

Automated Writing Assessment of Undergraduate Learning After Completion of a Computer-based Cellular Respiration Tutorial

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Education reform
encourages teaching core
concepts and practices

- Cellular respiration is a phenomenon of the Transformation of Energy and Matter Core Concept for Biological Literacy in Vision and Change (AAAS, 2011)
- Students have a mix of scientific and non-scientific ideas about cellular respiration (Sripathi et al, 2019)

Increased use of technology
in education raises potential
equity issues

Education reform
encourages teaching core
concepts and practices

- Machine learning tools in education allows rapid assessment of complex constructs (Zhai 2021)
- “Big data” increasingly used in education (Williamson et al., 2020)
- Only 7% of studies examined in a systematic review applied automated-scoring models to study students from different demographic groups (Paquette et al., 2020)

Increased use of technology
in education raises potential
equity issues

Education reform
encourages teaching core
concepts and practices

Biology Education Research
(BER) needs to be
representative of students in
multiple learning contexts

- Nearly half of all undergraduate students are enrolled in community colleges, yet most BER is on students enrolled in Research-Intensive Colleges and Universities (Schinske et al., 2017)
- On average, community colleges serve an older and more diverse student population than RICUs (Hussar et al., 2020)

Increased use of technology
in education raises potential
equity issues

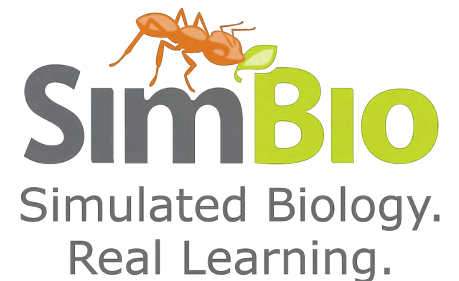
Education reform
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Biology education research
needs to be representative
of students in multiple
learning contexts

Need to assess
learning for
different groups of
students when
using technology-
based learning
tools

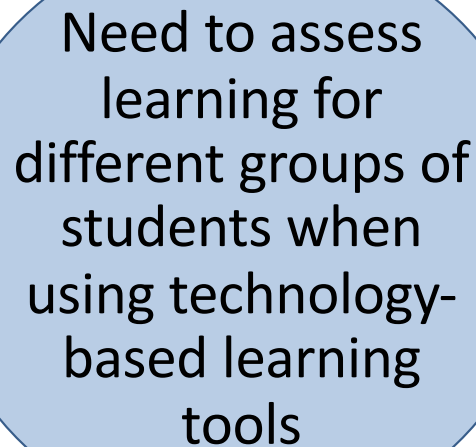


Develop and validate
automated assessments of
student writing



Develops and tests
interactive biology tutorials

Do descriptions about cellular respiration vary among students from different institution types?



