Feedback Loops for More Effective and Personalized Learning
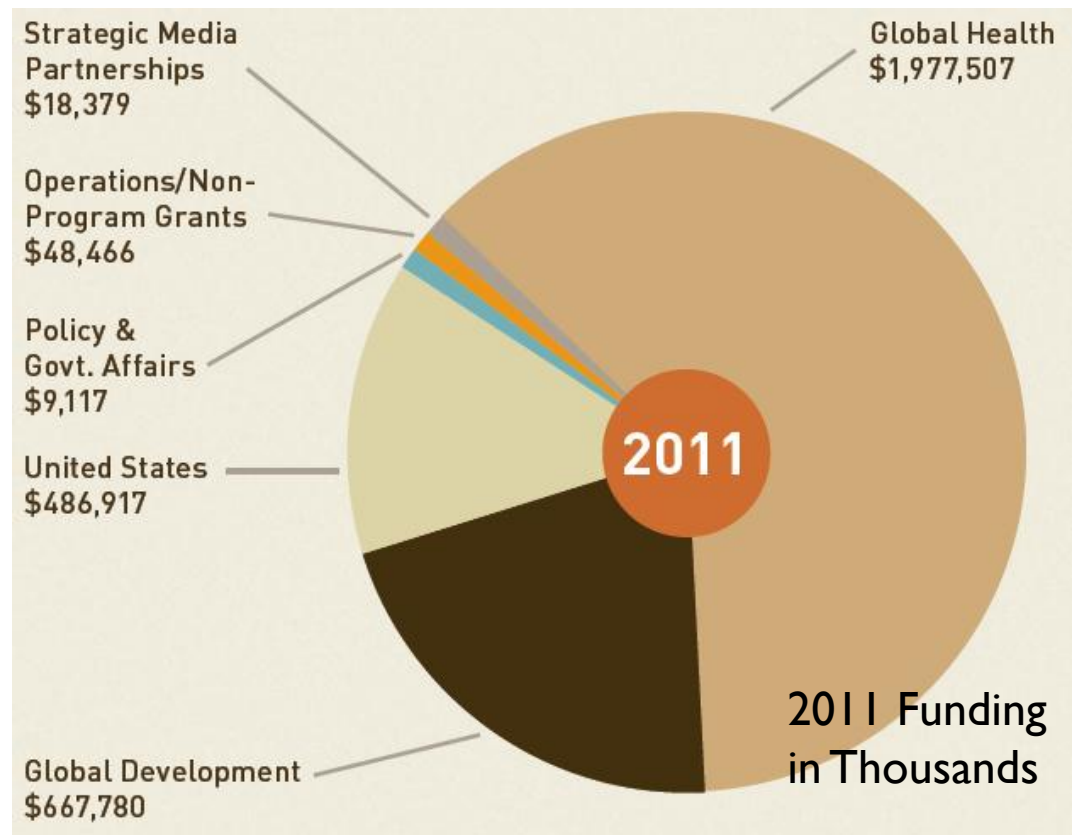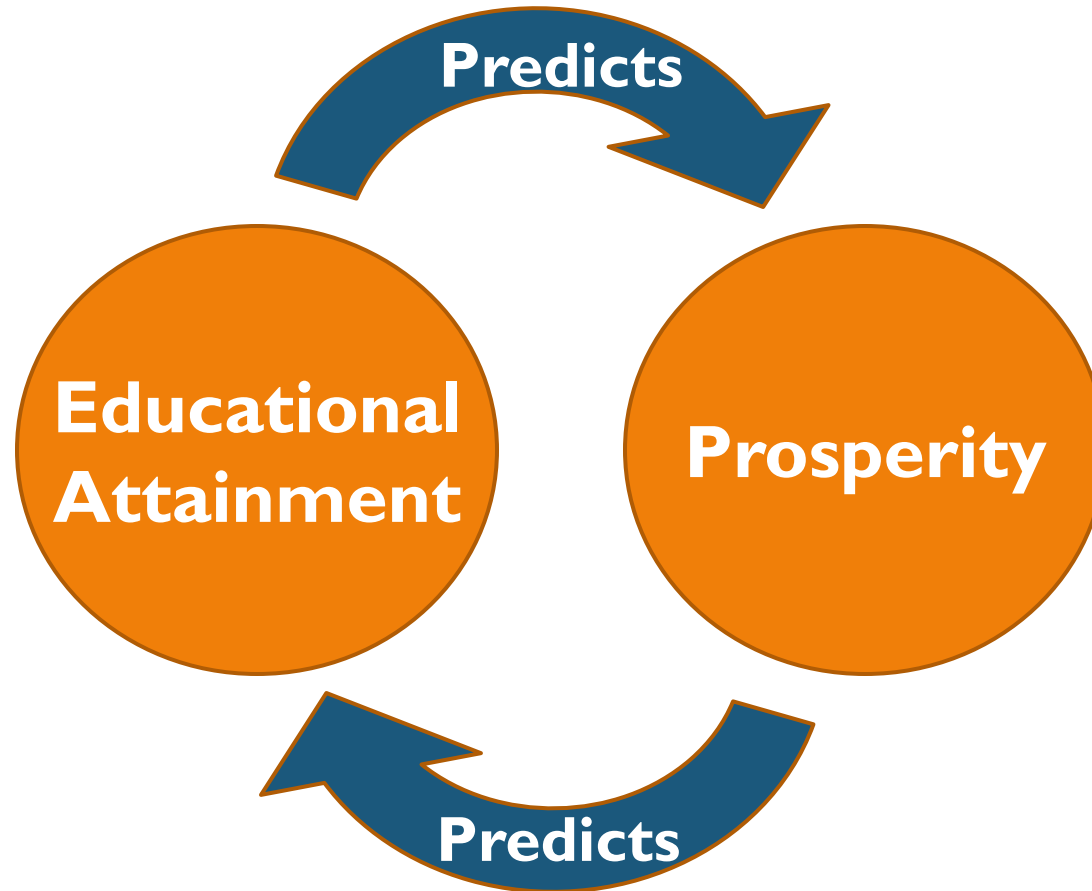
Brandt Redd

