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

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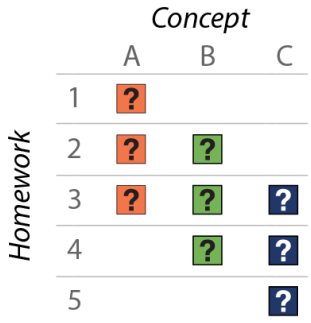
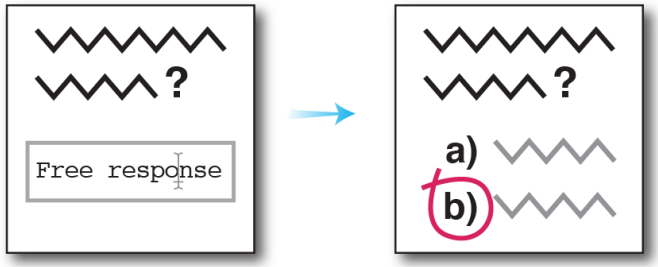
Cognitive science research

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



Spaced concept practice

Timely, informative feedback



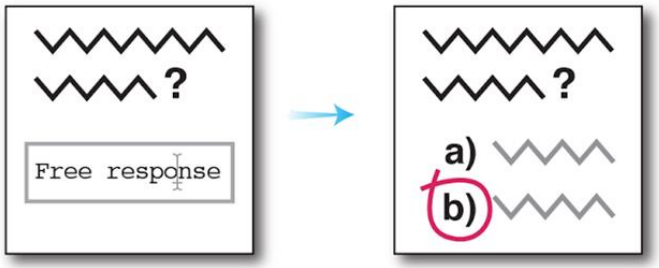
Two-step answer process engages students in retrieval practice

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

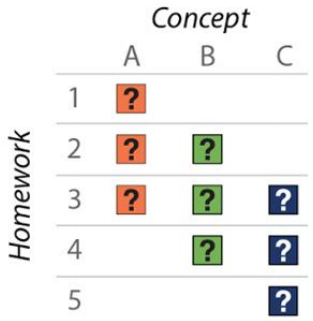


Two-step answer process engages students in retrieval practice

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



Spaced concept practice

Massed

Cohort 1	MMSM
Assignment 1 Concept Coach	Section covered
Q1	13.2
Q2	13.2
Q3	13.3
Q4	13.3
Q5	13.4
Q6	13.4
Q7	13.5
Q8	13.5
Assignment 2 Concept Coach	Section covered
Q1	13.6
Q2	13.6
Q3	13.7
Q4	13.7
Q5	14.2
Q6	14.2
Q7	14.3
Q8	14.3
Q9	14.4
Q10	14.4
Assignment 3 Concept Coach	Section covered
Q1	14.5
Q2	14.6
Q3	14.7
Q4	15.2
Q5	15.3
Assignment 4 Concept Coach	Section covered
Q1	15.4
Q2	15.4
Q3	15.5
Q4	15.5
Q5	15.6
Q6	15.6
Q7	15.7
Q8	15.7
Q9	14.5
Q10	14.6
Q11	14.7
Q12	15.2
Q13	15.3
Assignment 5 Concept Coach (Criterial Assignment #1)	Section covered
Q1	13.2
Q2	13.3
Q3	13.4
Q4	13.5
Q5	13.6
Q6	13.7
Q7	14.2
Q8	14.3
Q9	14.4
Q10	14.5
Q11	14.6
Q12	14.7
Q13	15.2
Q14	15.3
Q15	15.4
Q16	15.5
Q17	15.6
Q18	15.7

