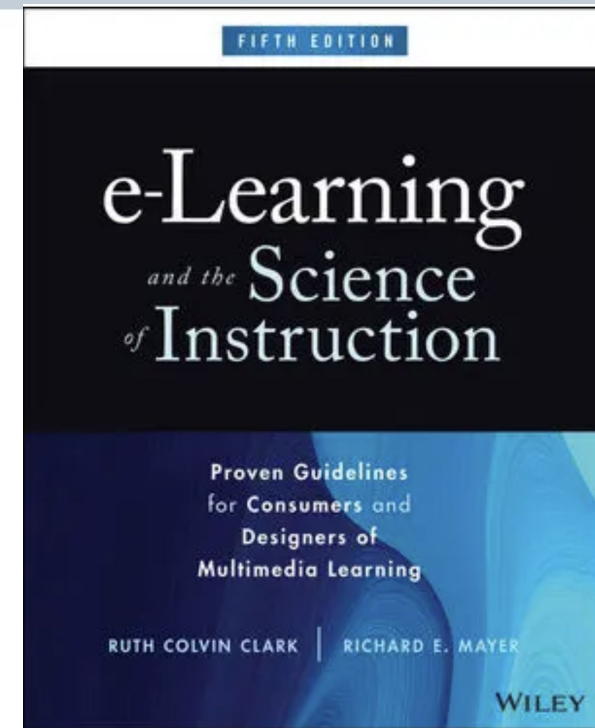


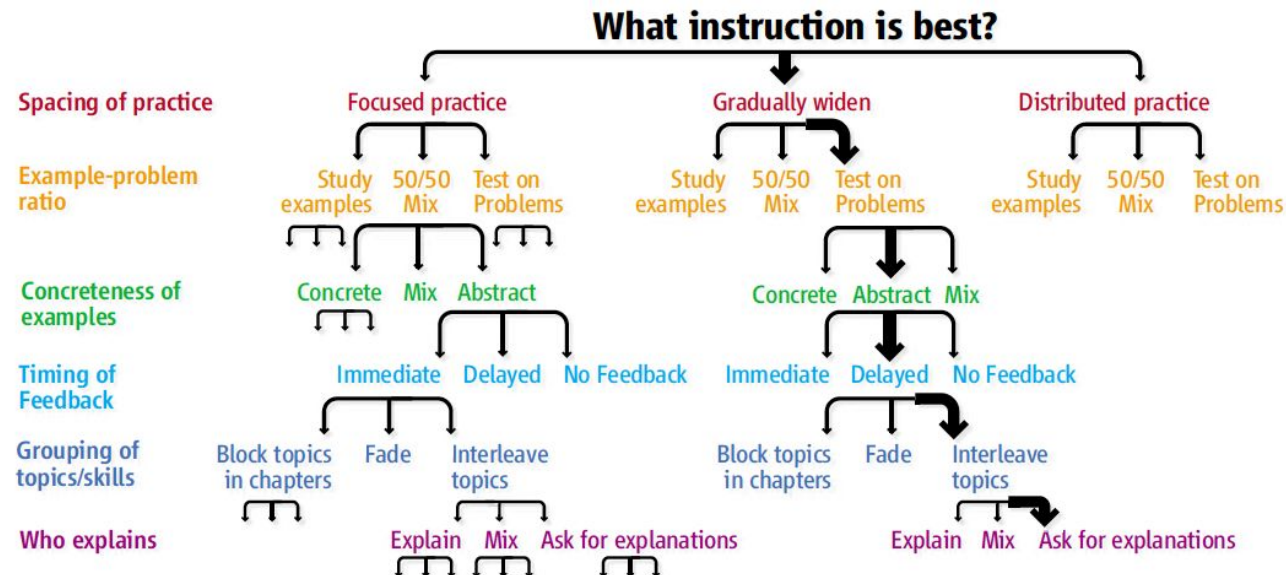
# E-Learning Design *Principles & Methods*

Learn about

- E-learning design *principles*
- *Evidence & theory* to know when to apply them
- *Methods* to adapt them to specific needs



Professor  
Ken Koedinger



# Online learning: important, interesting, challenging!!



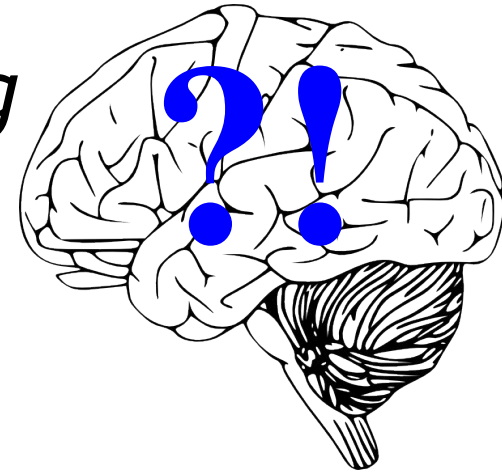
# Online learning: important, interesting, challenging!!