Senior Technology Officer

Bill & Melinda Gates Foundation

http://ofthat.com

Guided by the belief that every life has equal value, the Bill & Melinda Gates Foundation works to help all people lead healthy, productive lives.
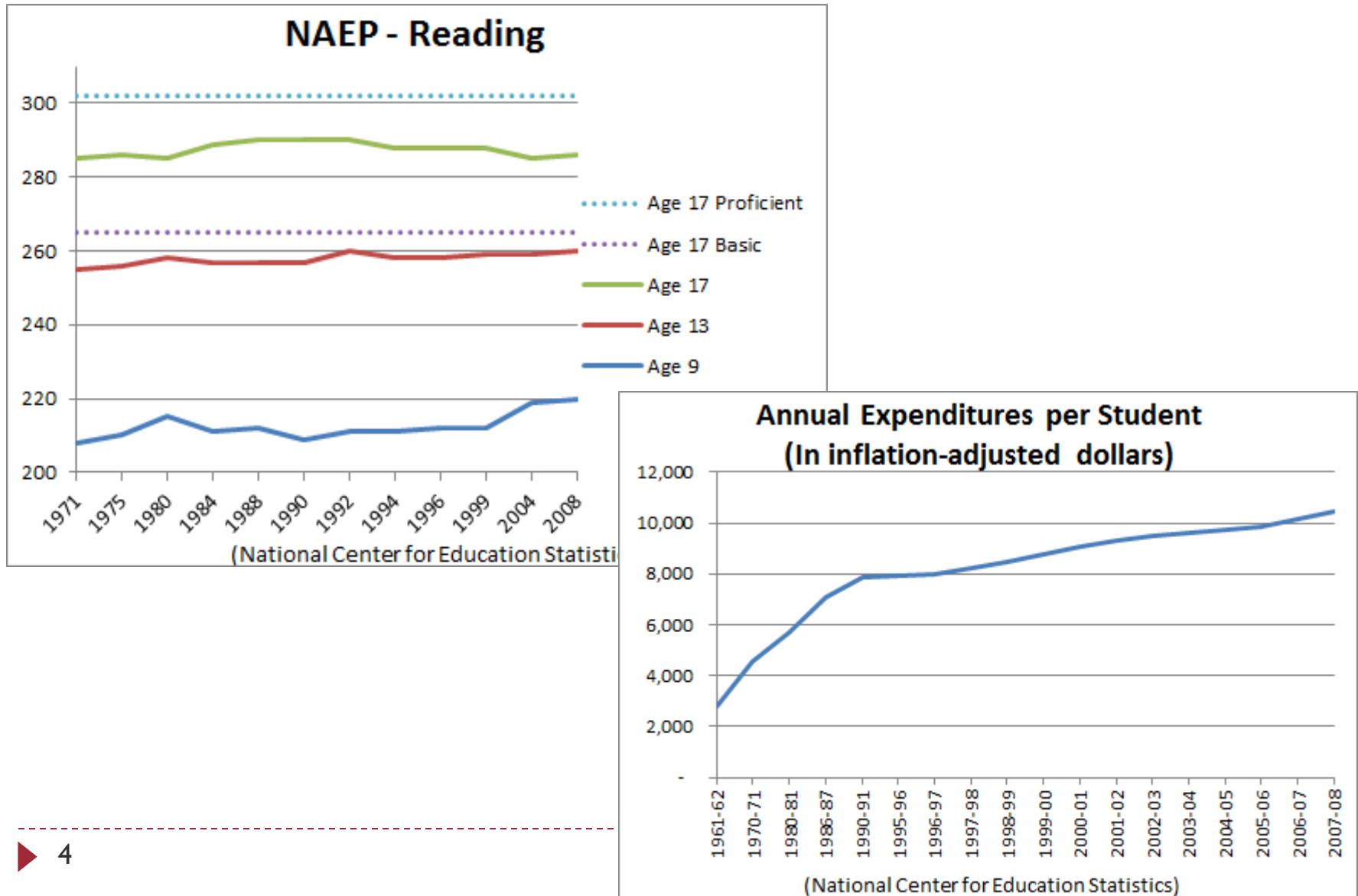
Strategic Media Partnerships $18,379

Operations/Non-Program Grants $48,466

Policy & Govt. Affairs $9,117

United States $486,917

Global Development $667,780

Global Health $1,977,507

2011

2011 Funding in Thousands

We can reduce inter-generational poverty through education.

