How do TAs Learn to Teach Inquiry-Based Labs?

Insights from Research & Practice

Inside UAZ-Funded Scholarship

November 9, 2022

11:00am – 12:00pm

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Center for University Education Scholarship

Land Acknowledgement

How do TAs Learn to Teach Inquiry-Based Labs?
Insights from Research & Practice

OFFICE OF THE PROVOST
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Event Introduction




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Speaker & Panelists

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Overview

Event Introduction

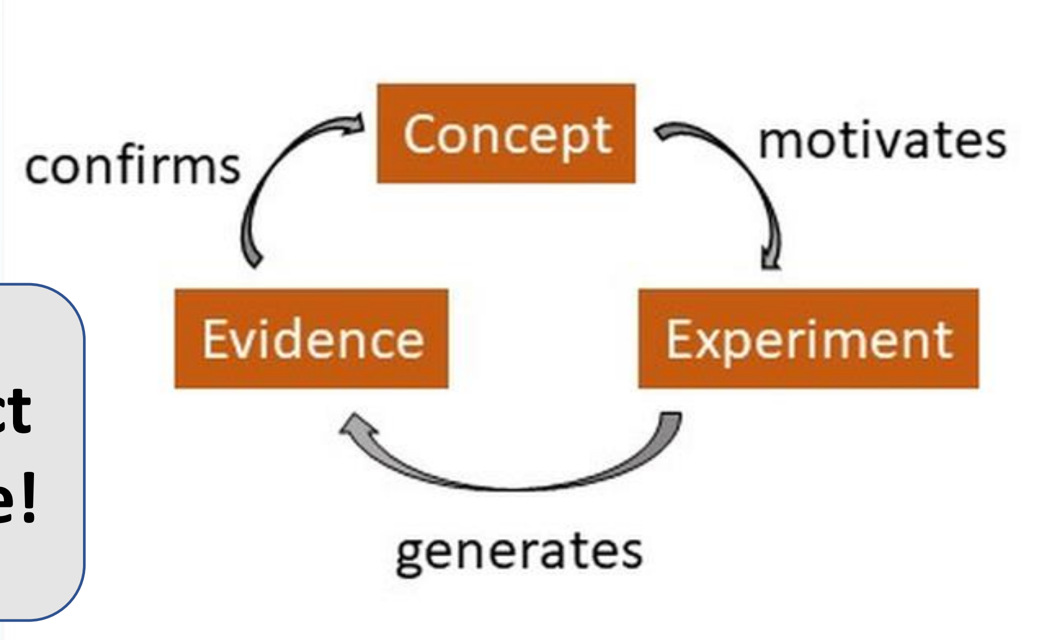
Segment 1: Project Presentation

Segment 2: Q&A with Panel

Closing

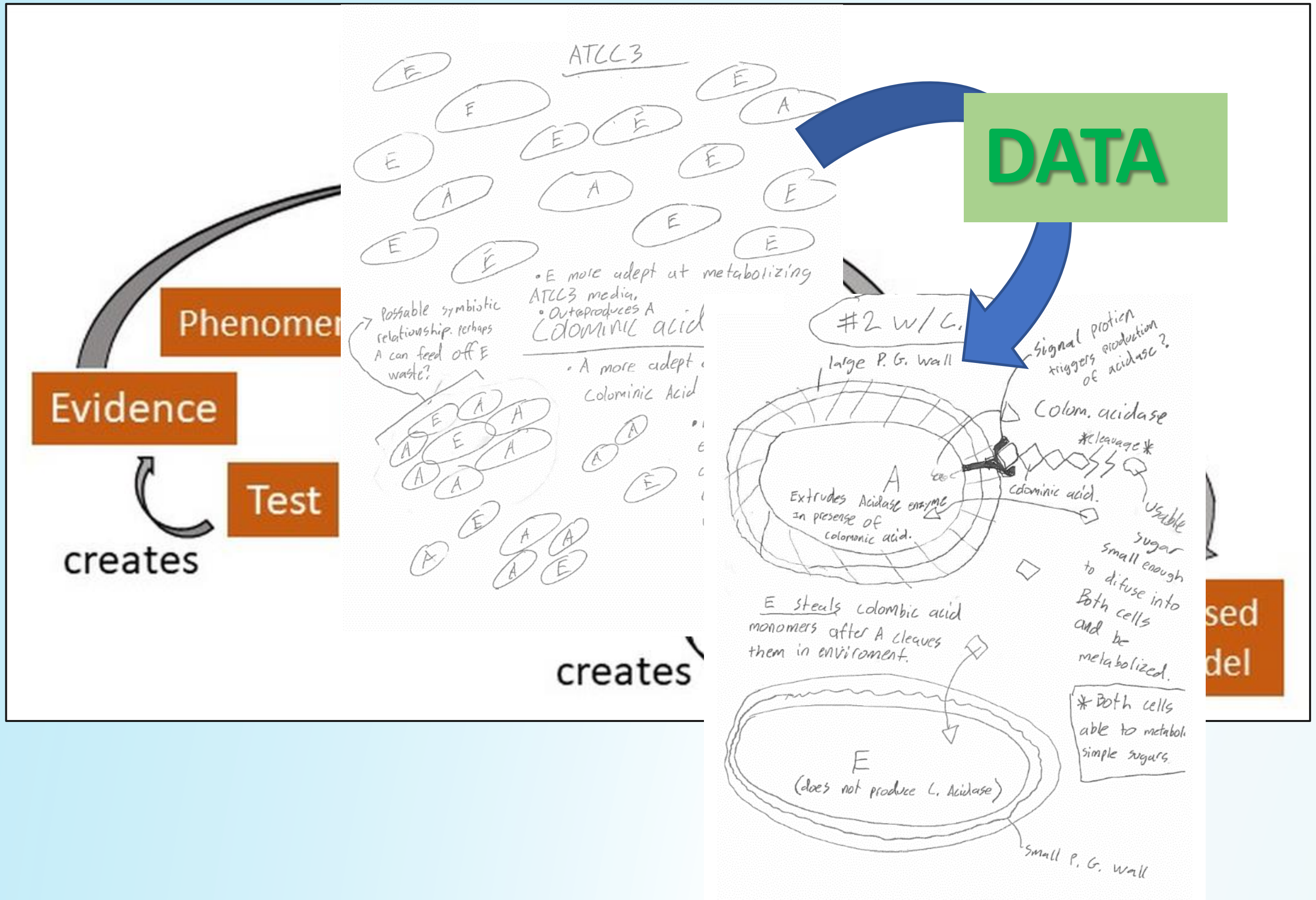
Laboratory classes are an opportunity to introduce undergraduate students to science.

Traditional laboratory curricula focus on reinforcing course content



This does not reflect how science is done!

