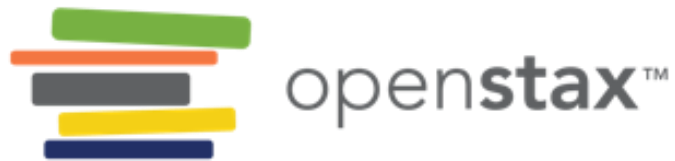


Improving the efficacy of Open Educational Resources (OER) and student learning outcomes



RICE®

learning challenges

effective learning



one-size-fits-all



poor **access** to high-quality materials (\$)

OpenStax/Rice research mission

Goals:

- Provide students with activities that have been repeatedly proven to produce better retention
- Test and validate the optimal ways to integrate cog sci principles into student learning experiences
- Test and validate the efficacy of machine learning-enabled personalization + learning analytics

30+ learning research studies since 2012, with partners at 12 higher ed institutions

RICE[®]



Duke
UNIVERSITY

Cognitive science research


Principles from cognitive science can help improve long-term retention and transfer of knowledge

		Concept		
		A	B	C
Homework	1	?		
	2	?	?	
	3	?	?	?
	4		?	?
	5			?


Spaced concept practice

That's Incorrect!

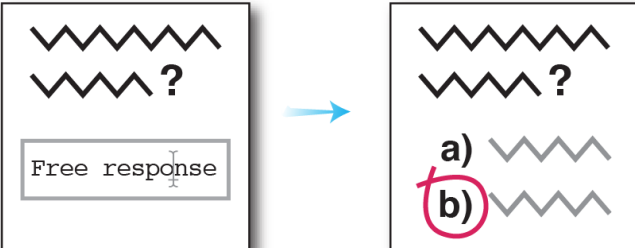
Here's why:



Help material:



Timely, informative feedback



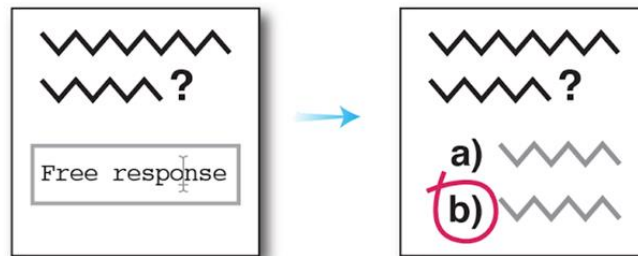
Two-step answer process engages students in retrieval practice

Principles from Cognitive Science

Principle	Description
Retrieval Practice	Retrieving information from memory strengthens memory for that information Can also improve understanding