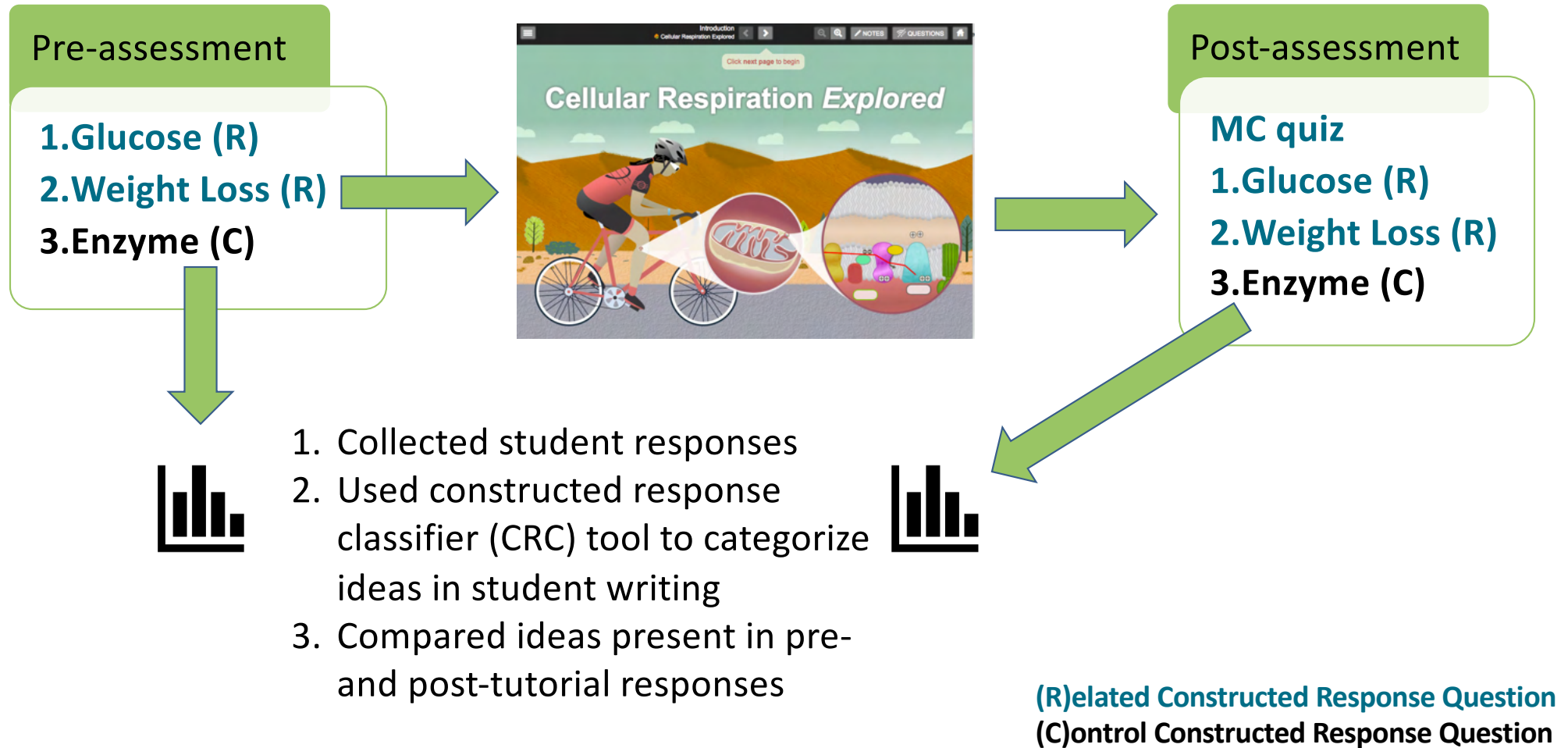
Need to assess learning for different groups of students when using technology-based learning tools

- Research Question 1. How do student descriptions about cellular respiration change after completion of an interactive computer-based tutorial focused on cellular respiration?
- Research Question 2. Do learning gains vary among students from different institution types?

Study population:

Institution type	Number of Classes	Number of students
Two-year colleges (TYC)	3	69
Primarily Undergraduate Institutions (PUI)	8	212
Research Intensive Colleges and Universities (RICU)	8	560
Total	19	841

Study design:



The “Weight Loss” Question: You have a friend that lost 15 lbs. on a diet. Where did the mass go?

Sample Pre-tutorial Response*

The *mass was converted into energy* that needed to be used because the new diet provided a different kind of nutrition that the body was not used to so the body used energy stored long-term to make up for it.

Sample Post-tutorial Response*

The mass was lost through exercise when the food that was consumed was converted to *CO₂ and H₂O*. The CO₂ was then breathed out and the **H₂O was sweated out** and the remaining energy was used during exercise, leaving the body with no gained mass.