Authentic Inquiry through Modeling in Biology (AIM-Bio)



A learning environment to:

- Support and motivate students with a wide diversity of educational backgrounds
- Connect students to biology research community

Hester *et al.* 2018

Instructional Context

Introductory Biology Course

- 1,800 students per year
- Sections of 25 students
- Taught by TAs (graduate and undergraduate)
- Required for 20 diverse majors across 7 colleges

Course Redesign Pilot (2016-2019)

- Student-driven inquiry related to ongoing biology research
- Demonstrated evidence of positive student outcomes

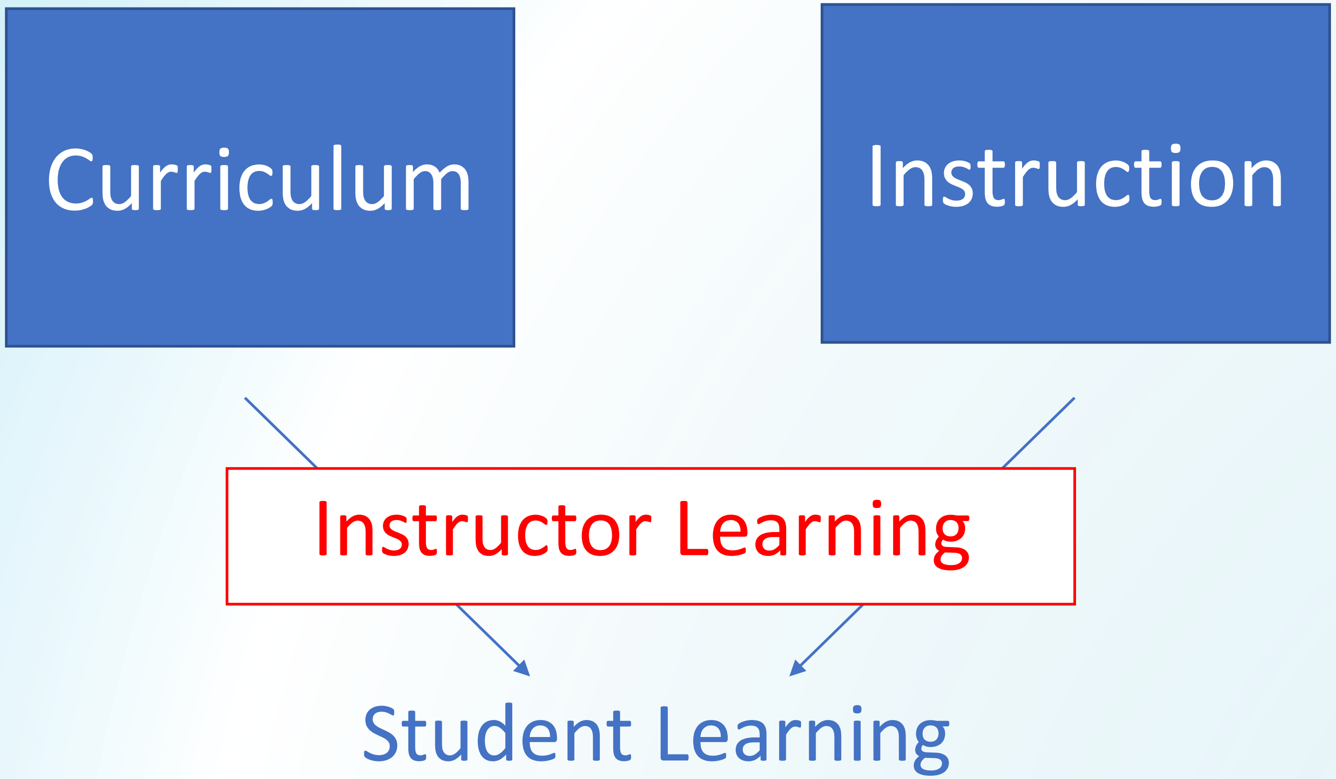
Scale-up for Large Course (2021-present)

- Training TAs for new ways of teaching

Reframing Laboratory Teaching and Learning

Purpose is to generate explanations		**Purpose is to confirm concepts**
Focus on Science Practices through Inquiry	VS	**Focus on Content Delivery**
Students given autonomy & diverse ideas are expected		**Students carry out standardized activities**
Scientific Uncertainty is Inherent		**Students find expected experimental outcomes**

Adapting an Instructional System



CUES Project Proposed Outcomes

1. A professional development program to support teaching assistants in implementation of an authentic inquiry curriculum.
2. A research study investigating the ways that teaching assistants implement the AIM-Bio curriculum.
3. An in-depth assessment of student outcomes from the AIM-Bio scale-up that addresses how variation in implementation by teaching assistants may affect these outcomes.

Professional Development Program

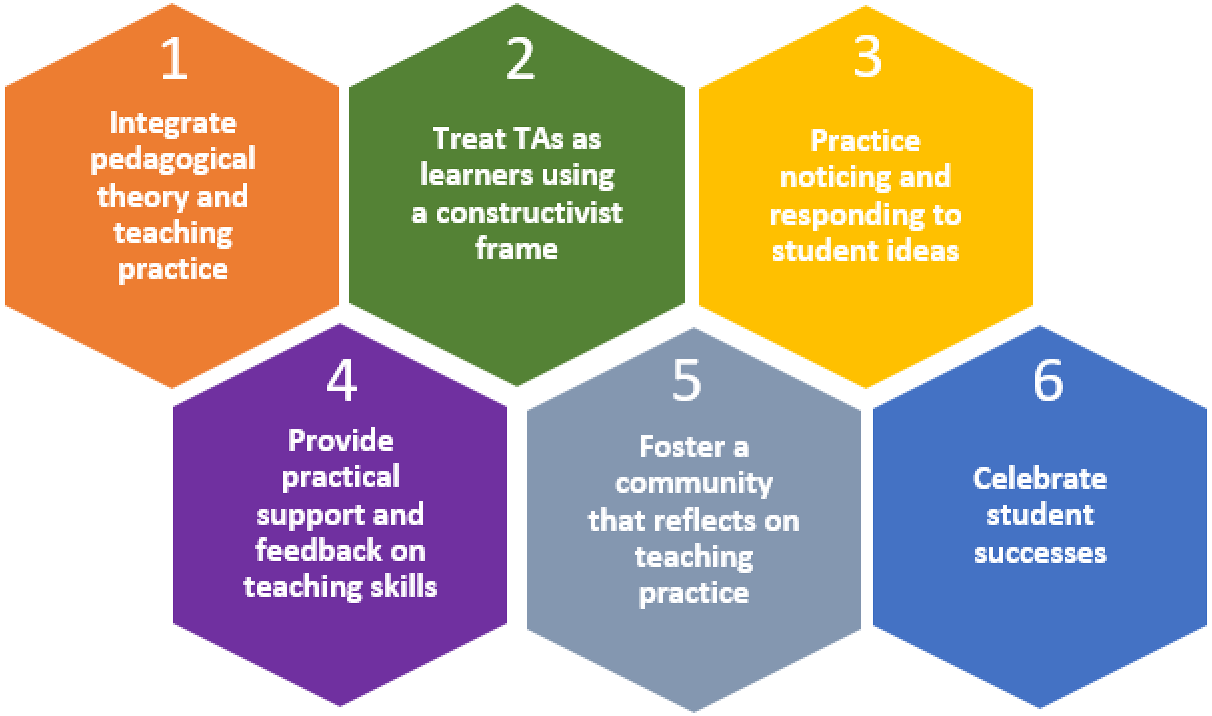
Meet with TAs and Preceptors Each Week for 3 Hours