- Education is *important*



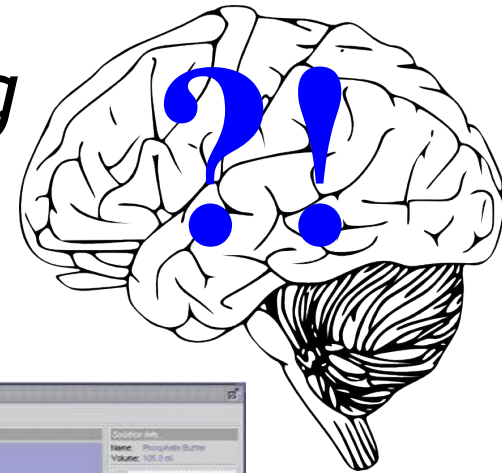
# Online learning: important, interesting, challenging!!

- Education is *important*
- Unlocking the mysteries of human learning is *interesting*



# Online learning: important, interesting, challenging!!

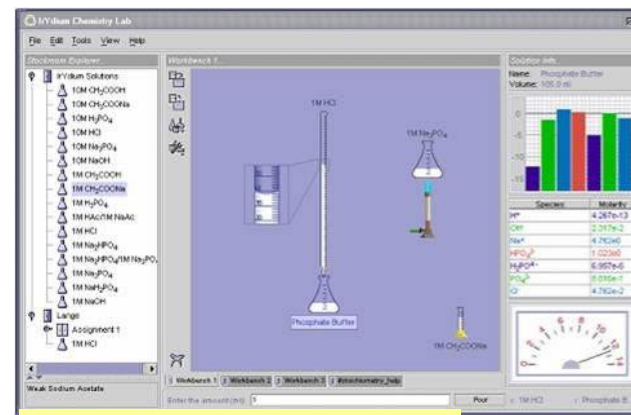
- Education is *important*
- Unlocking the mysteries of human learning is *interesting*
- Tech innovation is *challenging, fun, powerful*



Intelligent tutors helping city kids catch up in math



Learning games on mobiles in Africa



Virtual labs & MOOCs scaling education



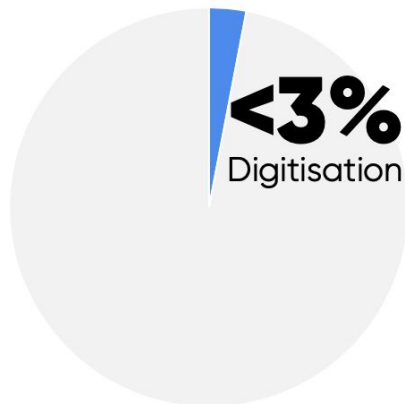
# Learning & Training Continues to Boom!!

- *New ideas*
- *New technologies*
- *New companies*
- *New careers*

Holon IQ

Education is a **Digitisation Outlier**

Education Technology vs Total Global Education Expenditure

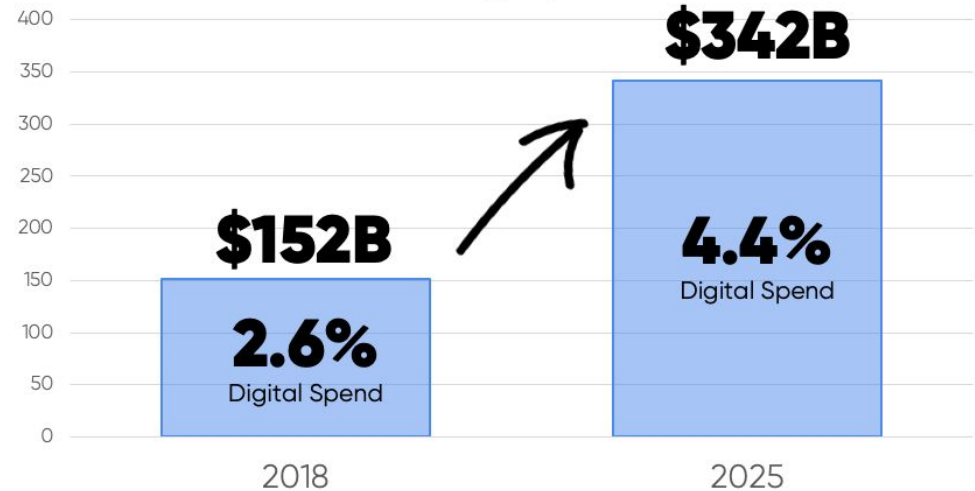


Source: HolonIQ

Holon IQ

Global **Education Technology**

Growth in Global Education Technology Expenditure



Source: HolonIQ, Smart Estimates™ January 2019

- *Incredible Opportunities*

# Overview

- ***Course big picture***
- Syllabus & Course Projects
  - Find syllabus link on Canvas
- Optional: Some exciting local ed tech projects



# Learning Objectives

## *What to do*

- Design Principles
  - Multimedia instruction
  - Learning by doing
  - Supporting metacognitive, motivation & dispositions

## *When & how to do it*

- Design Methods
  - Cognitive Task Analysis
  - Assessment design
  - User experience
  - A/B testing





# General Learning Objectives

- Question assumptions
  - Of others, but especially your own!
- Social-emotional & communication skills
  - Empathy for other views, humility about your own views, group decision-making
- Creativity & innovation
- Think in terms of *claims & evidence*
  - Use data for insight, to help resolve debates
  - Theories of truth: Correspondence >> coherence



# What's the best form of instruction? Two choices?

- More assistance vs. more challenge
  - Basics vs. understanding
  - Education wars in reading, math, science...