Scientific Ideas: *Correct products, Exhalation*

Non-scientific ideas: *Matter Converted to Energy, How to Lose Weight, Excretion*

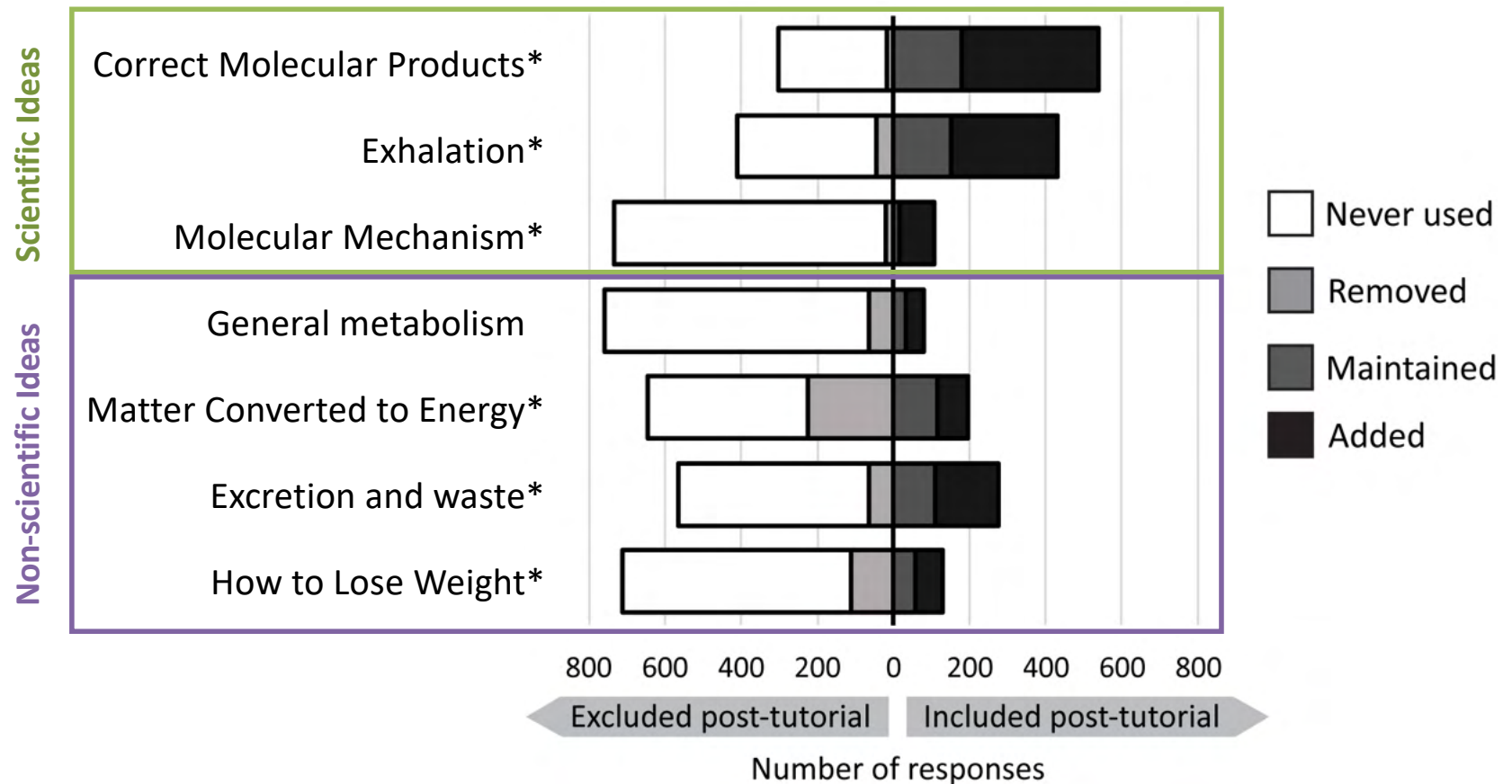
*Paired responses from PUI student; spell-checked

Research Question 1. How do student descriptions about cellular respiration change after completion of an interactive computer-based tutorial focused on cellular respiration?