Cohort 2	MSMM
Assignment 1 Concept Coach	Section covered
Q1	13.2
Q2	13.2
Q3	13.3
Q4	13.3
Q5	13.4
Q6	13.4
Q7	13.5
Q8	13.5
Assignment 2 Concept Coach	Section covered
Q1	13.6
Q2	13.7
Q3	14.2
Q4	14.3
Q5	14.4
Assignment 3 Concept Coach	Section covered
Q1	14.5
Q2	14.5
Q3	14.6
Q4	14.6
Q5	14.7
Q6	14.7
Q7	15.2
Q8	15.2
Q9	15.3
Q10	15.3
Q11	13.6
Q12	13.7
Q13	14.2
Q14	14.3
Q15	14.4
Assignment 4 Concept Coach	Section covered
Q1	15.4
Q2	15.4
Q3	15.5
Q4	15.5
Q5	15.6
Q6	15.6
Q7	15.7
Q8	15.7
Assignment 5 Concept Coach (Criterial Assignment #1)	Section covered
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Q2	13.3
Q3	13.4
Q4	13.5
Q5	13.6
Q6	13.7
Q7	14.2
Q8	14.3
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Spaced

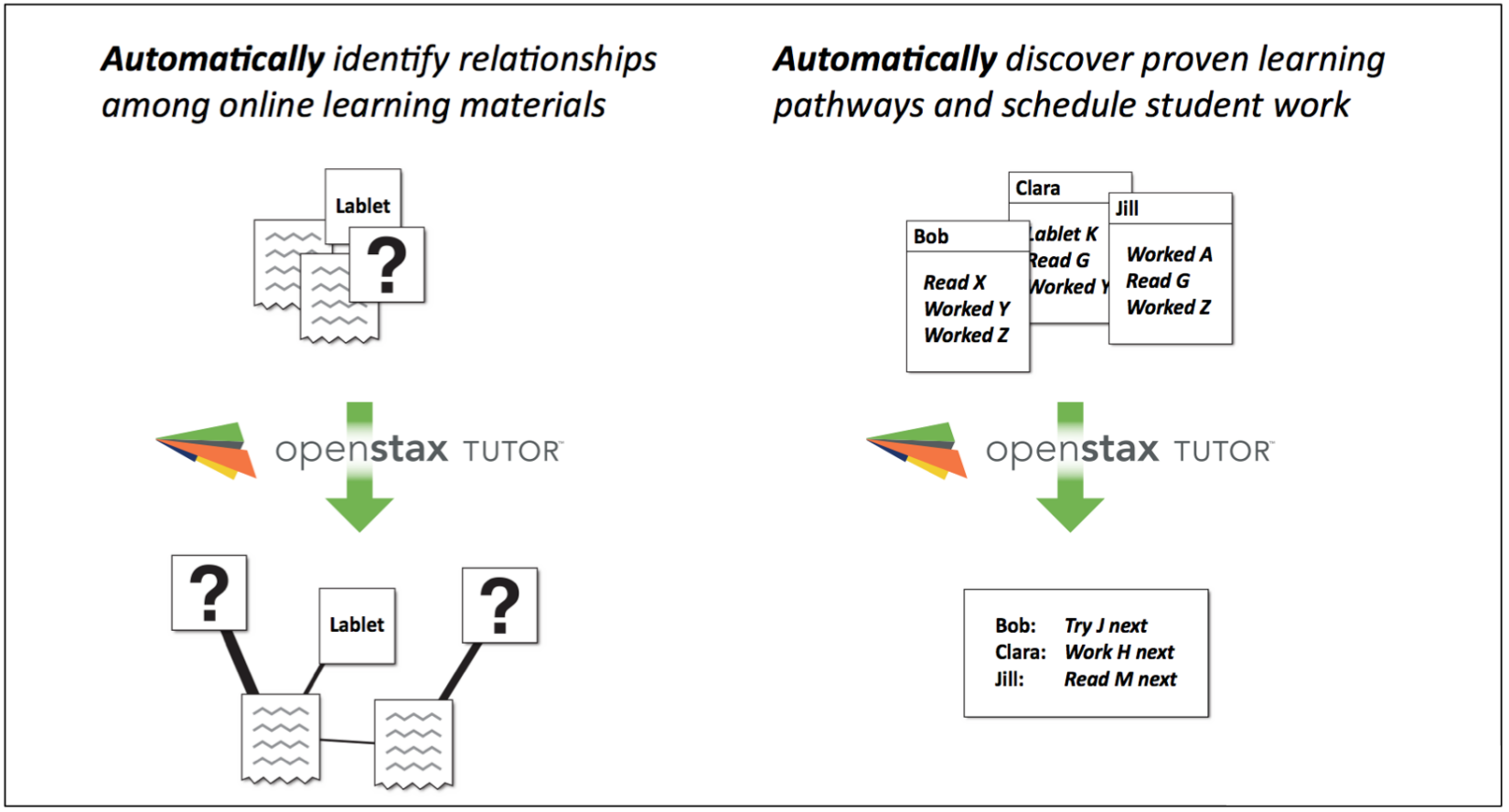
Spaced

Principles from Cognitive Science

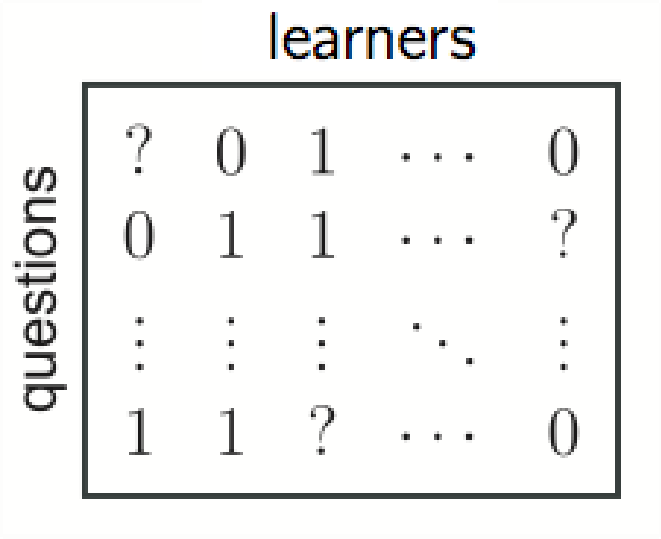
Principle	Description
Retrieval Practice	Retrieving information from memory strengthens memory for that information Can also improve understanding
Spacing	Spacing practice over time produces better long-term retention than massing practice
Feedback	Feedback enables learners to correct errors and reinforce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

Machine learning research

Machine learning algorithms can automate personalization



Understanding Learner Responses



- 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

openstax™ TUTOR

ELEC 301 Signals and Systems

Method

A few simple changes to standard practice:

- **Addition of spaced, retrieval practice**

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A few simple changes to standard practice:

- **Addition of spaced, retrieval practice**
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- **No machine learning-enabled personalization**