Educational Attainment **Predicts** Prosperity

Prosperity **Predicts** Educational Attainment

(Source: United Way Common Good Forecaster)

Educational spending alone doesn't seem to predict student achievement.

NAEP - Reading
(National Center for Education Statistics)

Annual Expenditures per Student
(In inflation-adjusted dollars)
(National Center for Education Statistics)

Without a change in practice, technology doesn't improve student learning.

"Feedback is a consequence of performance"
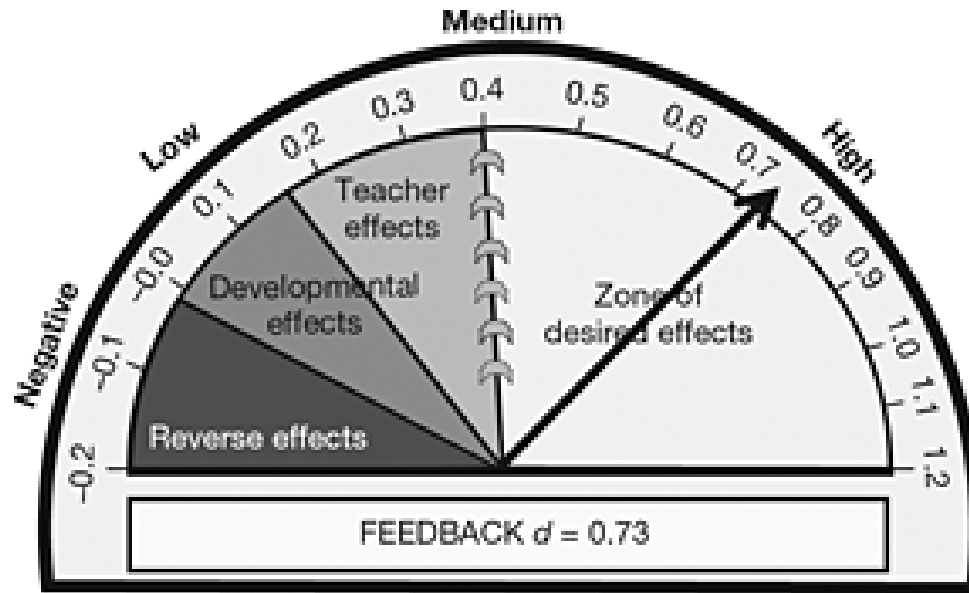
The most effective forms of feedback provide cues or reinforcement to the learner, are in the form of video, audio or computer-assisted instruction feedback, or relate feedback to learning goals.

(Hattie, John A. C. , Visible Learning, p. 174)

What Works?

| Rank	Influence	Effect Size
1	Self-report grades	1.44
2	Piagetian programs	1.28
3	Providing formative evaluation	0.90
4	Micro teaching	0.88
5	Acceleration	0.88
6	Classroom behavioral	0.80
7	Comprehensive interventions for learning disabled	0.77
8	Teacher clarity	0.75
9	Reciprocal teaching	0.74
10	Feedback	0.73

(Hattie, *Visible Learning*)