Scale-up Over Time

- Fall 2021 – 8 TAs and 11 Preceptors
- Spring 2022 – 9 TAs and 8 preceptors
- Fall 2022 – 23 TAs and 19 preceptors

Ongoing Assessment and Revision of PD curriculum

Design Principles for Professional Development Program



7. Acknowledge and build on TAs' diverse resources.

8. Continuously frame teaching as a learning /growing experience.

Lotter, et al., 2013; Schussler, 2008; Wee et al., 2007; Jacobs et al., 2010; Levin, Hammer and Coffey, 2009; Luft, 2001; Lotter & Miller, 2017; Sherin, 2004

Framework for Professional Development Activities

Categories of Activities to Support TAs Learning Needs

- Content and Activity Knowledge Supports
- Science Skills Practice
- Pedagogy Skills Development
- Metacognitive Reflection

Content and Activity Knowledge Supports

Example:

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
	Membrane Transport	Bacterial Growth	Computational Model of Cancer	Algal Phototaxis	Yeast Cell Signaling
Pose a Question				●	●
Create a Model	●	●		●	●
Design Experiments		●	●	●	●
Interpret Data	●	●	●	●	●
Revise a Model	●	●		●	●

Increasing Openness of Inquiry

"Take a look at the overview of the AIM-Bio curriculum (handout)."

"Working with a partner, decide on questions and comments you would like to share."

Content and Activity Knowledge Supports

Lessons Learned:

- TAs want to understand how tasks fit into the flow of a lesson and how lessons fit into the flow of the curriculum.
- Without confidence in the "purpose" of activities, TAs may alter the curriculum in ways that are not productive.

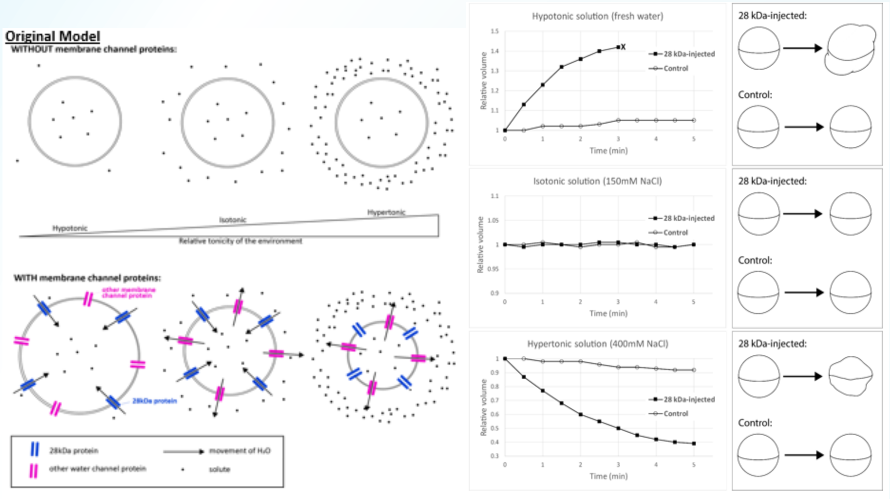
Science Skills Practice

Examples:

Evaluating Hypotheses

	Student Hypothesis	Comments
1	Tyrosine phosphorylation is integral in the signaling pathway of the phototaxis process in Chlamydomonas, and when a Chlamydomonas cell's tyrosine phosphorylation is blocked, it will not be able to perform phototaxis.	Testable Hypothesis? Yes/No/Maybe
2	If the wild type is deprived of Ca2+, then they fail to respond to light and phototax.	Testable Hypothesis? Yes/No/Maybe
3	At lower wavelengths, the Chlamydomonas will phototax more positively in comparison to a higher wavelength.	Testable Hypothesis? Yes/No/Maybe
4	Green and orange wavelengths have	Testable Hypothesis? Yes/No/Maybe

Interpreting Data



1) Describe the data in Figure 1
2) Interpret the data in Figure 1
3) Relate the data in Figure 1 to the model

Proposing Models

Biological Phenomenon:

Most bacteria cells can sense and respond to substances in their surroundings. For example, if you put bacteria near food substances (sugar) they will sense the food and move towards the food; if you put them near poisonous substances they will sense the poison and move farther away from it. Some bacteria have mutations and can no longer sense substances in their environment. These bacteria do not move towards food or away from poisons and therefore are more likely to die from starvation or poisoning.

Draw a model to explain what you think could be going on with the bacteria.

Science Skills Practice

Lessons Learned:

- TAs can benefit from practice with the science reasoning skills that are part of the curriculum.
- Including practice that is in a context related to the curriculum (but not the same activities that are in the curriculum) emphases the skills that TAs and students need to use.
- Allowing TAs to practice skills “as a learner” fosters productive metacognitive reflection on what is involved in using the skill.

Pedagogy Skills Development

Example:

Think-Pair-Share (1)

- Read through the transcript of an instructor talking with students as they design an experiment.
- Discuss with a partner:
    1. What are the students' ideas for their hypothesis and their experiment?
    2. Will this experiment actually test the students' hypothesis?

T: Alright. Can I see your model? (pauses to look at model drawing) So you guys are writing and they are still talking so I want to know what is going on. So, who can tell me your general thoughts? It's all of you guys right? Okay.
S1: That bacteria A, umm, contributes, or like alters in a way, bacteria E, that allows it to survive. So we were thinking like we could take bacteria E colony, like from the one where they grew together on the plate
T: mmhmm
S1: and introduce that to the media 2, so we will be able to test that...
T: Wait say that again. So if you take-
S1: So in the plates over there, bacteria A and E are growing together, right so you have colonies of E...
T: Right and they have now been separated?
S1: Yeah. So we are going to take that bacteria E and introduce it into the media to see if it survives, with developing with bacteria A.
T: So your, is your hypothesis that A did something, permanent to E?
S1: Yeah.
S2: Yes.
T: So what is the thing that you think it did?
S2: Contributed some chemicals that maybe-
T: That the E took?
S2: Yeah that the E took and maybe used. So like A generated something that E could use.
T: And now it has this thing that helps it survive?
S3: Yeah so if it grows then we are going to say that A is contributing something to E but if it dies than A is doing something.
T: In what media?
S: Media 2
T: So I like that, it is logical. It will be easy. So I want you to flesh that out, which is what you are doing....

