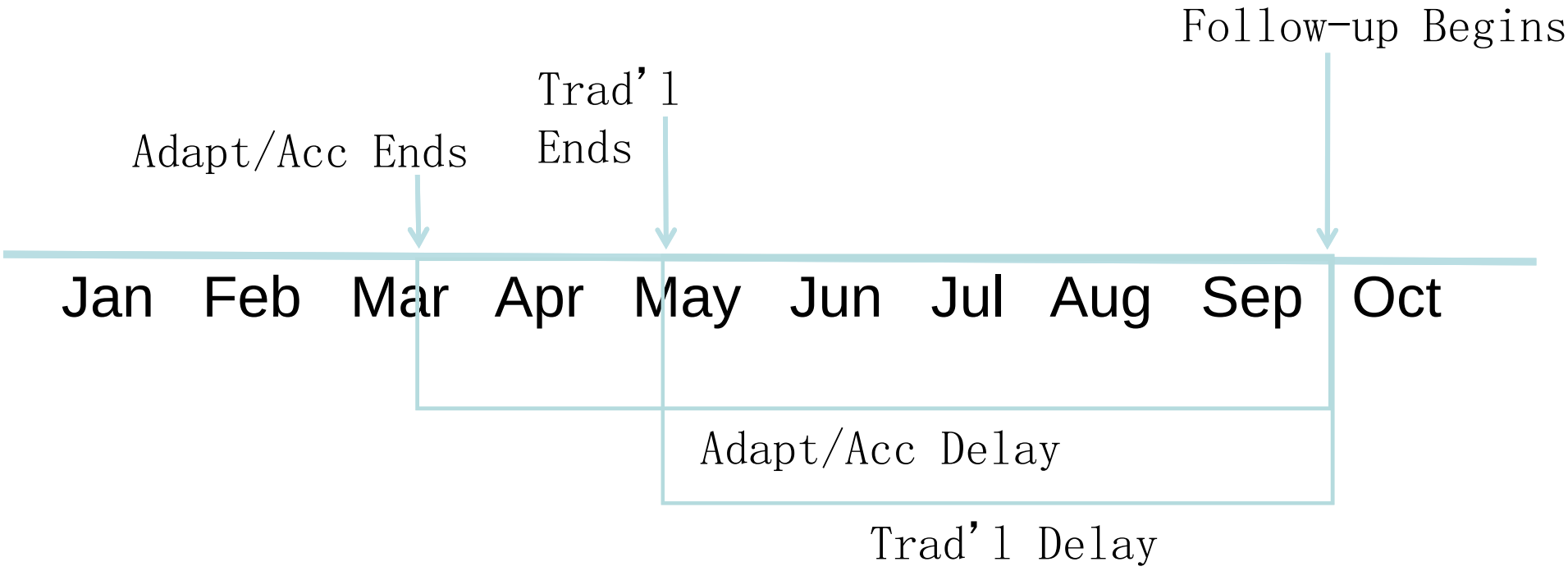


Adaptive/Accelerated group gained significantly more pre/post than the Traditional Control group, 18% vs. 3%