Personalized Learning Feedback Loop
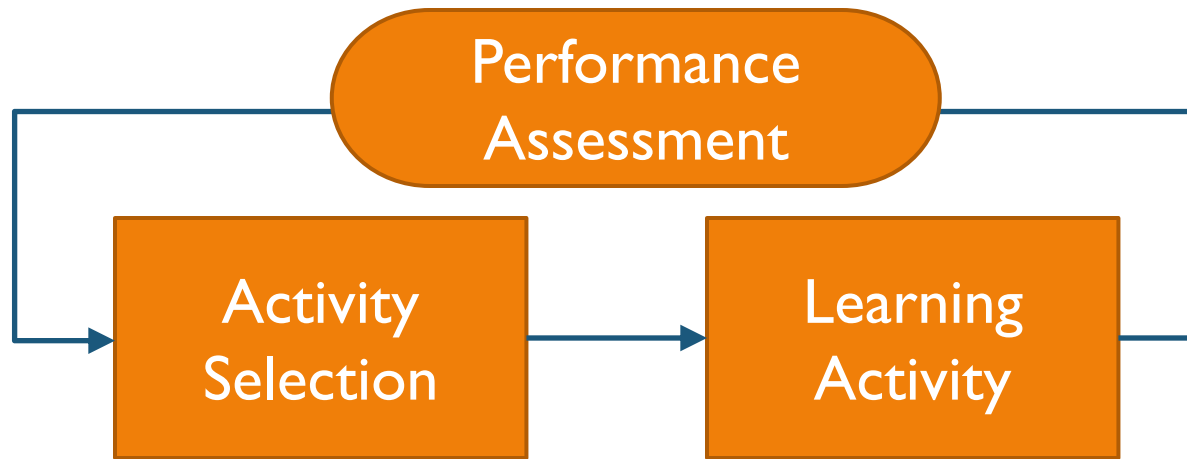
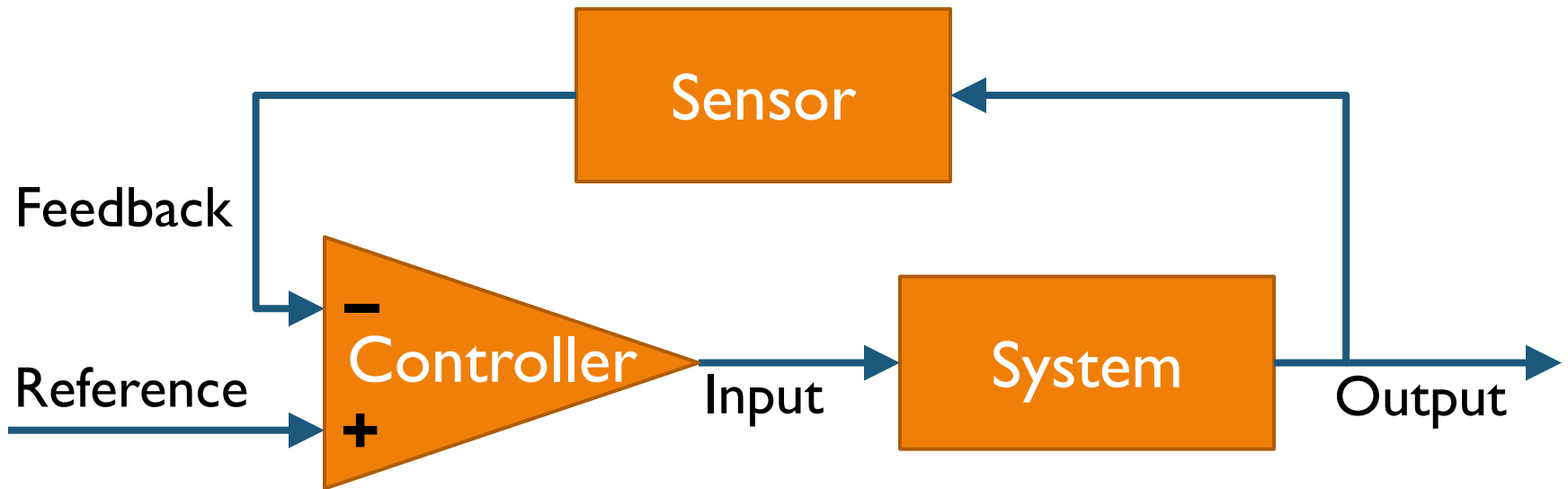# The CMU Open Learning Initiative defines four feedback loops.