Classroom Transcript

Think-Pair-Share (2)

- Looking at the transcript again, discuss this question:

What does the <u>instructor</u> do in this episode that enables them to answer those questions?

(1. What are the students' ideas for their hypothesis and their experiment? 2. Will this experiment actually test the students' hypothesis?)

Science Skills Practice

Lessons Learned:

- Once TAs have adapted to the goals of inquiry teaching, they are eager to add more "tools" to their inquiry-teaching toolbox.
- Practicing pedagogy skills in the same context as the curriculum fosters immediate transfer to the classroom and deeper reflection on instructional goals and accomplishments.
- Scaffolding TA noticing of student ideas can lead to increased precision in TAs' reasoning about student learning.

Metacognitive Reflection

Examples:

1. How has teaching AIM-Bio so far this semester going?

2. What challenges do you expect you may have when teaching AIM-Bio?

3. In order to effectively teach AIM-Bio, in what ways do you hope to learn/adapt as an instructor? What questions do you have for us?

D2l Discussion Thread

Work with your group facilitator to make a giant sticky note with your thoughts about these questions.

- How do you feel that you supported your students with modeling?
- What do you think is going well in your classroom? What have been the successes?
- What challenges are you facing in your classroom?
- After teaching the last 6 weeks, what have you learned? In what ways would you like to improve as an inquiry instructor?

Written Reflection → Group Sharing

Metacognitive Reflection

Lessons Learned:

- Reflection is essential to pedagogical learning, but TAs vary in the extent to which they spontaneously reflect on their teaching.
- Prompts for reflection should be timed to match the patterns of difficulty and resolution in the curriculum.
- Explicit discussion about the purpose of reflection as a learning tool can increase participation.

Findings from External Evaluation of PD Program

- **TAs learned from the PD how to communicate and guide students and how to encourage and value student ideas.**
- **The PD experience improved through curricular revision and building of a more experienced teaching team.**

"In the Spring 2022 cohort, TAs overall remarked on more detailed aspects of learning about teaching and how to better support student learning, especially with respect to perceptions of models" – Evaluator Report

CUES Project Proposed Outcomes

1. **A professional development program to support teaching assistants in implementation of an authentic inquiry curriculum.**
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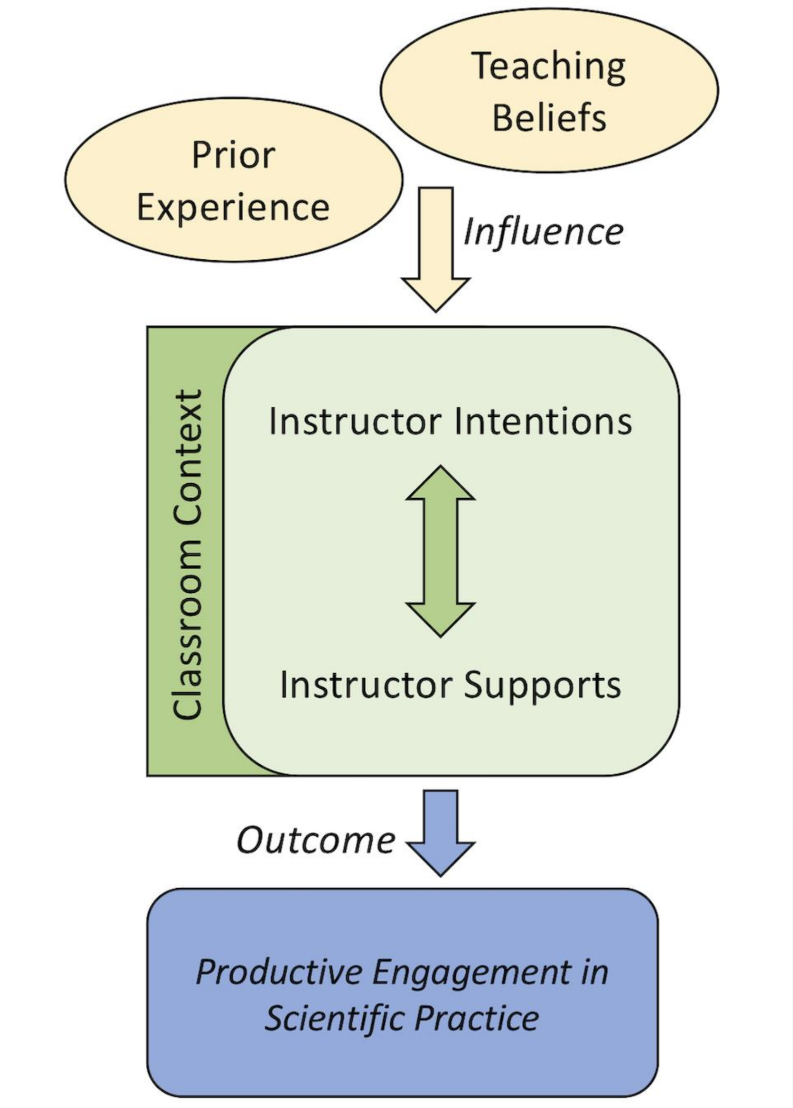
3. **An in-depth assessment of student outcomes from the AIM-Bio scale-up that addresses how variation in implementation by teaching assistants may affect these outcomes.**

Instructor Reasoning

Yellow boxes: Ravitz et al., 2000; Stuart and Thurlow, 2000; Harwood et al., 2006; Ferrare, 2019; Männikkö and Husu, 2019

Green box: Pratt, 1998; Schoenfeld, 2008; Hammer et al., 2012

Blue box: Passmore and Stewart 2002; Lehrer and Schauble, 2005; Schwarz et al., 2009; Louca and Zacharia, 2015



Cooper et al., *CBE-LSE* 2022

Example of Intentions and Supports:

Make Ideas in the Room Accessible

"I actually wanted them to look at other groups' data . I think it's easiest to just use your own. But you don't really get a full picture, especially with so many groups just looking at the light filters."

"Were you influenced by any of the other groups' findings?"