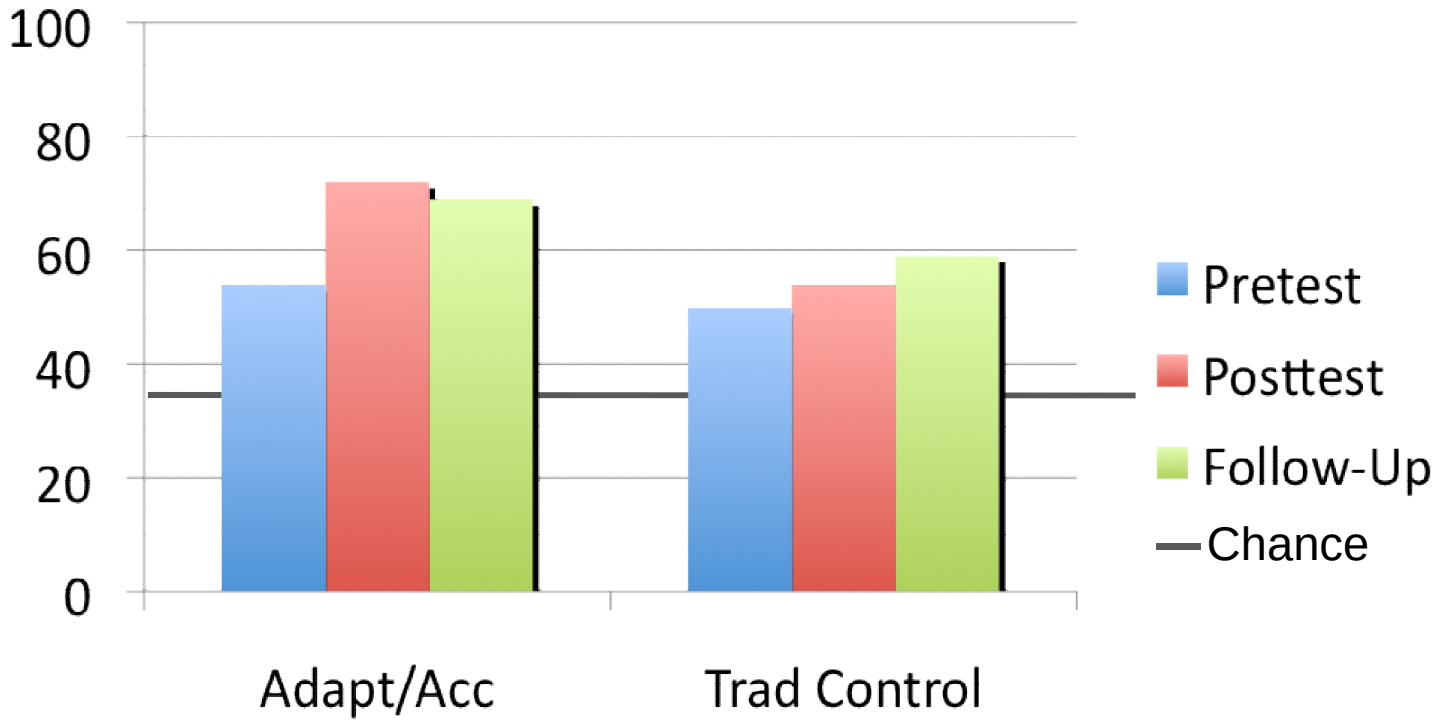
Follow-up: Retention & Transfer

Goal: Study students' retention and transfer in both groups

Students were recruited at the beginning of the following semester

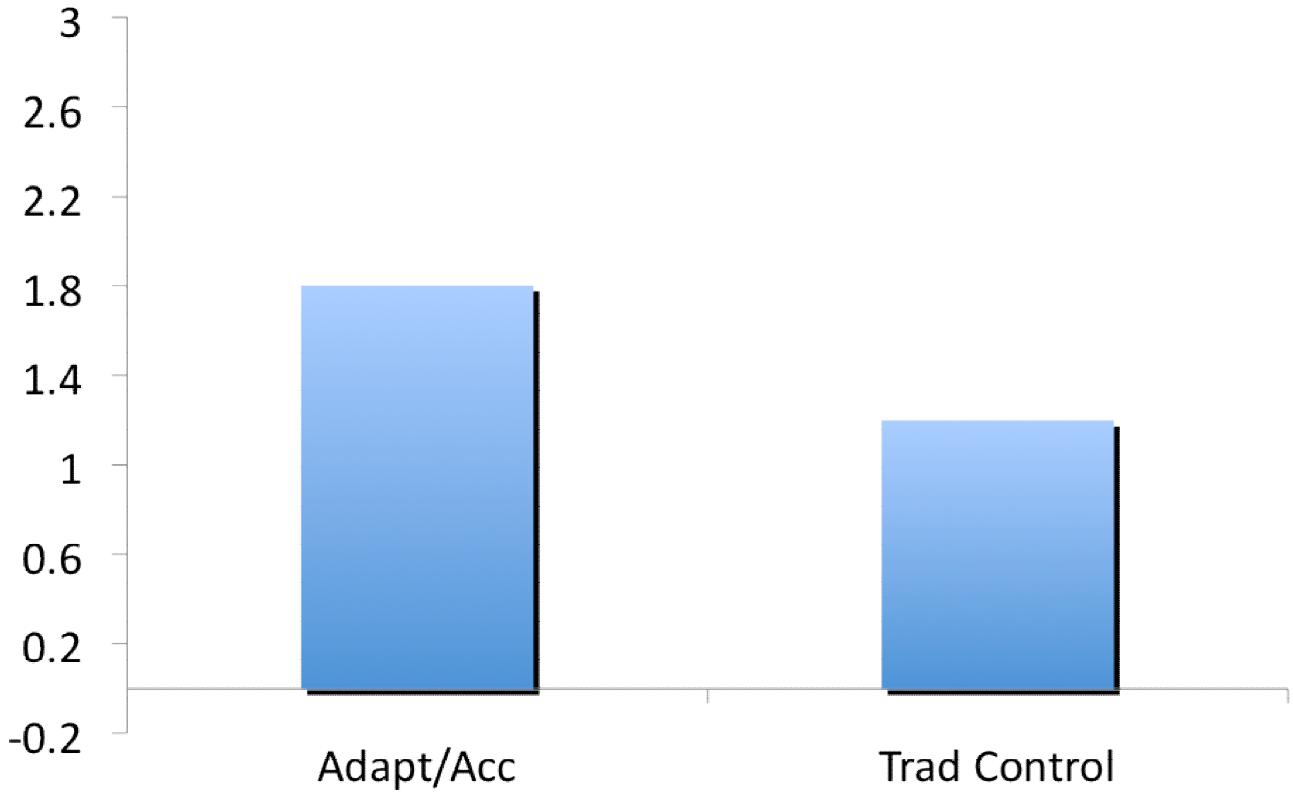


Retention: Standardized test



At 6-month delay, Adaptive/Accelerated group scored higher on CAOS than Traditional Control, $p < .01$.

Transfer: Open-Ended Data Analysis



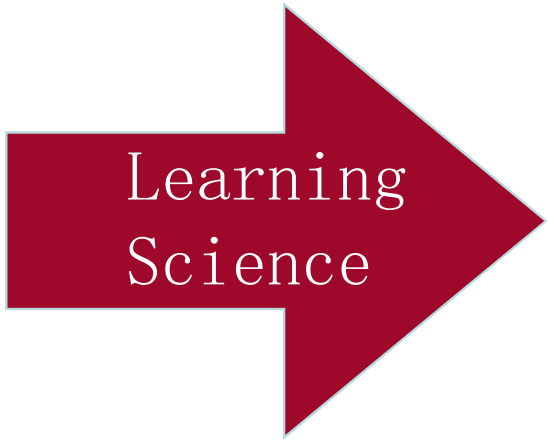
Adaptive/Accelerated group scored significantly higher than Traditional Control.

CMU Statistics Study

Traditional College Course

> 100 hours

~3% learning gain



Adaptive, Data-Driven OLI Course

< 50 hours

~**18%** learning gain

Replicated 3 times at CMU

External report by ITHAKA

Lovett, Meyer, & Thille (2008, 2010).
See jime.open.ac.uk/jime/article/view/2008-14

This is so much better than reading a textbook or listening to a lecture! My mind didn't wander, and I was not bored while doing the lessons. I actually learned something. – *Student in study*

The format [of the adaptive/accelerate course] was among the best teaching experiences I've had in my 15 years of teaching statistics. – *Professor from Study 1*

At the University of Maryland, Baltimore County, teacher Bonnie Kegan found one big advantage was the timely feedback the software gave by tracking students' answers to questions posed as they worked through each lesson. "You can drill down and see what questions they're missing," she says.