Classroom study

openstax™ TUTOR

ELEC 301 Signals and Systems

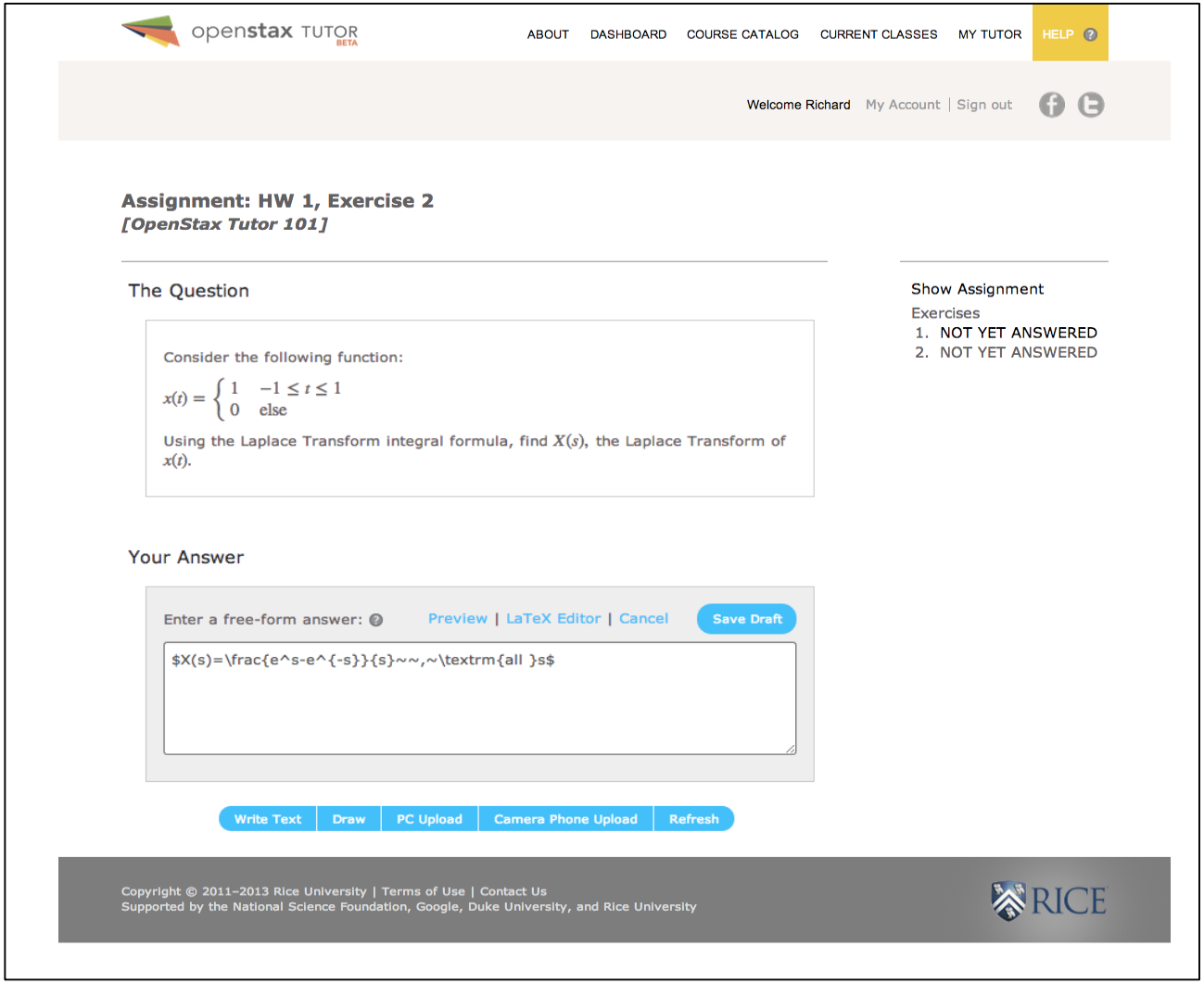
Method

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**

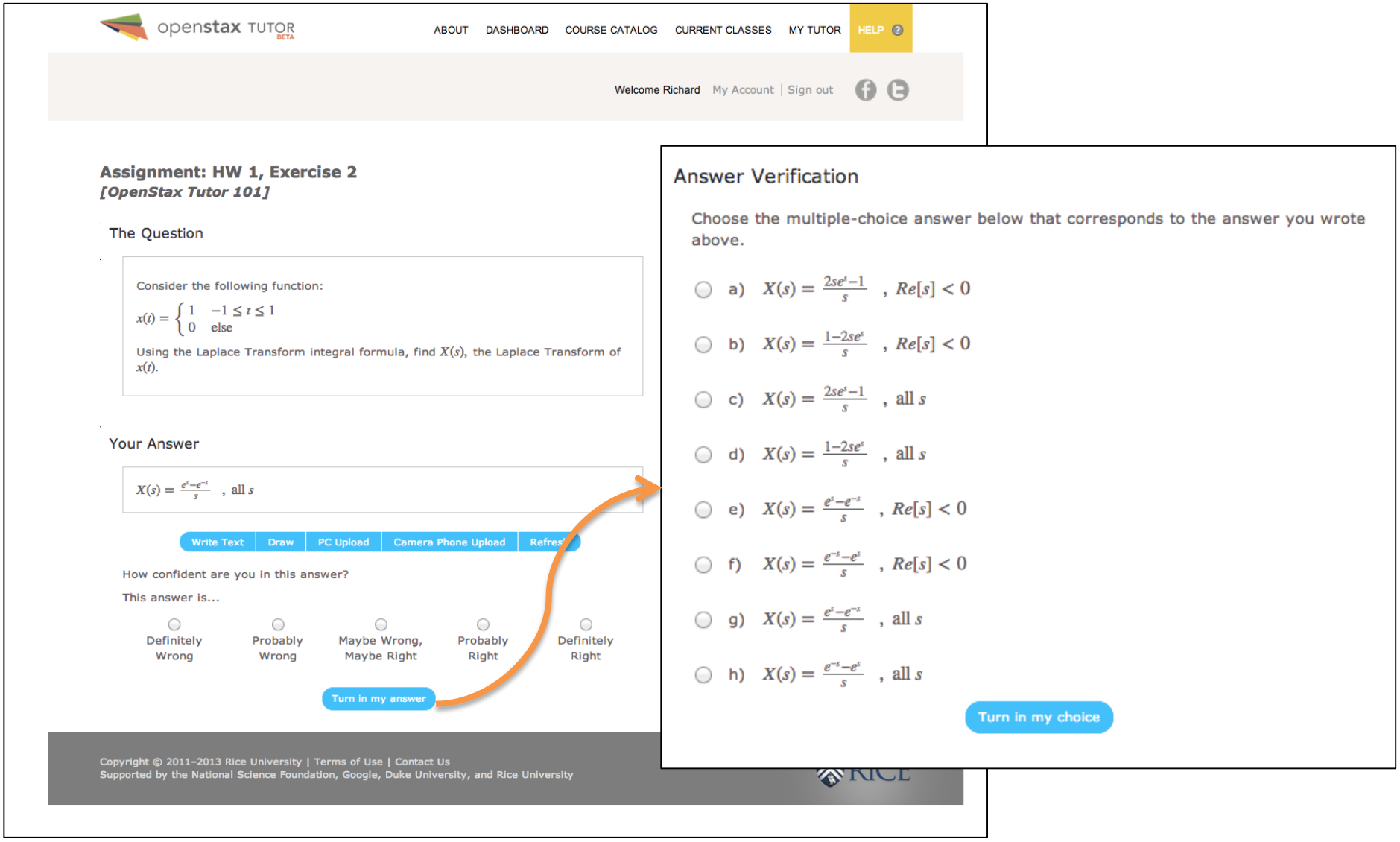
Student view: working a problem, step 1

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



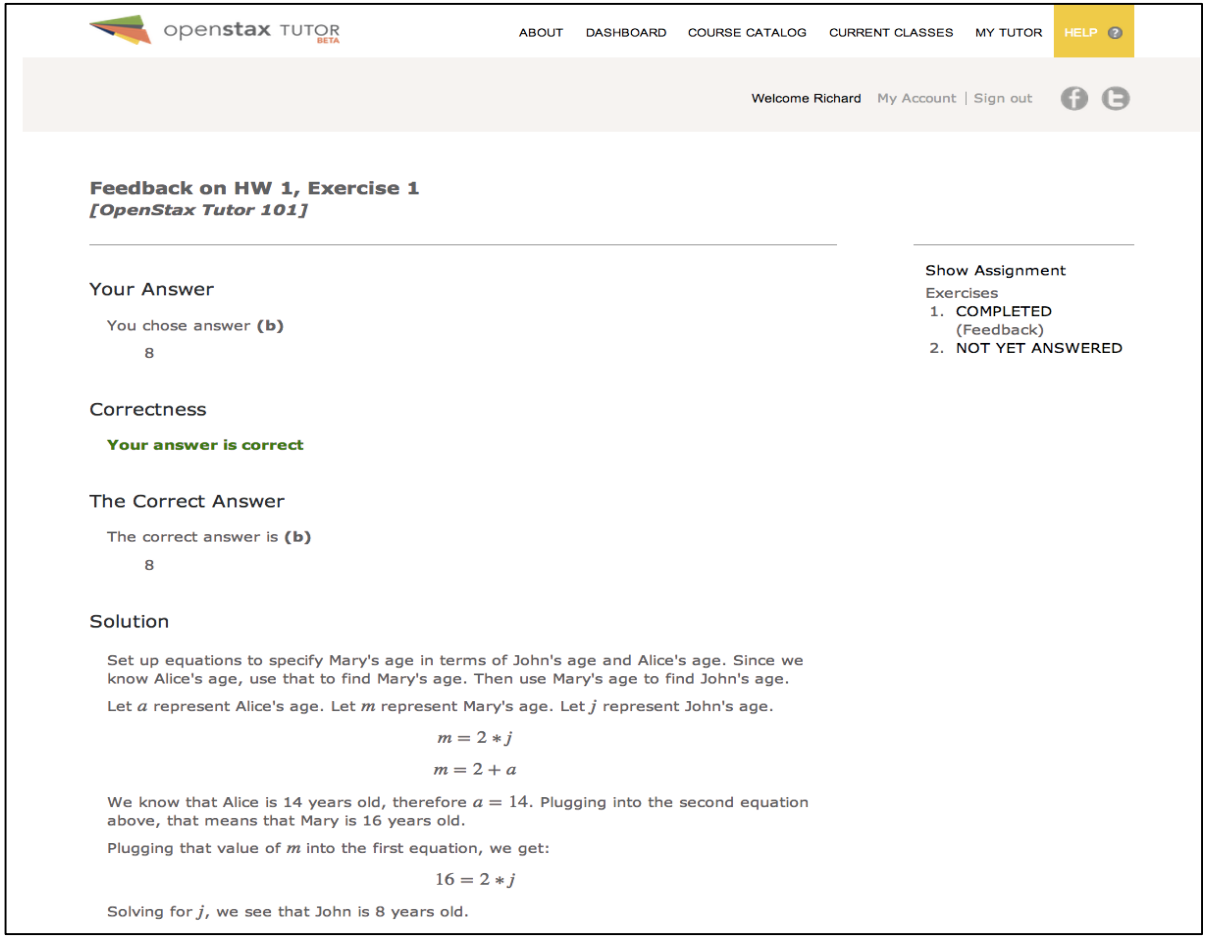