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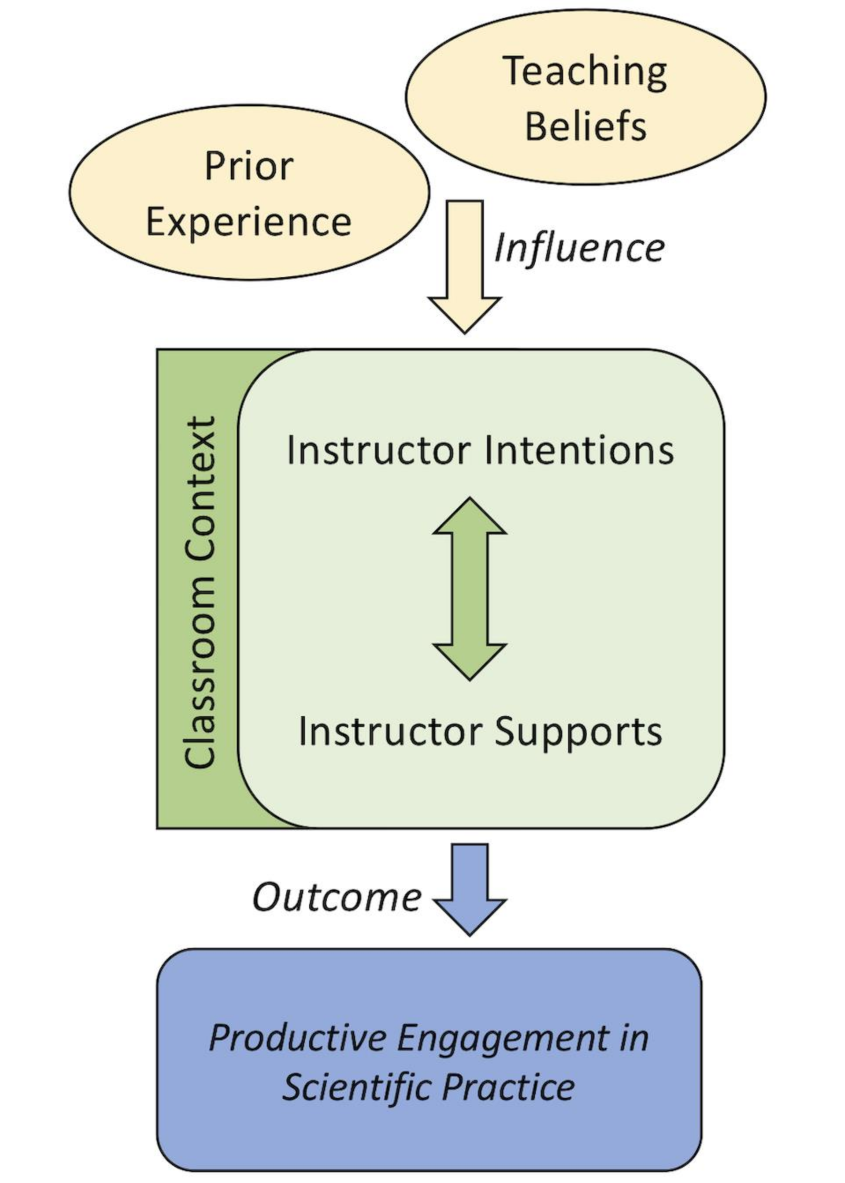
Instructor Reasoning

Cooper et al., *CBE-LSE* 2022

- Characterized experienced instructors' intentions and instructional supports in an inquiry setting
- Developed lens to investigate TA instruction
- Provided insight into supporting TAs:
- How and when should individualized instruction be provided?
- In what ways can TAs help students connect across science practice tasks?



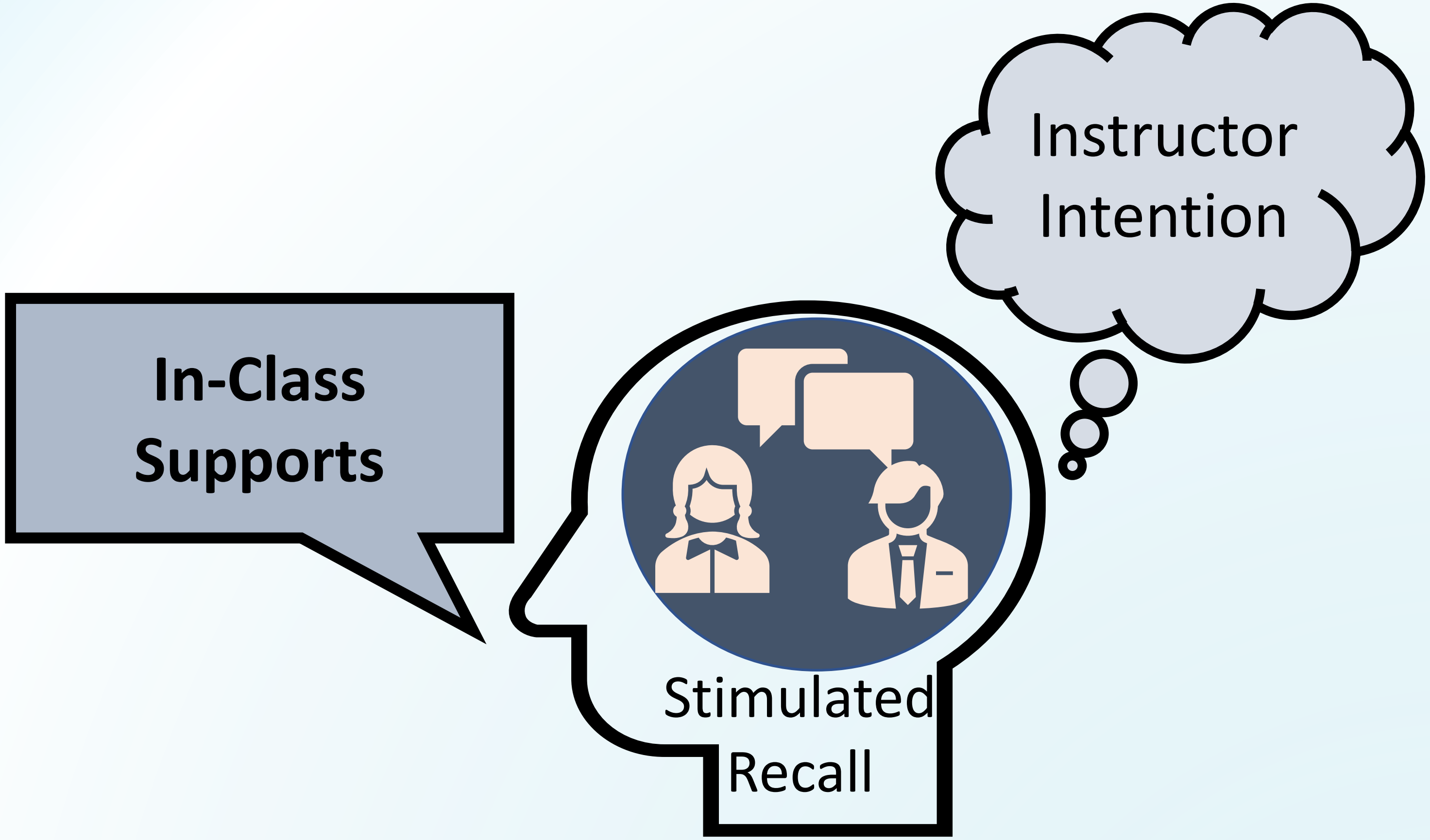
Methods

Data Collected

- 4 semesters, 37 TAs
- In-class audio (>1,500 hours)
- Instructor Interviews (39)

Analysis

- Qualitative coding
- Case study



Research Question: How do TA’s instructional values and classroom approach change through teaching over time?