Two-step answer process

Change multiple-choice recognition to recall



Two-step answer process engages students in retrieval practice

Principles from Cognitive Science

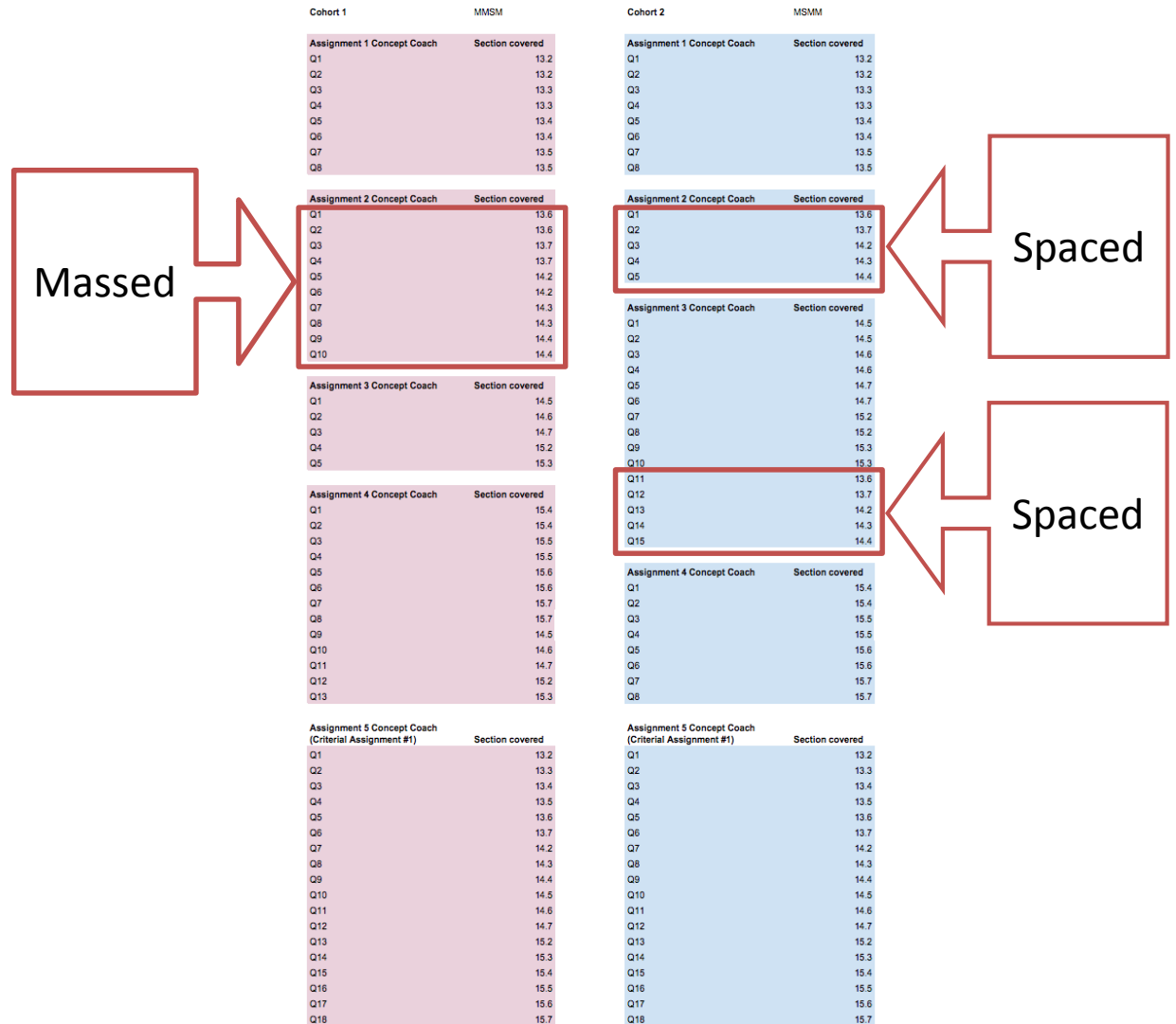
Principle	Description
Retrieval Practice	Retrieving information from memory strengthens memory for that information Can also improve understanding
Spacing	Spacing practice over time produces better long-term retention than massing practice

Spaced retrieval practice

Homework

	Concept		
	A	B	C
1	?		
2	?	?	
3	?	?	?
4		?	?
5			?

Spaced concept practice



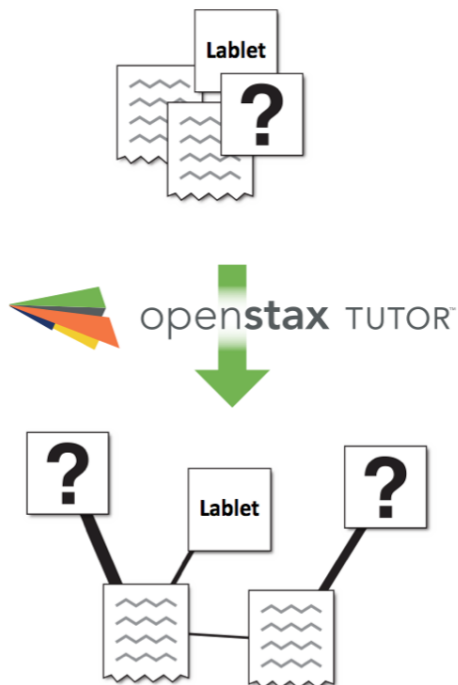
Principles from Cognitive Science

Principle	Description
Retrieval Practice	Retrieving information from memory strengthens memory for that information Can also improve understanding
Spacing	Spacing practice over time produces better long-term retention than massing practice
Feedback	Feedback enables learners to correct errors and reinforce correct knowledge