Students add scientific ideas after the tutorial

- Glucose and Weight Loss Questions
 - Students added scientific ideas about Cellular Respiration after the tutorial including correct products and molecular processes, correct mechanisms, and the role of ATP
 - Students remove the Matter Converted to Energy misconception after the tutorial
- Enzyme Question (control)
 - Students do not change the way they describe enzyme binding

Students add Scientific Ideas and Remove Non-scientific Ideas Post-tutorial

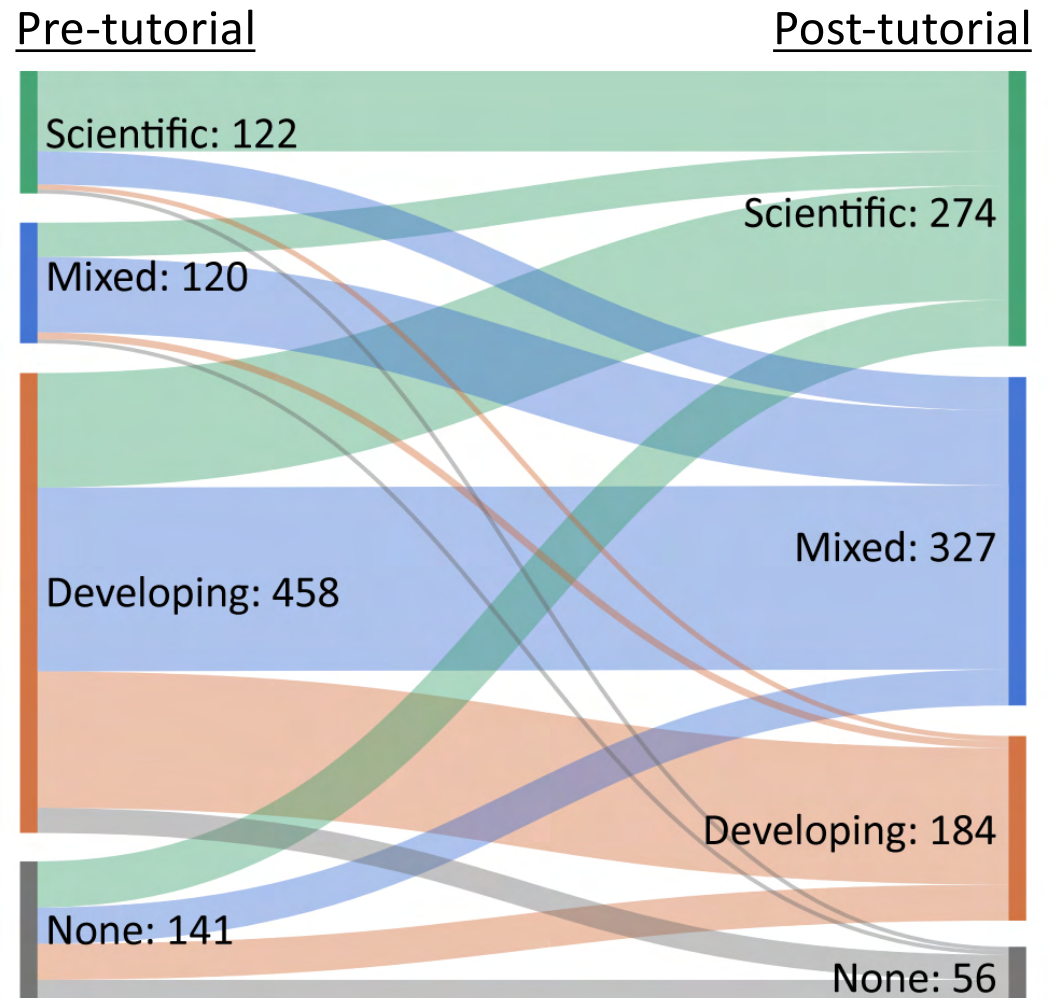


* $p < 0.05$, McNemar test of correlated proportions

Student thinking models become more scientific post-tutorial

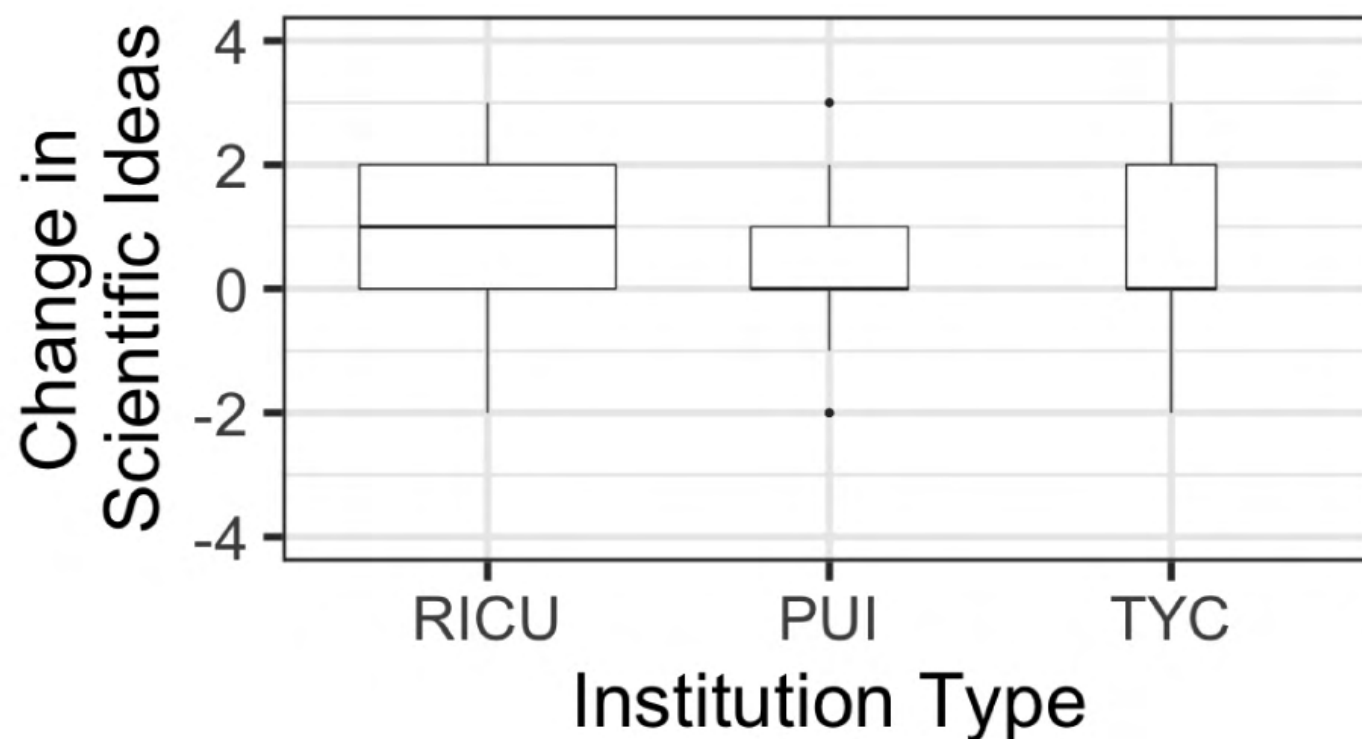
	Scientific Ideas	Non-Scientific Ideas
Scientific	≥ 1	0
Mixed	≥ 1	≥ 1
Developing	0	≥ 1
None	0	0