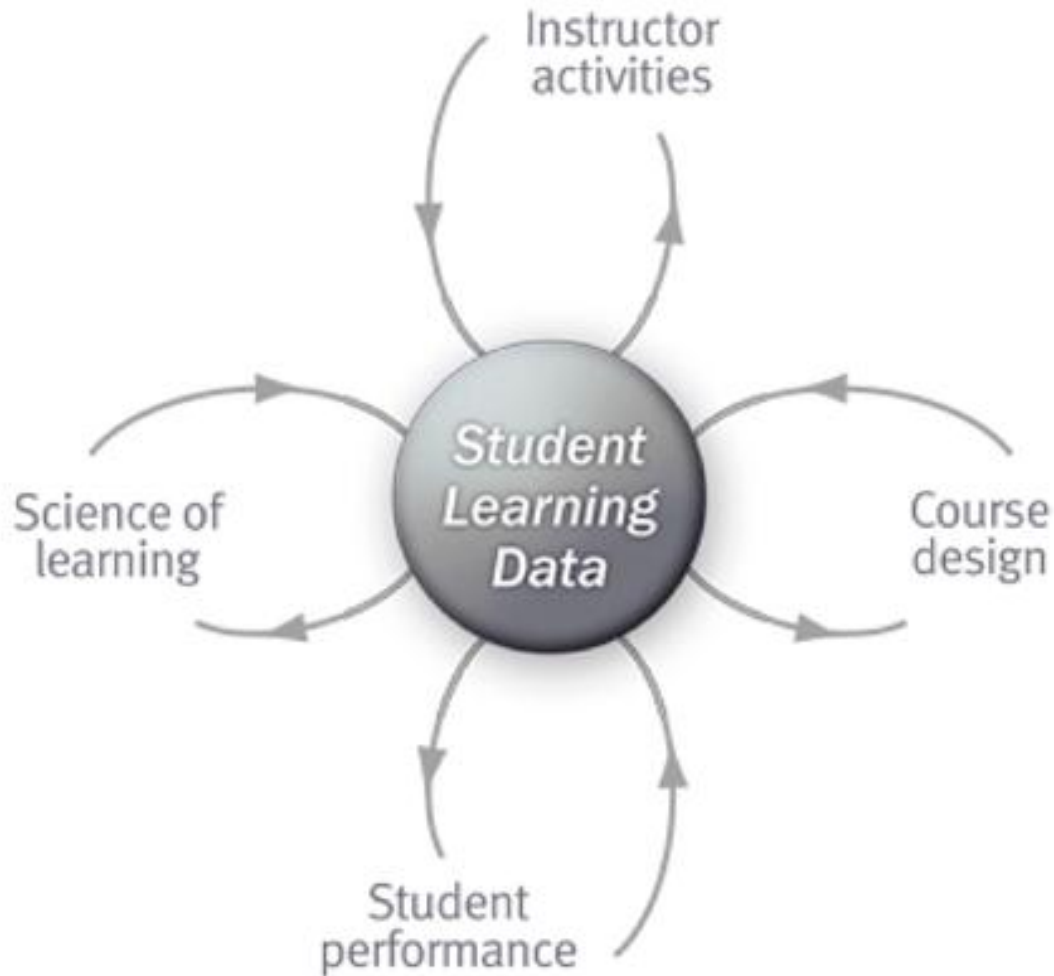
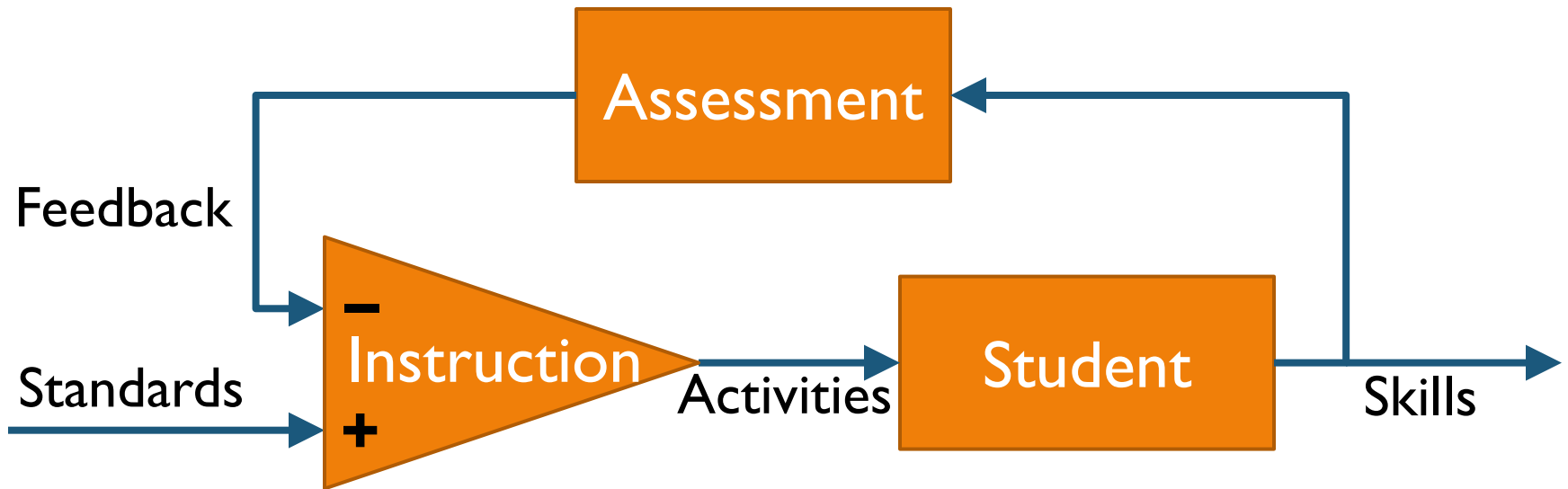# Intelligent Tutoring Systems (ITS) may have nested feedback loops.