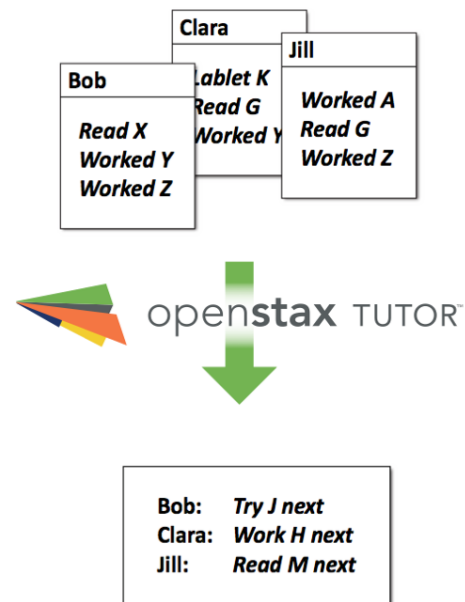
Machine learning research

Machine learning algorithms can automate *personalization*

Automatically identify relationships among online learning materials



Automatically discover proven learning pathways and schedule student work



Understanding Learner Responses

	learners				
questions	?	0	1	...	0
	0	1	1	...	?
	:	:	:	..	:
	1	1	?	...	0

- Which concepts interact with which questions?
- How important is each concept for each question?
- How easy/difficult is each question?
- How well has each learner mastered each concept?

Potential: use ML to choose assessment, content

Adaptively recommend questions to students based on predictions about their performance

Learn about student

- Select problems that will help determine what this student understands

Keep student engaged

- Choose problems with likelihood of success (proximal zone of learning)

Help student practice problems they missed

- Choose similar problems

A recent research study

Research Question:

Can three simple, but powerful principles from cognitive science improve learning in the classroom?

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Classroom study



ELEC 301 Signals and Systems

Method

A few simple changes to standard practice:

- **Addition of spaced, retrieval practice**

Classroom study



ELEC 301 Signals and Systems

Method

A few simple changes to standard practice:

- **Addition of spaced, retrieval practice**
- **Students given immediate feedback and required to view it to get credit**

Classroom study



ELEC 301 Signals and Systems

Method

A few simple changes to standard practice:

- **Addition of spaced, retrieval practice**
- **Students given immediate feedback and required to view it to get credit**
- **No machine learning-enabled personalization**

Classroom study



ELEC 301 Signals and Systems

Method

A few simple changes to standard practice:

- **Addition of spaced, retrieval practice**
- **Students given immediate feedback and required to view it to get credit**
- **No machine learning-enabled personalization**



Student view: working a problem, step 1

- *no multiple-choice options available until student generates and submits a free-form answer*

The screenshot displays the OpenStax Tutor interface. At the top, there is a navigation bar with links for ABOUT, DASHBOARD, COURSE CATALOG, CURRENT CLASSES, MY TUTOR, and HELP. A user profile section shows "Welcome Richard" and "My Account | Sign out" with social media icons for Facebook and Twitter. The main content area is titled "Assignment: HW 1, Exercise 2 [OpenStax Tutor 101]". Under "The Question", the user is asked to find the Laplace transform of a piecewise function $x(t)$. The function is defined as $x(t) = \begin{cases} 1 & -1 \leq t \leq 1 \\ 0 & \text{else} \end{cases}$. The question asks to use the Laplace Transform integral formula to find $X(s)$. To the right, a "Show Assignment" section lists two exercises, both marked as "NOT YET ANSWERED". Below the question, the "Your Answer" section features a text input field with a "Save Draft" button. The input field contains the LaTeX expression $X(s) = \frac{e^{-s} - e^{s}}{s} \sim \sim \sim \text{trm}{all } s$. At the bottom of the answer section, there are buttons for "Write Text", "Draw", "PC Upload", "Camera Phone Upload", and "Refresh". The footer contains copyright information for Rice University and the Rice University logo.

openstax TUTOR BETA

ABOUT DASHBOARD COURSE CATALOG CURRENT CLASSES MY TUTOR HELP ?