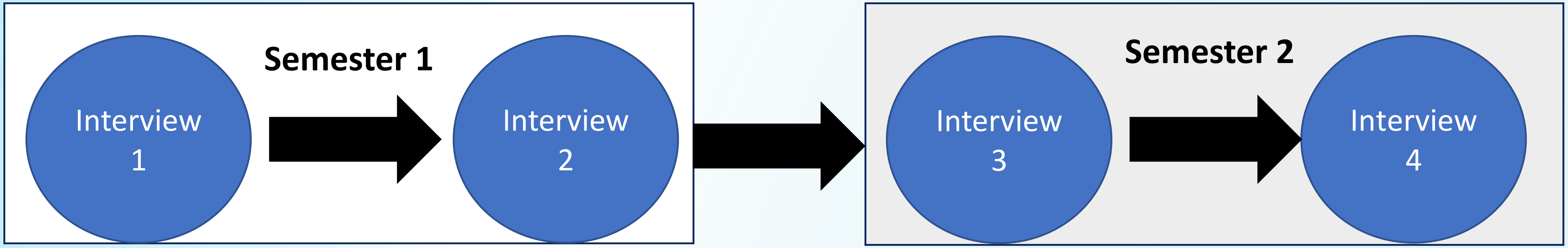
Case Study: Aria

Undergraduate TA

Major= Neuroscience and Biochemistry

First semester teaching (prior preceptor experience)

First semester in undergraduate research lab



Student-centered ideas:

Interview 1

- **Encourage student collaboration**
- **Wants students to be comfortable asking her for help**
- **She cares about nurturing her students as people**

Teacher-centered ideas:

Push towards "ideal" answer

"I wanted them to also include other groups data because there was very specific experiments that were really important. . . **They're like, really key to what this new phenomena- like mechanism for the phenomena is.** So I wanted to make sure they had those key points down."

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Aria develops an inquiry frame.

Interview 4

In-class Episode: Allowing student freedom

“. . .I wanted to kind of let them think through it because sometimes it's beneficial for you to walk them through it but this time it's pretty straightforward, in my opinion, for how different colors can affect it differently. **So I want them to think through it themselves, yeah.**”

Wants students to do the reasoning and participate in forming hypotheses

In-class Episode: Interpreting data with students

“. . .I come back a few minutes later. He's like, "What did we say again? I'm trying to type it out," and he had like no idea. So then I felt like, okay, **maybe I almost did too much if they can't even say it in their own words**. . .”

Begins to understand how students learn

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Aria’s instructor intentions move towards supporting scientific practices.

Semester 1

“I want to make sure every **group member was included**, and they all knew what was going on. I wanted to keep in mind, like, **time management**, because I don't want to overwhelm themselves with the amount of tests that they were going to run. And then I think they also had to **do the order form** today. So, I wanted to make sure that they had a **clear idea of what each task was** going to entail and outline it in the chart.”

Same task

Semester 2

“. . .I think they usually get a lot of information with the tools and I like to go through it with them. And I like when they get kind of-- they take ownership. . . We're like, "Okay, take out something that you're interested in studying and then figure out with a tool can actually experiment with that."

Aria's classroom approach for teaching changes over time.

Through experience in AIM-Bio, she develops a framework for inquiry teaching.

Begins to develop constructivist framework for learning.

Values supporting students participating fully in science practices.

Evidence for Mechanisms of Change:

- Pedagogical Content Knowledge
- Reflection on teaching
- Moments of teaching dissatisfaction

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Question 1: Does AIM-Bio result in positive student outcomes when taught by TAs at scale?

Question 2: How do variations in teaching affect student outcomes?

Question 1: Does AIM-Bio result in positive student outcomes when taught by TAs at scale?

Question 2: How do variations in teaching affect student outcomes?

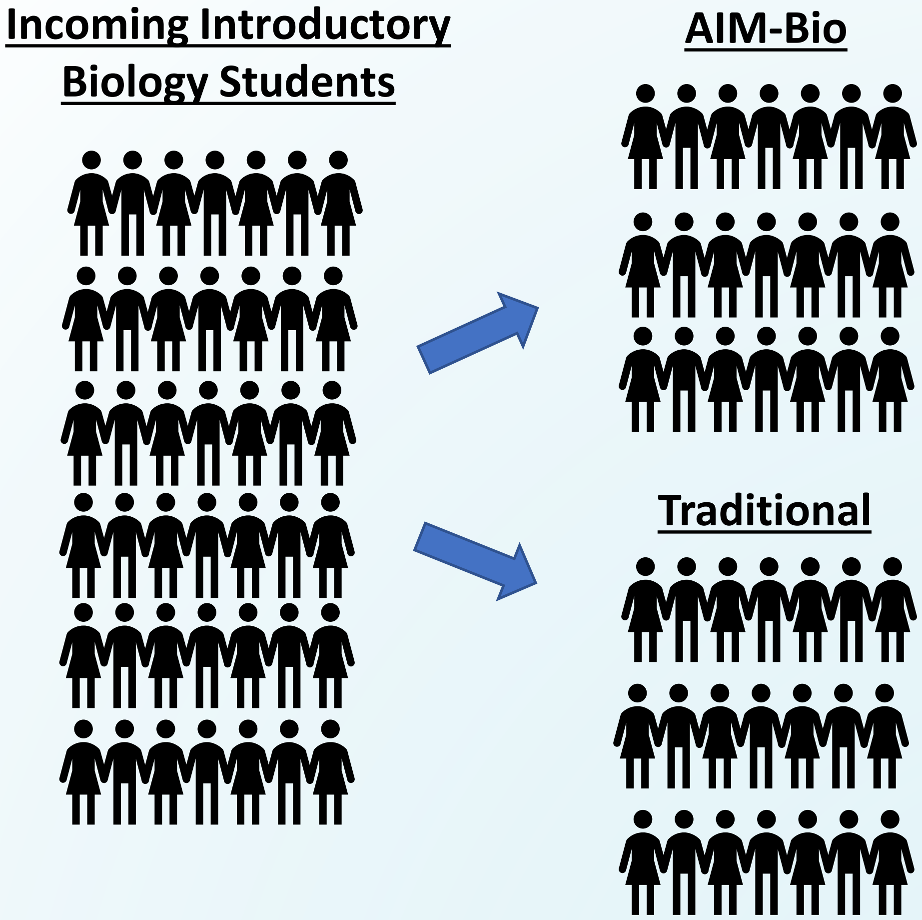
Staged scale-up effort created a natural experiment