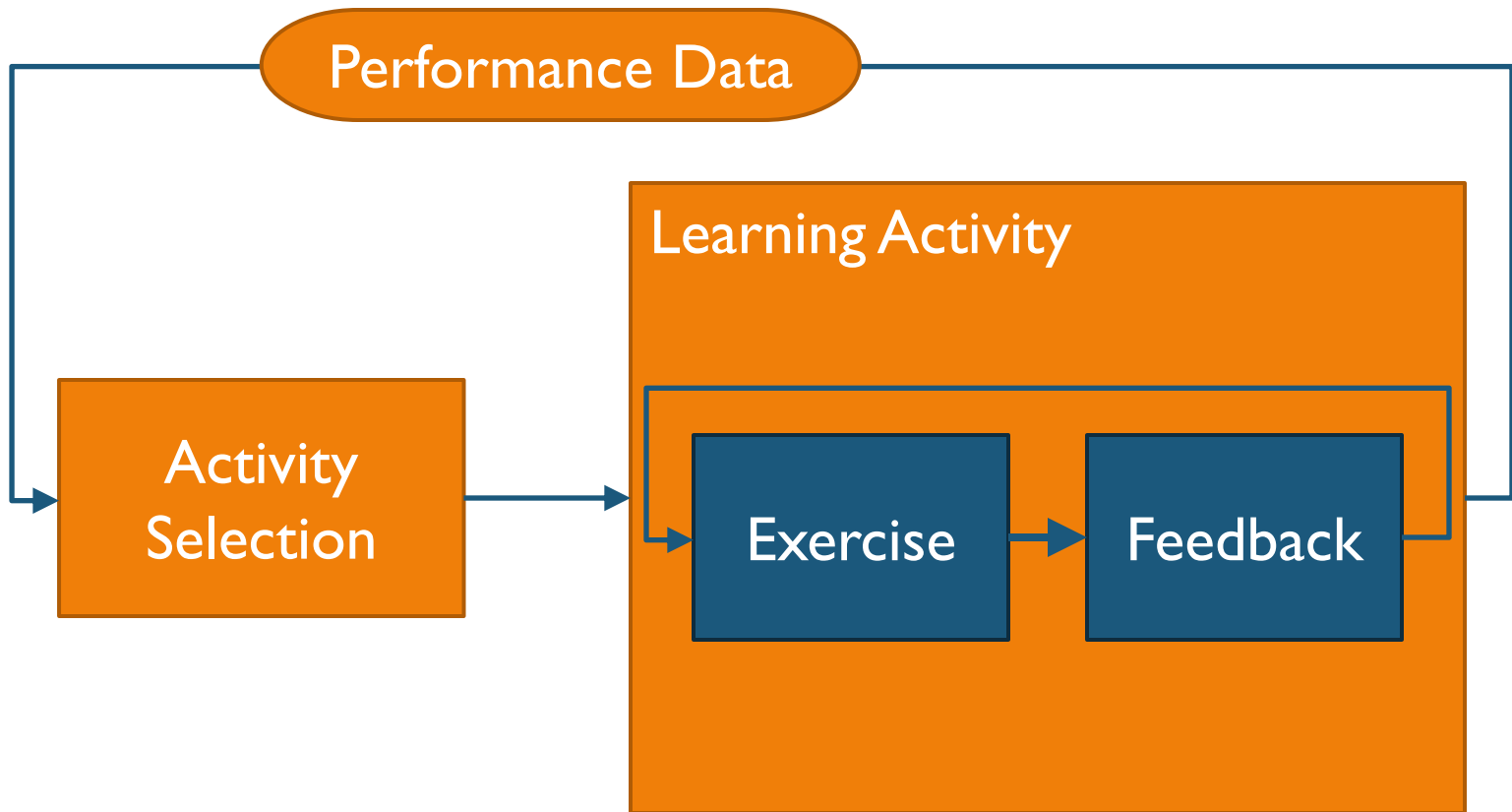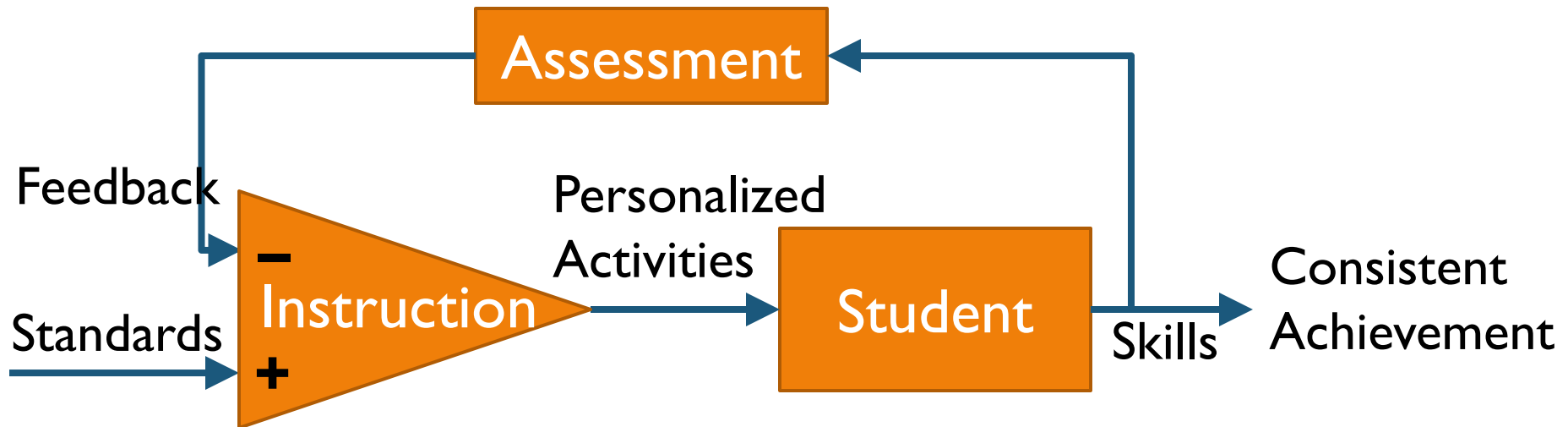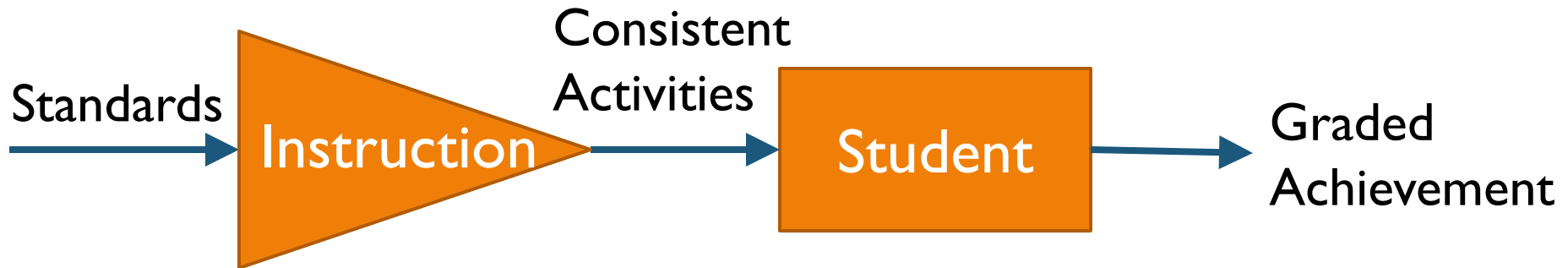
Recess – Time for an activity