Welcome Richard My Account | Sign out  

Assignment: HW 1, Exercise 2
[OpenStax Tutor 101]

The Question

Consider the following function:

$$x(t) = \begin{cases} 1 & -1 \leq t \leq 1 \\ 0 & \text{else} \end{cases}$$

Using the Laplace Transform integral formula, find $X(s)$, the Laplace Transform of $x(t)$.

Show Assignment

Exercises

1. NOT YET ANSWERED
2. NOT YET ANSWERED


Your Answer

Enter a free-form answer: ? [Preview](#) | [LaTeX Editor](#) | [Cancel](#) [Save Draft](#)

$X(s) = \frac{e^{-s} - e^{s}}{s} \sim \sim \sim \text{trm}{all } s$

[Write Text](#) [Draw](#) [PC Upload](#) [Camera Phone Upload](#) [Refresh](#)

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Supported by the National Science Foundation, Google, Duke University, and Rice University



Student view: working a problem, step 2

- multiple-choice options revealed to facilitate objective grading

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Answer Verification

Choose the multiple-choice answer below that corresponds to the answer you wrote above.

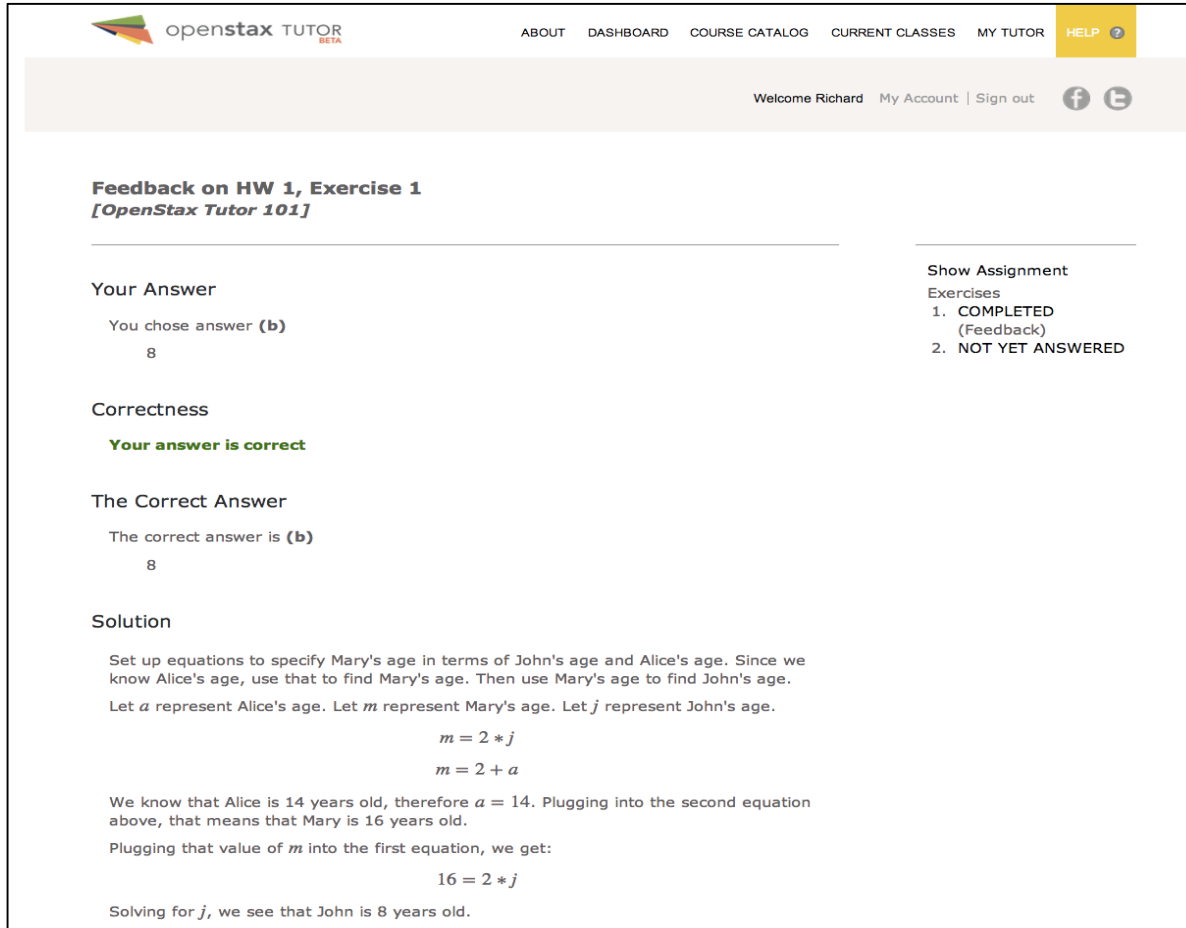
- a) $X(s) = \frac{2se^s - 1}{s}$, $Re[s] < 0$
- b) $X(s) = \frac{1 - 2se^s}{s}$, $Re[s] < 0$
- c) $X(s) = \frac{2se^s - 1}{s}$, all s
- d) $X(s) = \frac{1 - 2se^s}{s}$, all s
- e) $X(s) = \frac{e^s - e^{-s}}{s}$, $Re[s] < 0$
- f) $X(s) = \frac{e^{-s} - e^s}{s}$, $Re[s] < 0$
- g) $X(s) = \frac{e^s - e^{-s}}{s}$, all s
- h) $X(s) = \frac{e^{-s} - e^s}{s}$, all s