If you read about education policy & education debates, you might think there are just two ways to teach.  
*Is that right?*



# What's the best form of instruction? Two choices?

- More assistance vs. more challenge
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  - Education wars in reading, math, science...
- Researchers like binary oppositions too. We just produce a lot more of them!
  - Massed vs. ***distributed*** (Pashler)
  - Study vs. ***test*** (Roediger)
  - ***Examples*** vs. problem solving (Sweller ...)
  - ***Direct instruction*** vs. discovery learning (Klahr)
  - Re-explain vs. ***ask for explanation*** (Chi, Renkl)
  - ***Immediate*** vs. ***delayed*** (Anderson vs. Bjork)
  - ***Concrete*** vs. ***abstract*** (Pavio vs. Kaminski)
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  - ...



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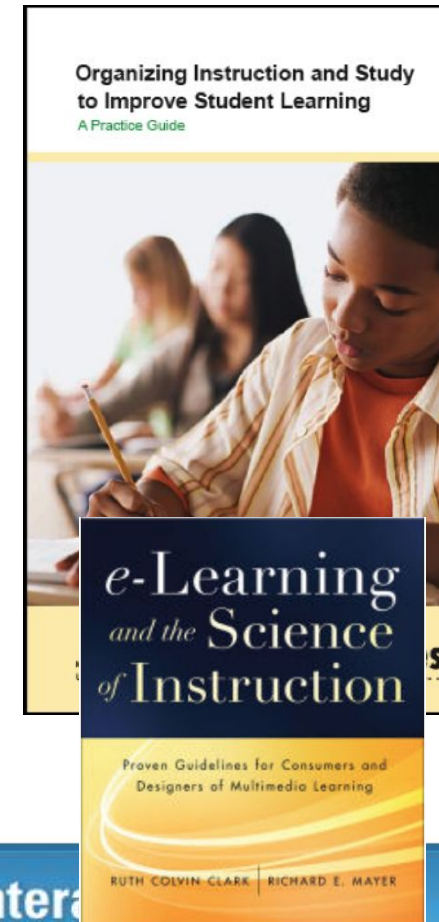
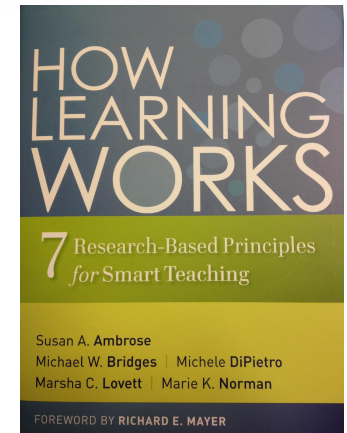
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A number of books and reports have reviewed these factors, including the text we use by Clark & Mayer ...