Control theory

Pedagogical Theory

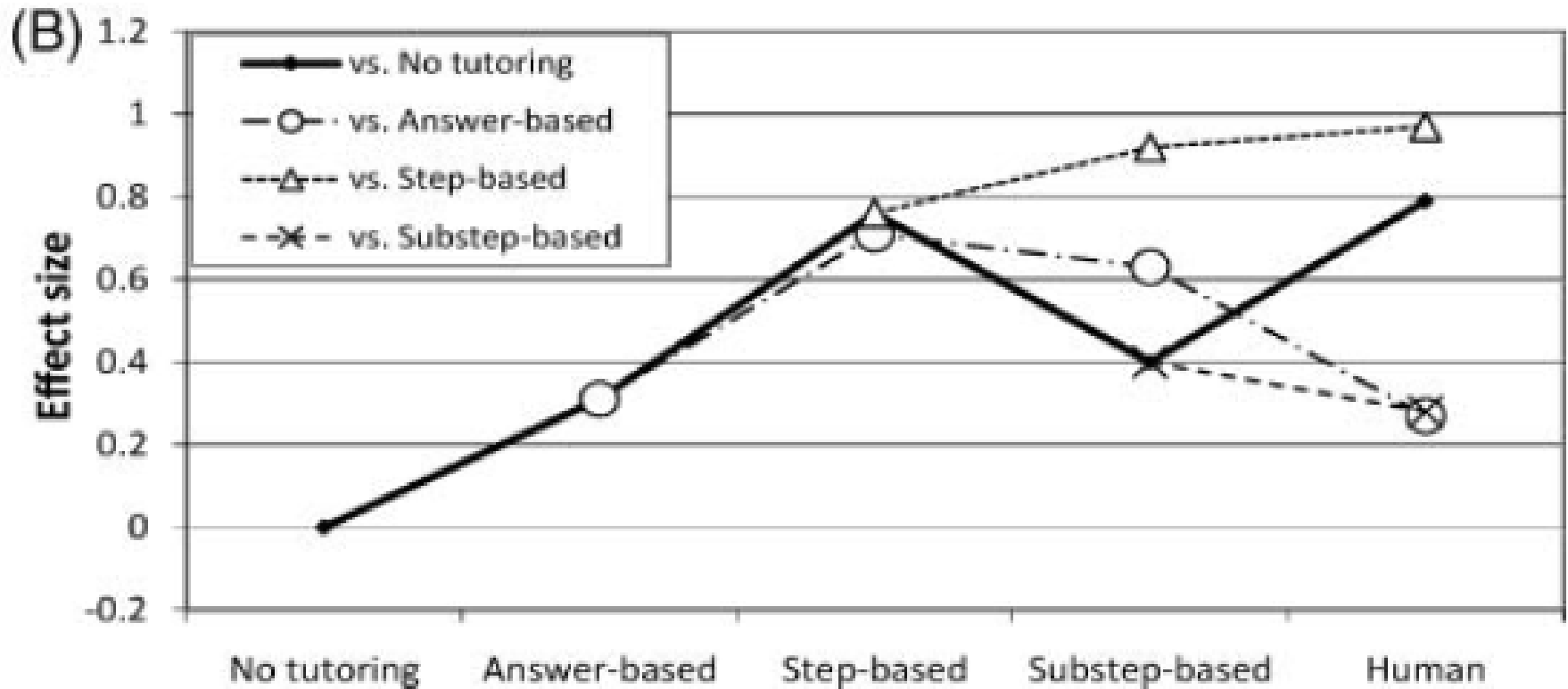# Closed-loop learning results in consistent student achievement

Opportunities for Feedback improvement

- Feedback Needs to be
    - Faster
    - More frequent
    - Richer
- But doing this is expensive
    - To Compose
    - To Administer
    - To Score
    - To Report

Research supports the application of feedback-loops to education.


(VanLehn, Kurt: "The Relative Effectiveness of Human Tutoring, Intelligent Tutoring Systems and Other Tutoring Systems", 2011)

The next frontier is instrumentation of authentic learning activities.