Student view: working a problem, step 2

- multiple-choice options revealed to facilitate objective grading

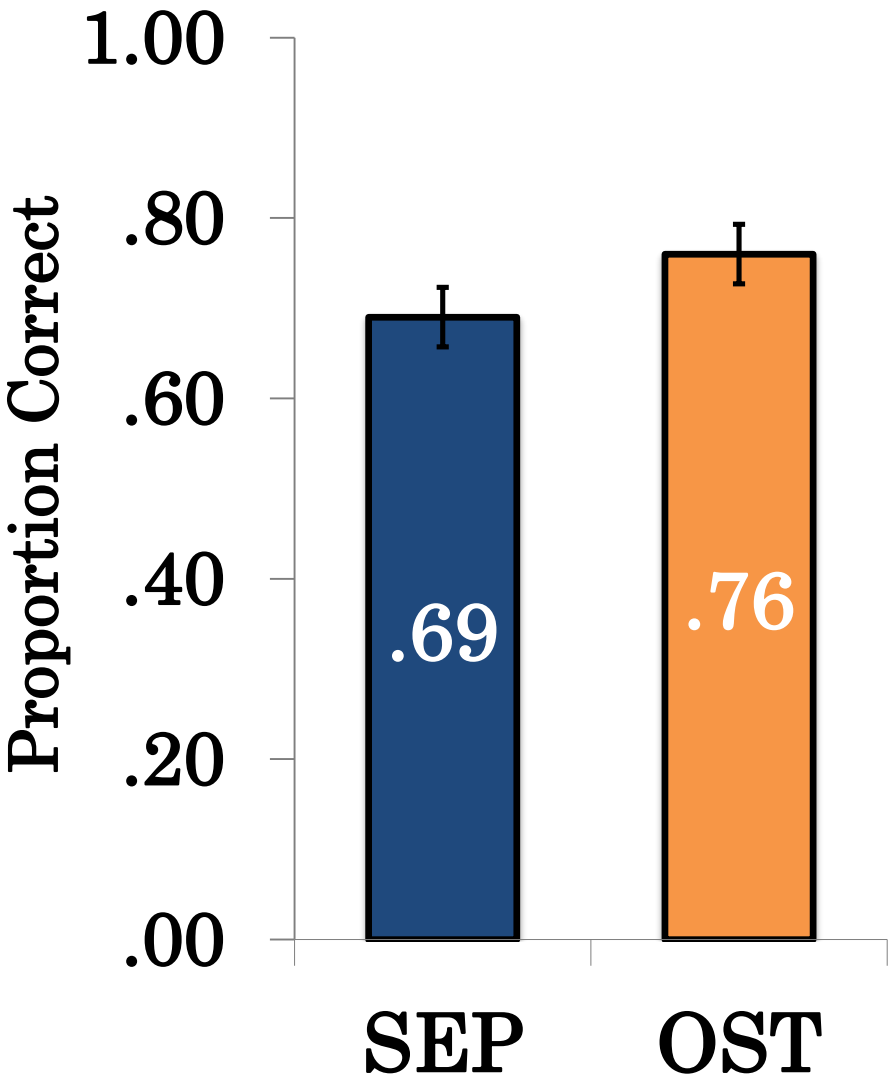


Student view: feedback

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



Did the intervention improve learning?



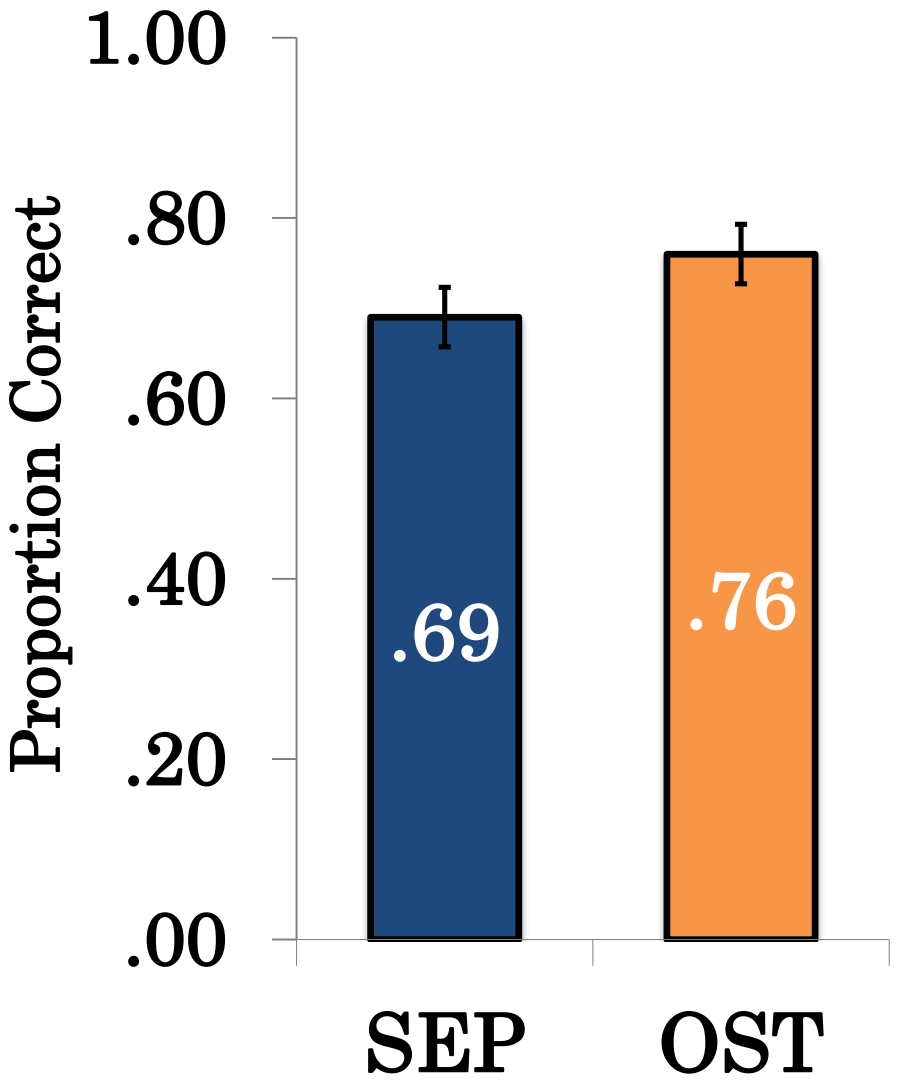
Butler et al., *Educational Psychology Review*, 2014

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.



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Challenges around personalized learning and learning analytics

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

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Challenges around personalized learning and learning analytics

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- 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

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- Adaptive requires data on a large scale
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  - 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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