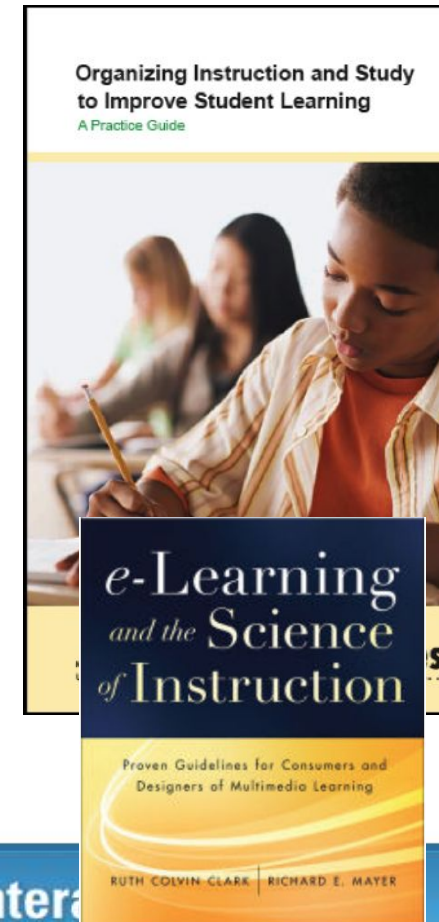
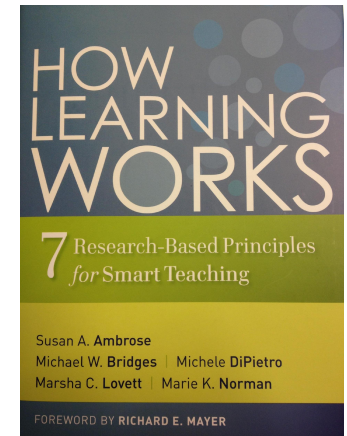
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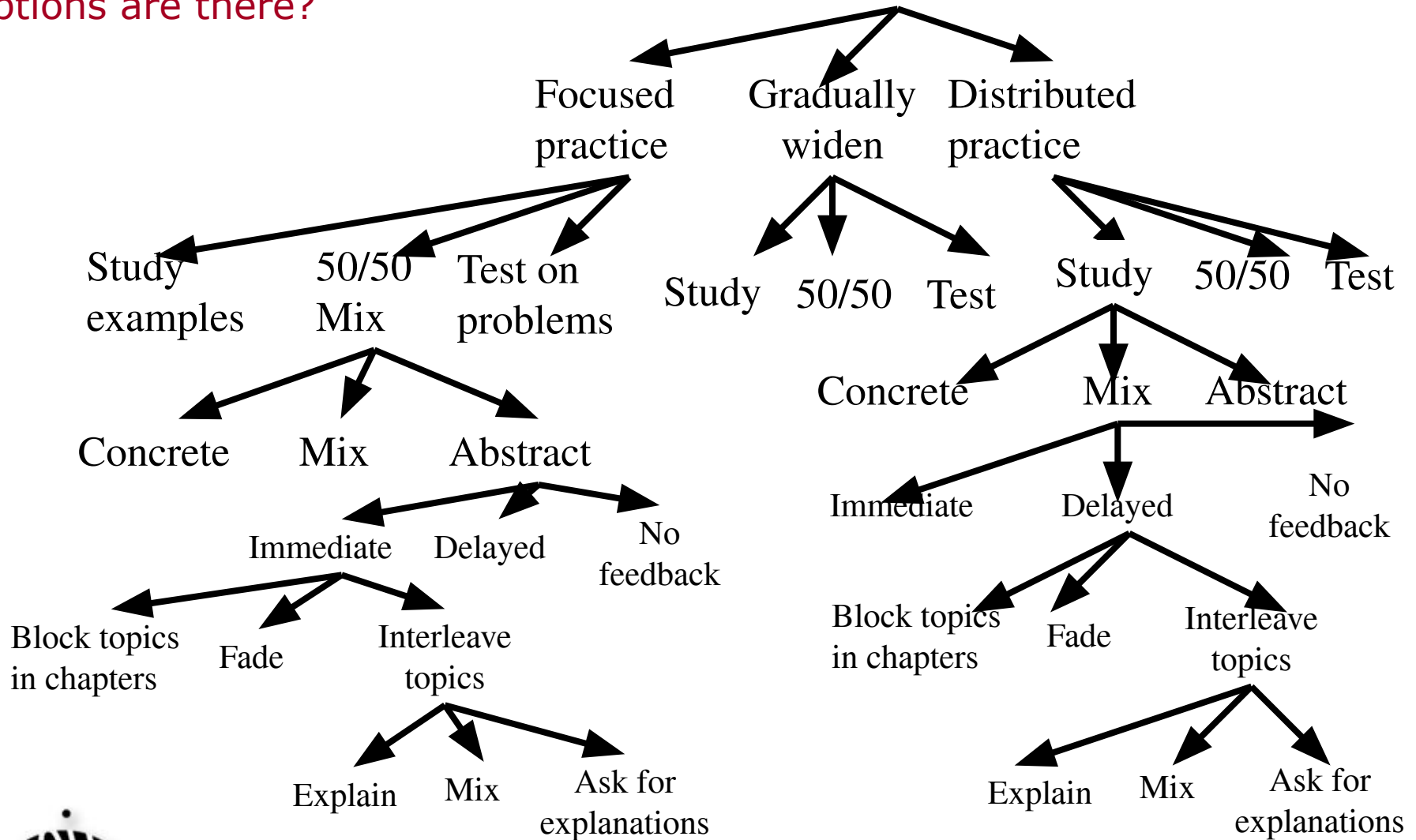
# Instructional Complexity

How many instructional options are there?

More help,  
*passive*

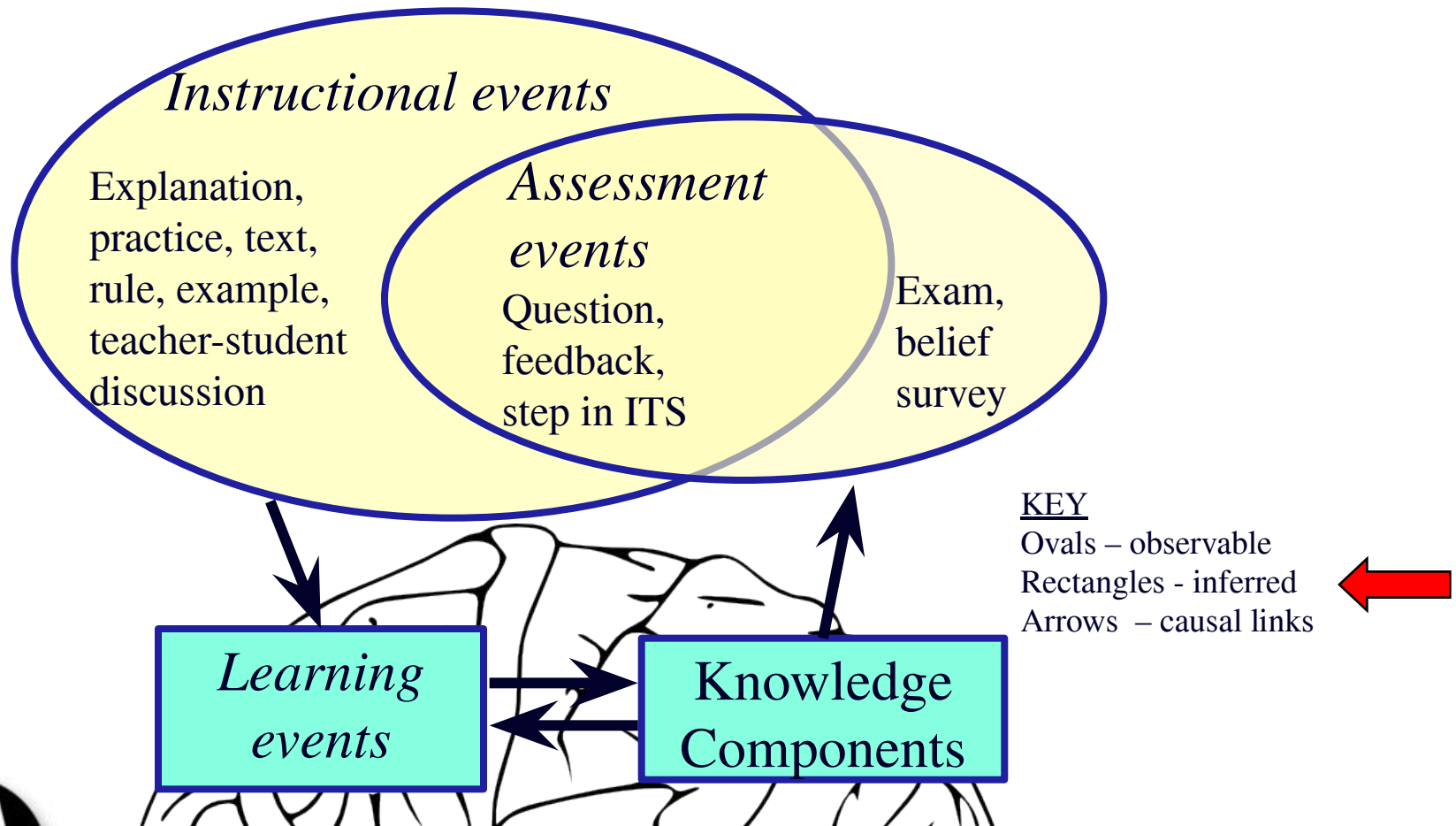
What's best?