Turn In my choice



Student view: feedback

- *intervention: students received feedback immediately after the deadline and were required to view it to receive full credit*



The screenshot displays the OpenStax Tutor interface. At the top, there is a navigation bar with links for ABOUT, DASHBOARD, COURSE CATALOG, CURRENT CLASSES, MY TUTOR, and HELP. Below this, a user greeting reads "Welcome Richard" with links for "My Account" and "Sign out", along with social media icons for Facebook and Twitter. The main content area is titled "Feedback on HW 1, Exercise 1 [OpenStax Tutor 101]". It is divided into two columns. The left column contains sections for "Your Answer" (showing the user chose answer (b) 8), "Correctness" (stating "Your answer is correct"), "The Correct Answer" (showing the correct answer is (b) 8), and "Solution" (providing a step-by-step explanation with equations $m = 2 * j$ and $m = 2 + a$, and concluding that John is 8 years old). The right column contains a "Show Assignment" section with a list of exercises: "1. COMPLETED (Feedback)" and "2. NOT YET ANSWERED".

openstax TUTOR BETA

ABOUT DASHBOARD COURSE CATALOG CURRENT CLASSES MY TUTOR HELP ?

Welcome Richard My Account | Sign out

Feedback on HW 1, Exercise 1
[OpenStax Tutor 101]

Your Answer

You chose answer (b)
8

Correctness

Your answer is correct

The Correct Answer

The correct answer is (b)
8

Solution

Set up equations to specify Mary's age in terms of John's age and Alice's age. Since we know Alice's age, use that to find Mary's age. Then use Mary's age to find John's age.
Let a represent Alice's age. Let m represent Mary's age. Let j represent John's age.