The circuit below contains an inverter designed to be used in a system where $V_S = 3V$, $V_{OL} = 0.25V$ and $V_{OH} = 2.5V$. The input to the inverter is hooked to a voltage source that makes a $0 \rightarrow 1$ transition at $t = 0$. The performance of the inverter is measured as it drives a 200fF capacitive load, which represents the parasitic capacitance of the wiring and the inputs of other logic gates hooked to the output of the inverter.
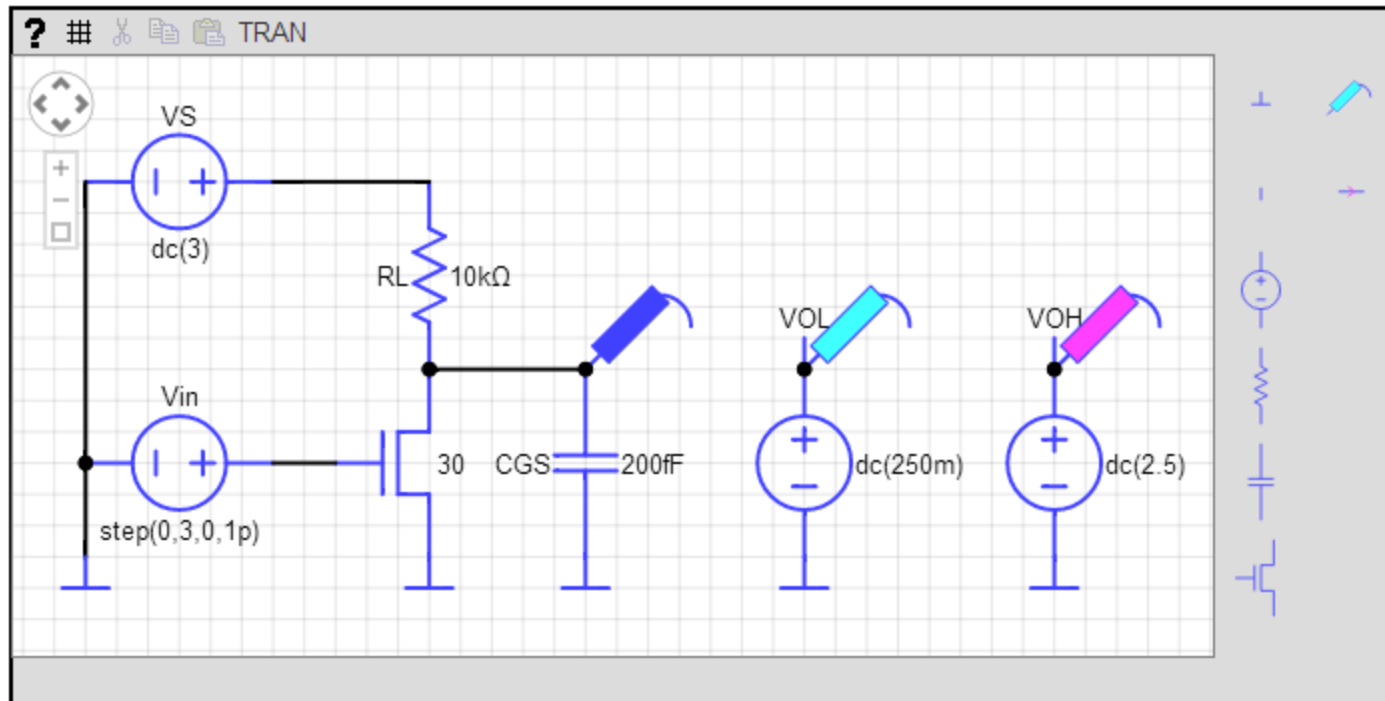
Initiatives to foster better feedback

▸ Shared Learning Collaborative (http://slcedu.org)

▸ Khan Academy (http://khanacademy.org)

▸ NROC Math (http://nrocmath.org)

▸ Open Learning Initiative (http://oli.cmu.edu/)

▸ Hewlett Foundation Automated Scoring Challenges (http://www.hewlett.org/newsroom/press-release/hewlett-foundation-sponsors-prize-improve-automated-scoring-student-essays)

▸ Commercial Products (Aleks, Knewton, LiveMocha, etc.)

Summary

‣ Quality feedback results in a standard deviation improvement in student learning.

‣ To close the feedback loop, performance measures must be used to change the learning experience before a particular topic is closed.

‣ Frequent and fast feedback compensate for less sophisticated transfer functions (or recommendation engines).

‣ The student is involved in the feedback loop not only as the individual being assessed but also interpreting results and choosing activities.

‣ Be cautious about using psychometric approaches in a feedback context. The goals are different.

Q & A

- Resources / References
  - The Shared Learning Collaborative (http://slcedu.org)
  - *Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement,* John Hattie
  - "The Relative Effectiveness of Human Tutoring, Intelligent Tutoring Systems and Other Tutoring Systems", Kurt VanLehn (http://www.public.asu.edu/~kvanlehn/Stringent/PDF/EffectivenessOfTutoring_Vanlehn.pdf)
  - The Open Learning Initiative (http://oli.cmu.edu)
  - The United Way Common Good Forecaster (http://apps.unitedway.org/forecaster)
  - The National Center for Education Statistics (http://nces.ed.gov/)
  - My Blog (http://ofthat.com)