More challenge,  
*active*



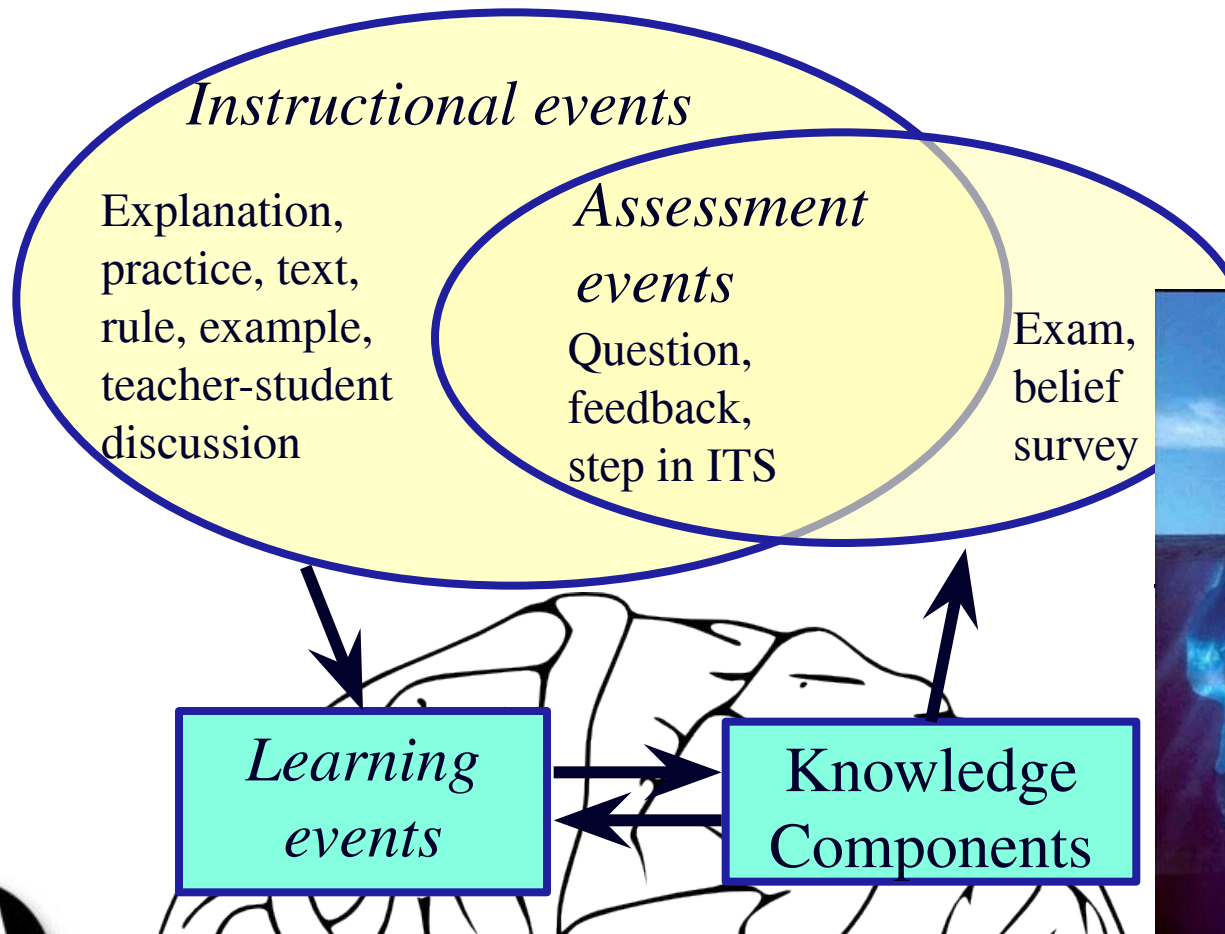
Many other choices: animations vs. diagrams vs. not, audio vs. text vs. both, ...