Thinking models per Sripathi et al., 2019

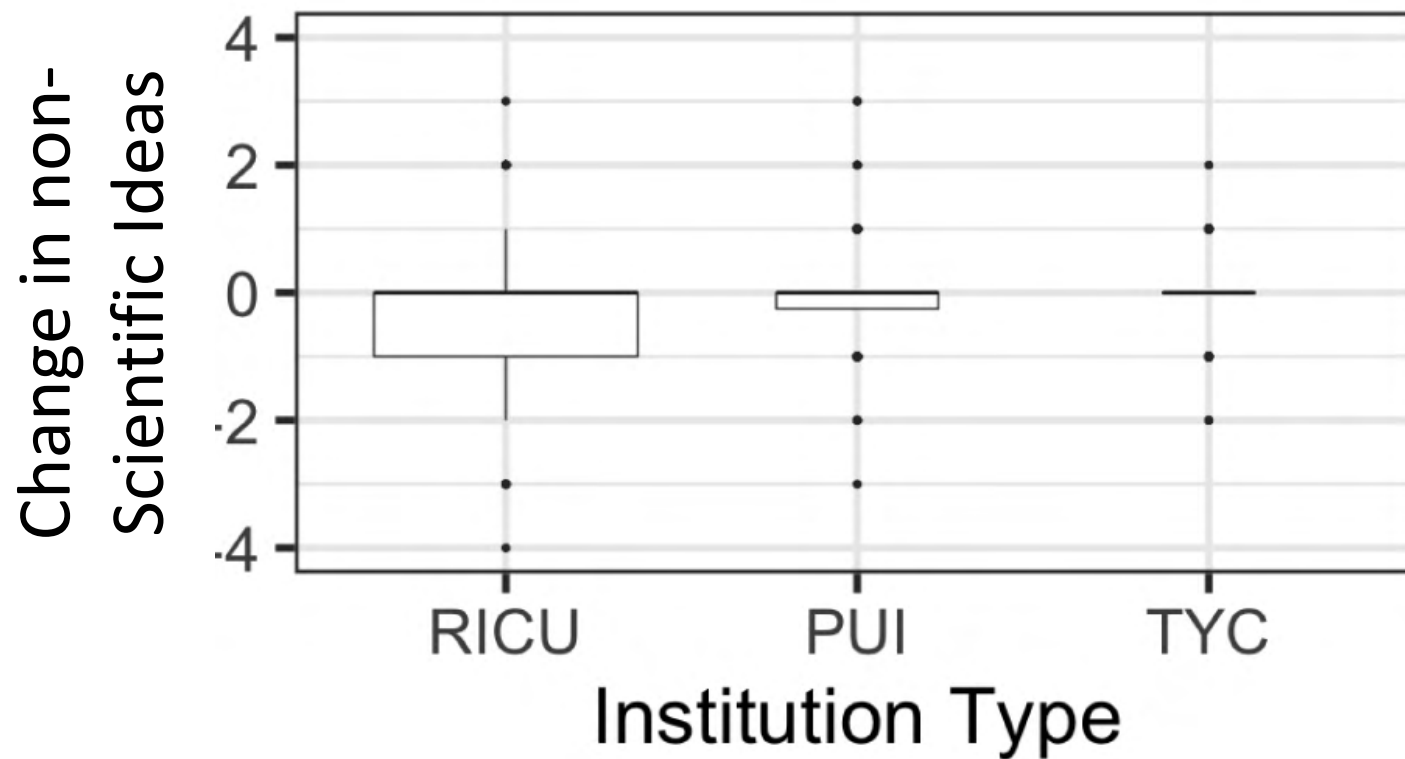


Research Question 2. Do learning gains vary among students from different institution types?

Students from three institution types have similar changes in numbers of scientific ideas



Students from three institution types have similar numbers of non-scientific ideas



Conclusions and Future Directions

- Combining an automated scoring system with an online tutorial allows measuring changes in complex student thinking
 - Students most often use a developing model pre-tutorial
 - Students most often use a mixed thinking model post-tutorial
- Students seem to be responding to the tutorial in similar ways across institution types:
 - Students from TYCs, PUIs, and RICUs add scientific ideas at similar rates
 - Students from all three institution types use similar numbers of developing ideas
- Future goals include applying and testing accuracy of additional CRC models to broader student populations
- For more detailed analyses, see our paper: Uhl et al., 2021 CBE-Life Sciences Education: <https://doi.org/10.1187/cbe.20-06-0122>

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- Nicholas Yoshida presented a poster in session 3 on improving accuracy of CRC machine-learning scoring models
- Jenifer Saldanha is presenting an application of a CRC machine-learning scoring model in an introductory biology course at 4:25 pm July 30
- Megan Shiroda has completed work testing the accuracy of the CRC model and found similar model performance from students across institution types (Shiroda et al., under review)



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Questions?