$$m = 2 * j$$
$$m = 2 + a$$

We know that Alice is 14 years old, therefore $a = 14$. Plugging into the second equation above, that means that Mary is 16 years old.
Plugging that value of m into the first equation, we get:

$$16 = 2 * j$$

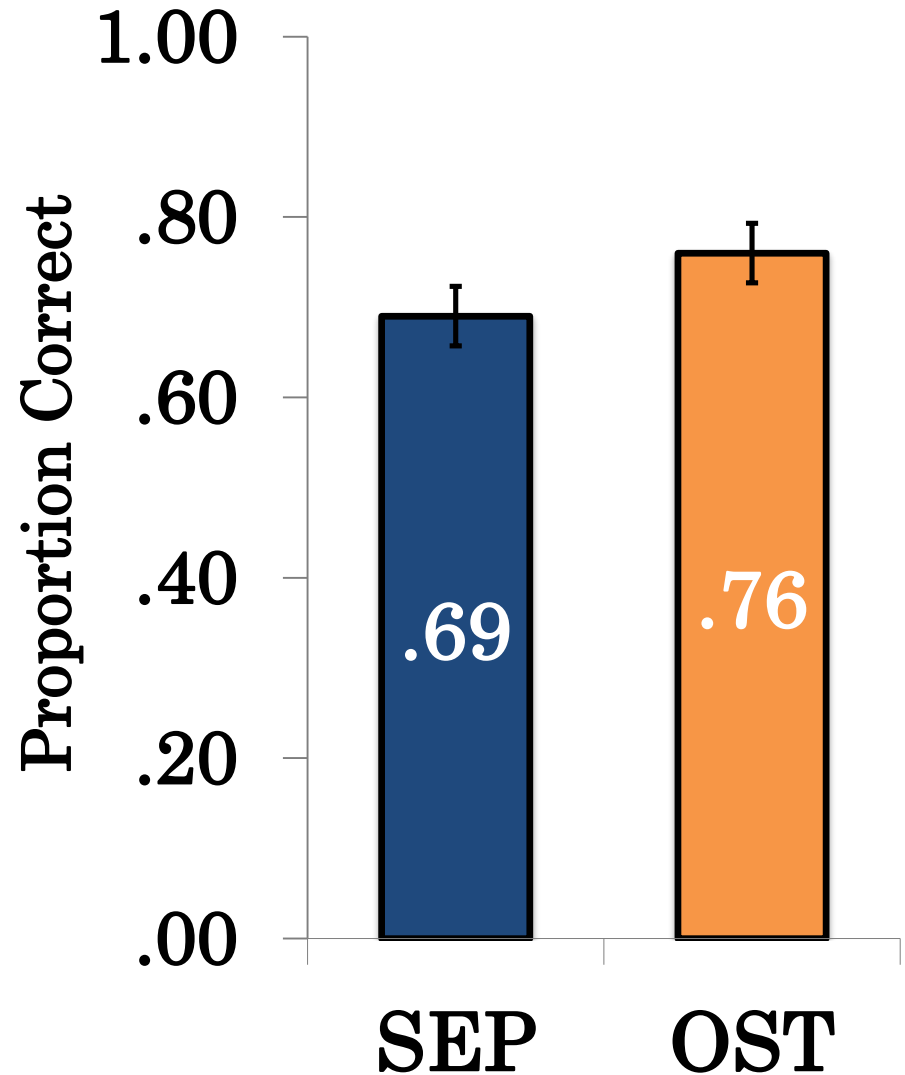
Solving for j , we see that John is 8 years old.

Show Assignment

Exercises

1. COMPLETED (Feedback)
2. NOT YET ANSWERED

Did the intervention improve learning?