# Knowledge-Learning-Instruction Framework (called KLI, rhymes with key)



Koedinger, Corbett & Perfetti. (2012). The Knowledge-Learning-Instruction (KLI) framework: Bridging the science-practice chasm to enhance robust student learning. *Cognitive Science*

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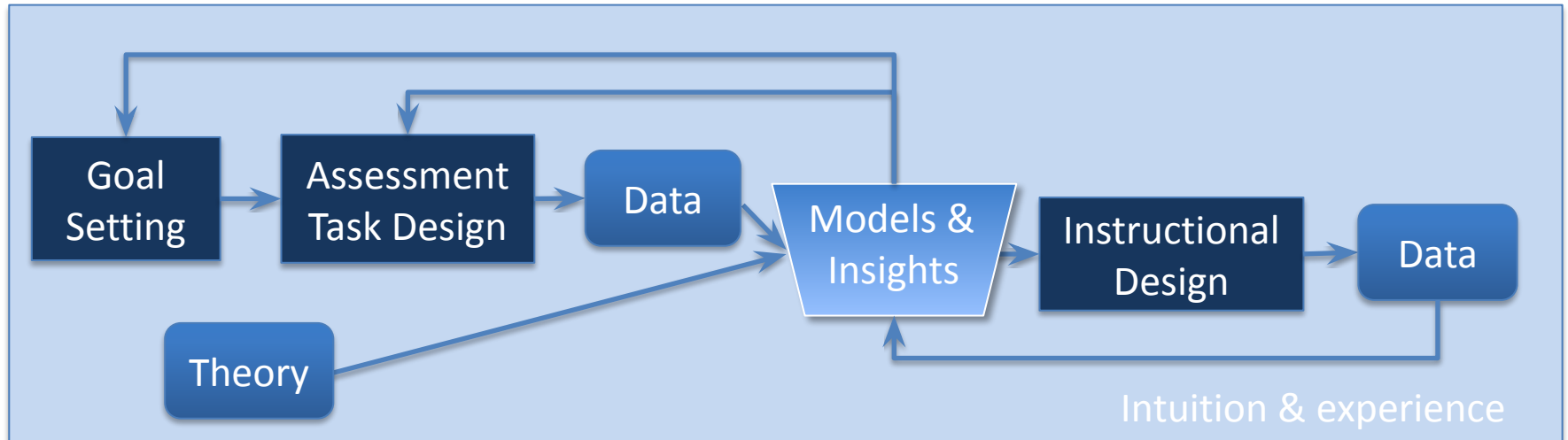


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an-Comp

# Instructional Design Process: The BIG PICTURE

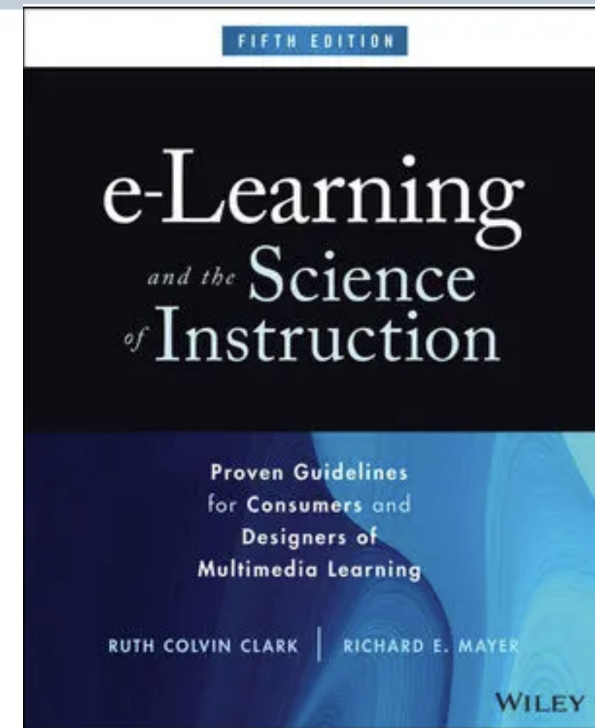


- *Goals* guide *assessment* tasks guide *instruction*
- *Theory, data, & model building* support decisions
  - *Intuition & experience* still relevant  
(but are nearly imperceptible)