– from "Tapping Technology to Keep Lid on Tuition" by David Wessel, *Wall Street Journal,* July 19, 2012

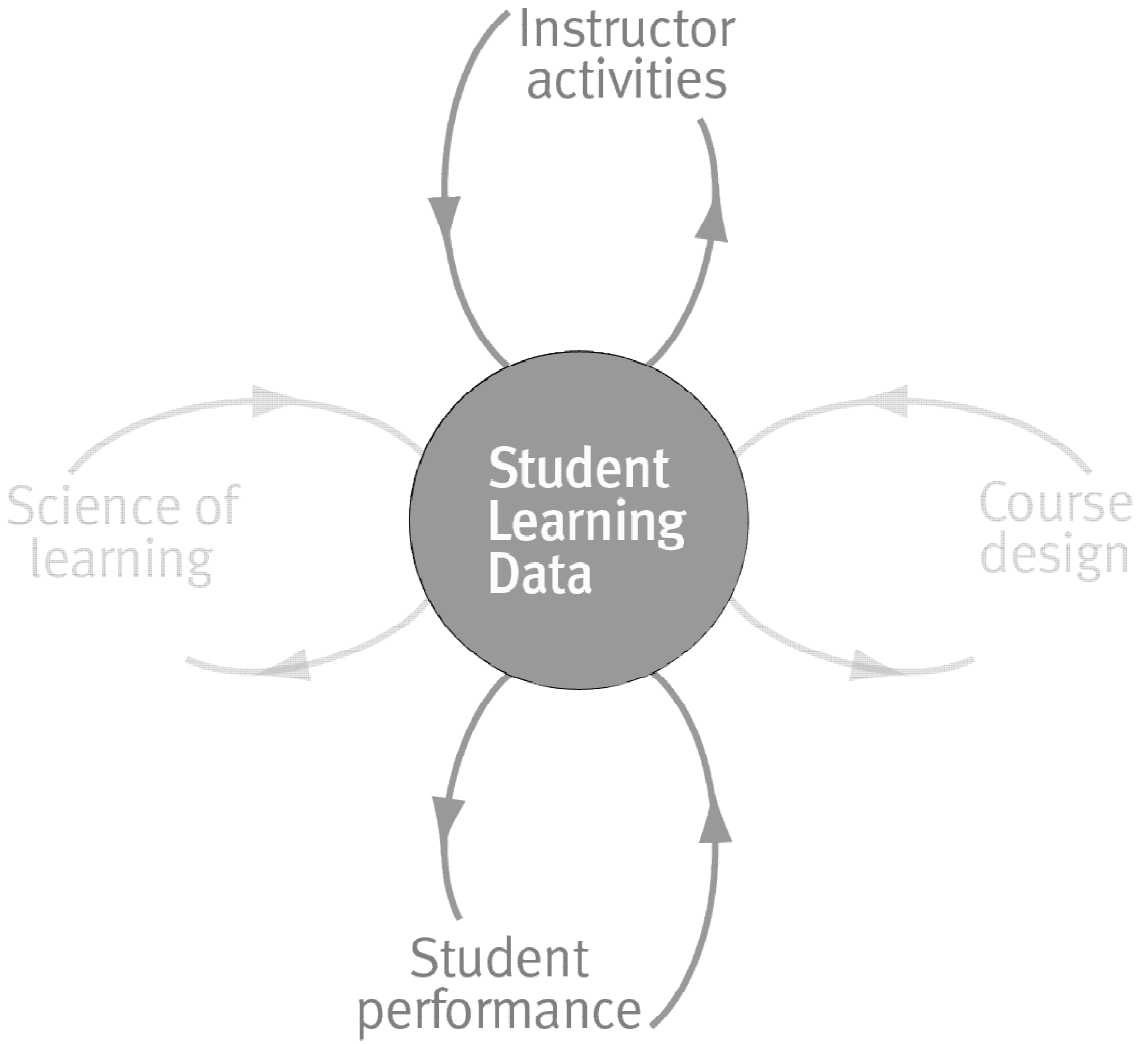
Take-Home Messages

Learning science research provides rich theory and results on how students learn

Designing instruction based on learning science principles produces positive results

Key role for technology is to automate and augment putting them into practice

Interaction data drive feedback loops



CMU Accelerated Learning Studies

#1 Small class, expert instructor

Collect baseline data on standard measures

Test new dependent measures

#2 Replication with larger class

With retention & transfer follow-up 4+ months later

#3 Replication and extension to a new instructor

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