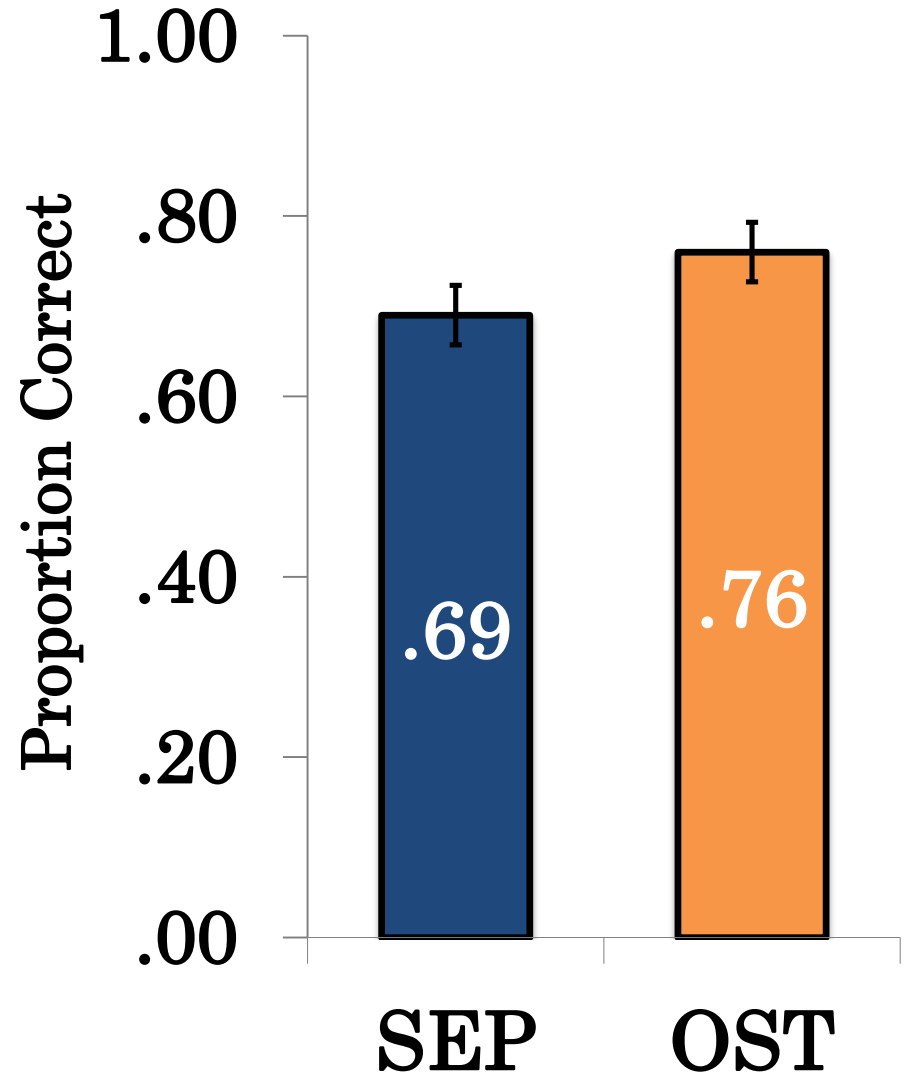


Did the intervention improve learning?

Experiment:

Intervention (OST)
vs.
Standard Educational
Practice (SEP)

Students performed significantly better on exam problems when learned via the Intervention method.



Challenges around personalized learning and learning analytics

- Hype and nifty tech – **but does it improve learning?**

Challenges around personalized learning and learning analytics

- Hype and nifty tech – **but does it improve learning?**
- How to best employ learning analytics to help teachers and motivate students?

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- Scalability
- Development is costly

Challenges around personalized learning and learning analytics

- Hype and nifty tech – **but does it improve learning?**
- How to best employ learning analytics to help teachers and motivate students?
- Scalability
- Development is costly
- Last but not least... student privacy

Why is OER good for personalized learning?

- Adaptive requires data on a large scale
- Closed systems may not be enough
 - Examples: OpenStax CNX, Wikipedia draw millions of users and materials that are continually growing and updated

Why is OER good for personalized learning?

- Adaptive requires data on a large scale
- Closed systems may not be enough
 - Examples: OpenStax CNX, Wikipedia draw millions of users and materials that are continually growing and updated
- Open content, if its quality and cost attracts users, can reduce the cost of developing educational technology

Thanks!



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