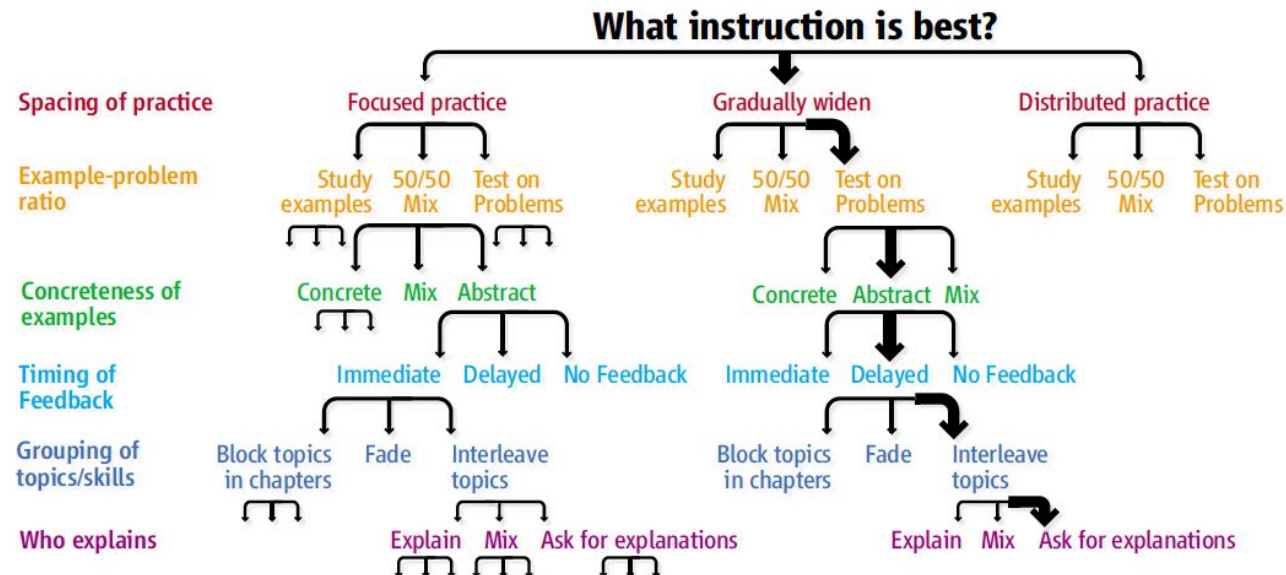
# E-Learning Design *Principles & Methods*

Learn about

- E-learning design *principles*
- *Evidence & theory* to know when to apply them
- *Methods* to adapt them to specific needs



Professor  
Ken Koedinger



# Extra, bonus slides ...

- Some examples of cutting-edge tech from CMU!!





# CMU Learning Science

- CMU spin-off Carnegie Learning Inc  
Real-world impact of Cognitive Tutors
  - 500,000 students per year!
  - many full year evaluations
- LearnLab:  
Pittsburgh Science of Learning Center
  - \$50 million national center
    - Ten years of funding: 2004-14
  - Field-based basic research
    - Improve learning science via technology use in schools



# Cognitive Tutor Math Courses Making a Difference

The New York Times

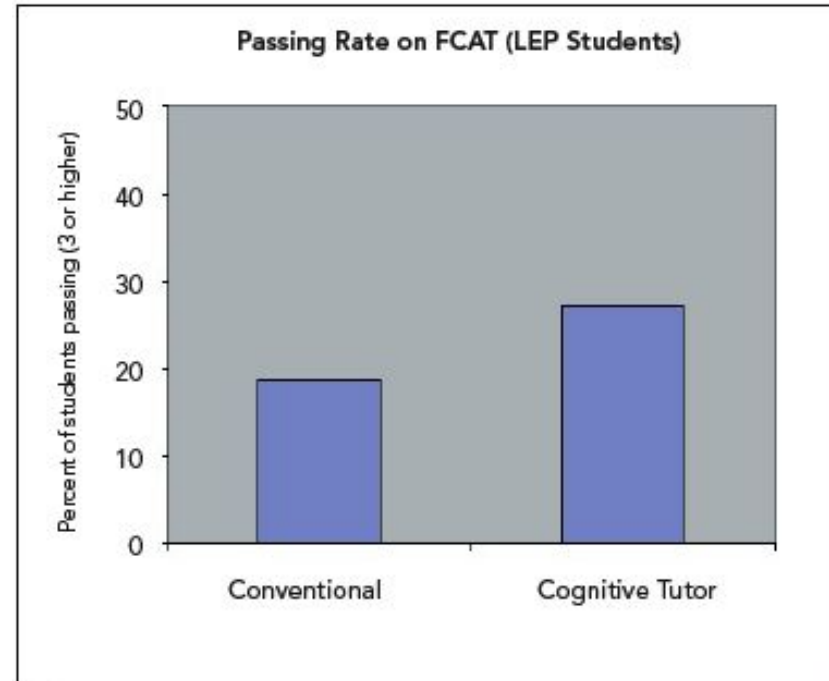
## Technology

### Software Tutors Offer Help and Customized Hints



Chris Maynard for The New York Times

MATH COACH - Rochelle Brown, left, and Iesha Antonetti, students at Middle School 103 in the Bronx, use Cognitive Tutor software to reinforce math skills. The software is designed to give students individualized instruction when personal attention is scarce.



- Widespread use: 500,000 students
- Students learn more



# Learning from Mixed-Reality Games



[norilla.org](http://norilla.org)

<https://www.youtube.com/watch?v=9bvPOAiZK5g>

<https://www.youtube.com/watch?t=16&v=4M31Zh7t9eA>

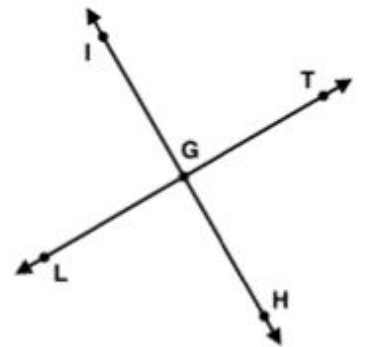
# Assessing & Tutoring Meta-Cognition

## E-learning to help students *learn to learn*

- student self-explanation
- error self-correction
- collaboration skills
- *help-seeking skills*

Scenario

Given: Line LT intersects Line HI at Point G.