Students chose sections based on schedule (not curriculum)

Data:

All consenting students: class work, surveys, demographics, institutional data

Some consenting students: classroom audio



Science self-efficacy, science identity and science values

Survey of students' science self-efficacy, science identity, and science values

(Estrada *et al.*, 2011, 2018)

Likert-scale survey of three factors:

- **Science Self-Efficacy**
- **Science Identity**
- **Science Community Values**

Science self-efficacy, science identity and science values

Survey of students' science self-efficacy, science identity, and science values

(Estrada *et al.*, 2011, 2018)

Likert-scale survey of three factors:

- **Science Self-Efficacy**
- Science Identity
- Science Community Values

Example items:

"[I feel confident to] generate a research question to answer"

"[I feel confident to] figure out what data/observations to collect and how to collect them"

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Science self-efficacy, science identity and science values

Survey of students' science self-efficacy, science identity, and science values

(Estrada *et al.*, 2011, 2018)

Likert-scale survey of three factors:

- Science Self-Efficacy
- **Science Identity**
- Science Community Values

Example items:

"I have a strong sense of belonging to the community of scientists"

"I have come to think of myself as a 'scientist' "

Science self-efficacy, science identity and science values

Survey of students' science self-efficacy, science identity, and science values

(Estrada *et al.*, 2011, 2018)

Likert-scale survey of three factors:

- Science Self-Efficacy
- Science Identity
- **Science Community Values**

Example items

How much is the person in the description like you?

"A person who feels discovering something new in the sciences is thrilling"

"A person who thinks discussing new theories and ideas between scientists is important"

Science self-efficacy, science identity and science values

Survey of students' science self-efficacy, science identity, and science values

(Estrada *et al.*, 2011, 2018)

Likert-scale survey of three factors:

- **Science Self-Efficacy**
- **Science Identity**
- **Science Community Values**

Evidence that science self-efficacy is important, but that "identifying with and endorsing the values of the social system reflect a deeper integration and more durable motivation to persist as a scientist." (Estrada *et al.*, 2011)

Scale-up: AIM-Bio students gain in science self-efficacy, science identity and science values

Estrada pre-/post- survey results (Fall 2021)

	Traditional Lab % of possible increase (pre mean, post mean) [N=502]	AIM-Bio Lab % of possible increase (pre mean, post mean) [N=185]
Science Self Efficacy (5-point scale)	**40%** (3.662, 4.194)	**47%** (3.752, 4.344)
Science Identity (5-point scale)	**16%** (3.697, 3.901)	**29%** (3.716, 4.086)
Science Values (6-point scale)	**-15%** (4.992, 4.845)	**24%** (5.032, 5.262)

Scale-up: AIM-Bio students gain in science self-efficacy, science identity and science values

Estrada pre-/post- survey results (Fall 2021)

	Traditional Lab % of possible increase (pre mean, post mean) [N=502]	AIM-Bio Lab % of possible increase (pre mean, post mean) [N=185]	P value (ANCOVA)	Effect Size (Hedge's g)
Science Self Efficacy (5-point scale)	**40%** (3.662, 4.194)	**47%** (3.752, 4.344)	0.0094	0.28 (small)
Science Identity (5-point scale)	**16%** (3.697, 3.901)	**29%** (3.716, 4.086)	2.11e-08	0.330 (small)
Science Values (6-point scale)	**-15%** (4.992, 4.845)	**24%** (5.032, 5.262)	1.046e-15	0.71 (medium)

Scale-up: AIM-Bio students gain confidence in research-relevant skills

Free Response Reflection Surveys (3 points during semester)

So far, have you gained confidence in anything during lab? Please explain.

Coding Categories

School Learning: Grades, Science Content, Completing Tasks

Transferrable Skills: Communication, Teamwork, Writing

Lab Learning: Technical Skills, Scientific Reasoning

Science Practices: Hypothesizing, Predicting, Generating Ideas, Modeling, Experimental Design, Reasoning with Data

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Scale-up: AIM-Bio students gain confidence in research-relevant skills

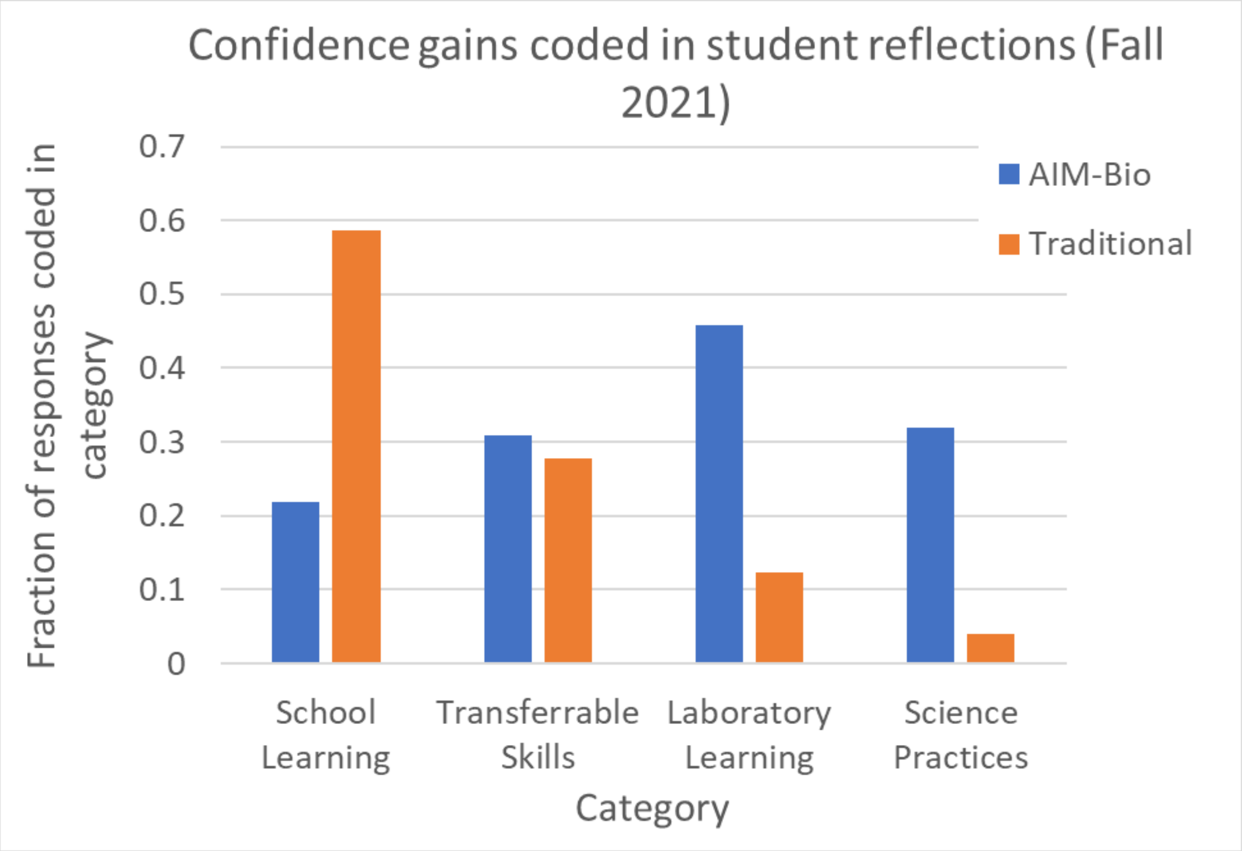
Free Response Reflection Surveys (3 times during semester)