1. If the measure of Angle LGH = 77 degrees, find the measures of Angles IGT and TGH.

m $\angle$ LGH	77	Reason	Given
m $\angle$ IGT	77	Reason	Vertical Angles
m $\angle$ TGH		Reason	



In *S. cerevisiae*, which produces unordered tetrads, the following tetrad types were observed from this cross: trp5 cly8 X + + (t = trp5, c = cly8)

Type 1	Type 2	Type 3	
t +	+ c	t c	
t +	+ +	++	
+ c	t +	t c	
+ c	t c	++	
141	925	232	Total = 1298

## 1) Classify

## 2) Totals

PD Total	232
NPD Total	141
TT Total	925

## 4) Qualitative concl

Genes are tightly linked to ear  
Genes are not linked to each  
Both genes are tightly cen-link  
Both genes are cen-linked  
One or both genes are not cer

## 5) Map Distance Cal

$((1/2 * TT) / \text{Total}) *$   
 $((1/2 * TT + 3 * NPD)$

## Stoichiometry Tu

### Problem Statement

Suppose the WHO re  
the concentration of a  
arsenite ( $\text{AsO}_2^-$ ) / L  
2 significant figures. (Hint: the molecular weight of arsenite ( $\text{AsO}_2^-$ ) is 106 g  $\text{AsO}_2^-$  / mol  $\text{AsO}_2^-$ )

### Problem

#	Units	Substance	#	Units	Substance	#	Units	Substance	#	Units	Substance
0.58	mol	AsO <sub>2</sub> <sup>-</sup>	1	g	solution	1.06	g	AsO <sub>2</sub> <sup>-</sup>			
100	g	solution	1000	L	solution						

### Reason

Given Value

### Reason

Unit Conversion

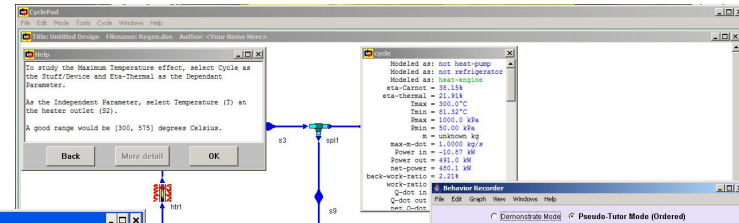
### Reason

### Reason

u. 16.26

Hint: The goal is to convert the amount of substance in moles to grams by using molecular weight

get next hint



## The "Chocolate Problem"

You have 1/2 of a chocolate bar. Write this as a fraction in three different ways! Before you do this, please explain the steps you need to do to convert a fraction.

First, multiply the numerator with a number > 1.

multiply the denominator with the same number

This Number Line will help you to solve the conversion problems. To set the number of sections on the line, enter a number in the Divisions field.

1/2 = 2/4

1/2 = 3/6

1/2 = 8/16

Hint

No, this is not correct. Think back - what is the denominator and what is the numerator in the fraction?

dnt expect what happened

In this clip from the end of the school year, the two oldest students are about to hear the results of their exams and whether they will move on to middle school the following year.

Continue



# Machine learning detectors of motivation, reflection, affect

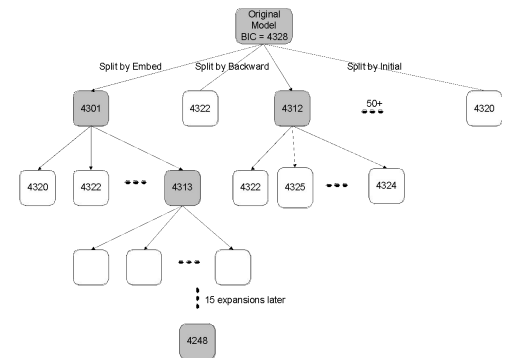
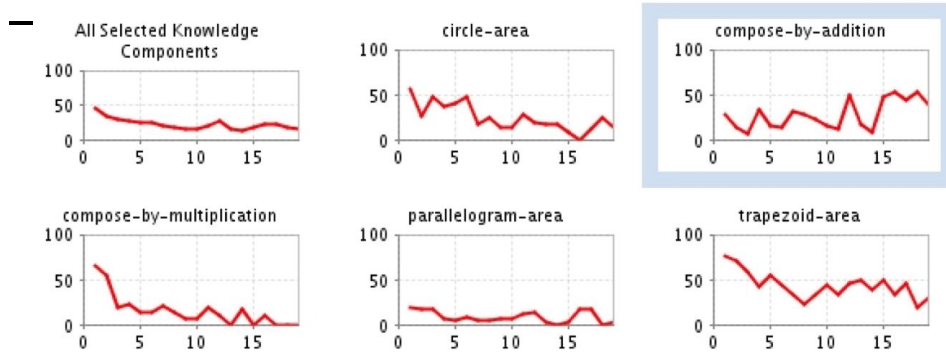
- Example: When are students “gaming the system”? (Baker, et al)
  - Classroom observers tag off-task behavior events
  - Apply machine learning -> automated detectors
  - Use detector to assess & give feedback on student work habits
- Also detectors of
  - Off-task vs. on-task long pauses
  - Deep vs. shallow reflection
  - Boredom, confusion, flow





# Automated discovery of better cognitive models

- Human & machine learning
  - Visualizations to aid human discovery
  - AI search for statistically better models



- Better models discovered in Geometry, Statistics, English, Physics ...
- Used to improve student learning outcomes