So far, have you gained confidence in anything during lab? Please explain.

<u>Data</u>

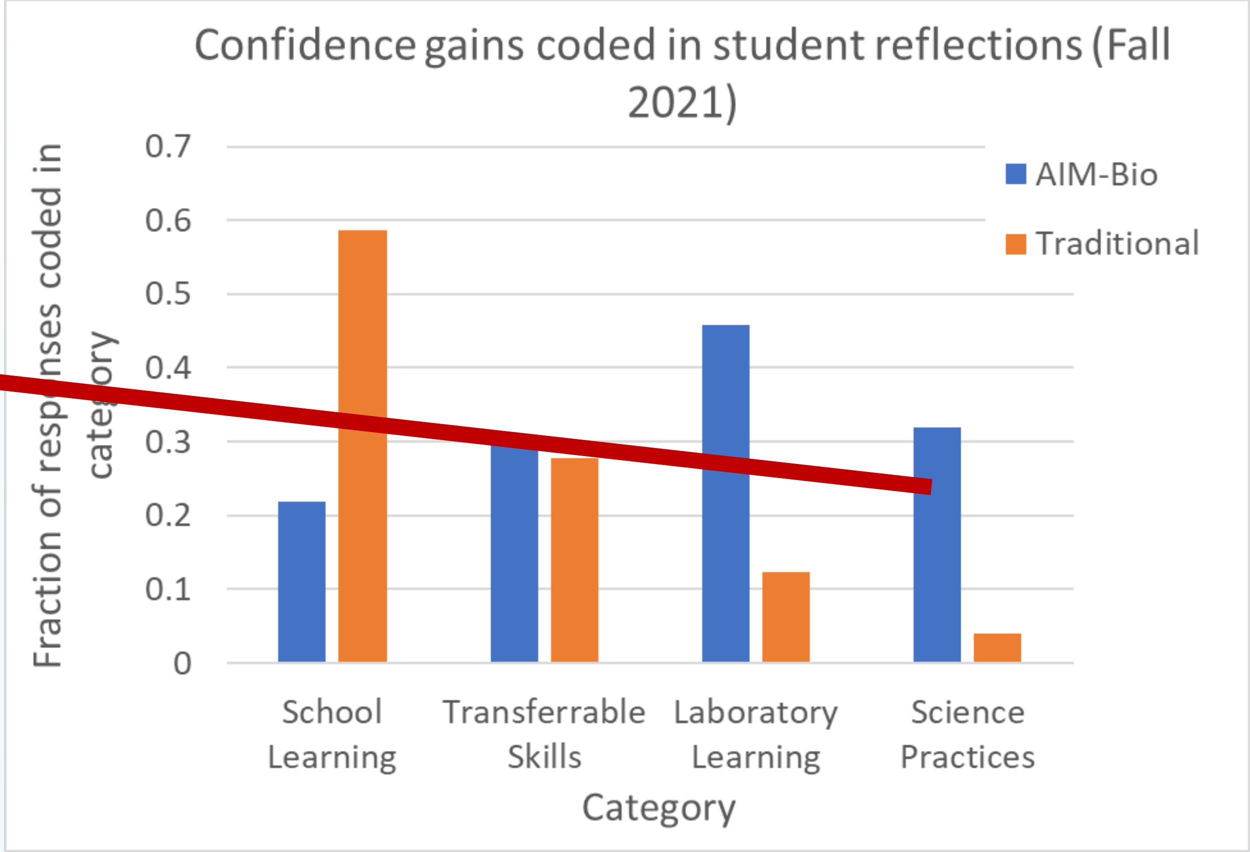
AIM-Bio: 533 responses from 185 students

Traditional: 532 responses from 206 students



Scale-up: AIM-Bio students gain confidence in research-relevant skills

"I feel really confident now to be able to have a question, form a model based on different biology that I know, come up with the experiment and then be able to accurately interpret the data. I now know why it is so important to be able to interpret data and connect it to the biological explanations."



AIM-Bio results in positive student outcomes when taught by TAs at scale

AIM-Bio students taught by TAs:

- Experienced increased science self-efficacy, science identity, and science community values
- Gained confidence in research-relevant skills

Next steps:

- Investigating long-term impacts on students' persistence in STEM
- Connecting features of instruction to student outcomes

Conclusions and next steps

- **Professional Development can play a role in supporting TAs in authentic-inquiry based instruction.**
- **TA learning is a fascinating and complex area for investigation!**
- **Authentic inquiry at scale can have positive outcomes for students, with the potential to impact STEM persistence.**

Next Steps:

- Manuscripts on "Classroom Research Mentor" and "Community of Science Practice" impacts Science Identity
- Analysis of differences between and/or changes in TA intentions and classroom supports
- Ongoing large-scale data collection to look for connections between TA actions and student outcomes

Special Thanks!!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AIM-BIO Scale-up Collaborators

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NSF IUSE Program
DUE-1625015, DUE 2020788

Center for University Education Scholarship (CUES)

Q&A with Panel

How do TAs Learn to Teach Inquiry-Based Labs? Insights from Research & Practice

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CUES Distinguished Fellowships: Proposal Workshop Series

Spring 2023 | *Dates to be announced soon!*

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