The Tigriopus CURE: A Scalable Model for Engaging Students in Authentic Scientific Practices

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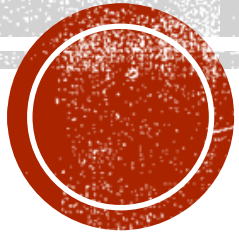
April 5, 2019



Focal Questions

- What are course-based undergraduate research experiences (CUREs), and how do they differ from traditional laboratory coursework?
- What impact do CUREs have on student outcomes?
- How do we "frontload" the CURE experience such that students are (more) successful at engaging in inquiry?

Scientific Practices and the STEM Landscape

- 36% of incoming freshmen will major in a STEM field
- 60% attrition rate nationwide
- Factors contributing to high levels of attrition (Rask, 2010; Ost, 2011; Conley, 2003; Seymour & Hewitt, 1999):
  - "Pushing and Pulling"
  - Classroom culture
  - Lack of success in introductory coursework
  - Lack of "habits of the mind"

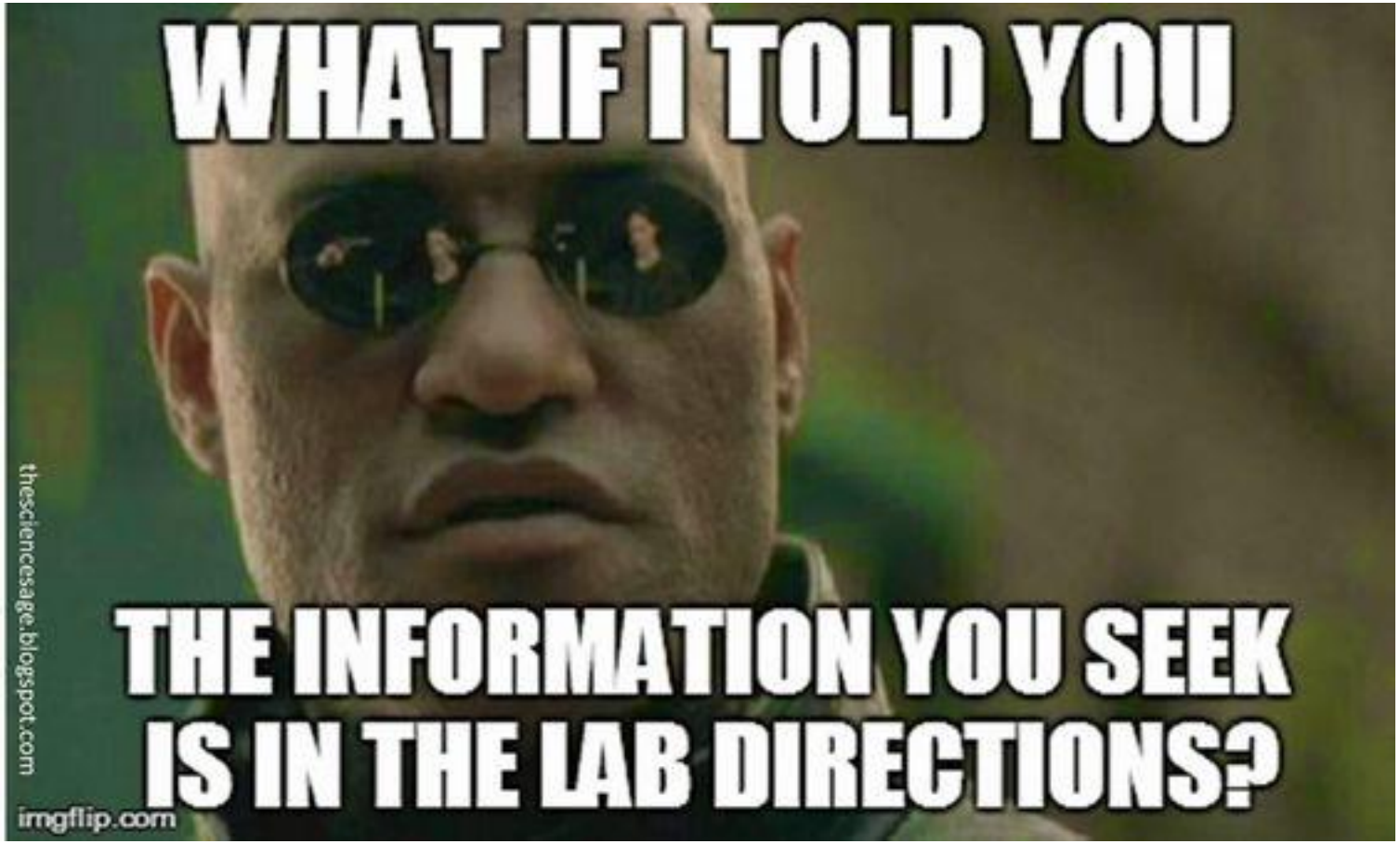
- Engaging students in authentic scientific practices is one posited mechanism for increasing student success and persistence in STEM

The introductory biology laboratories I completed as an undergraduate prepared me to conduct rigorous scientific research.

1. Strongly Agree
2. Agree
3. Neutral
4. Disagree
5. Strongly Disagree

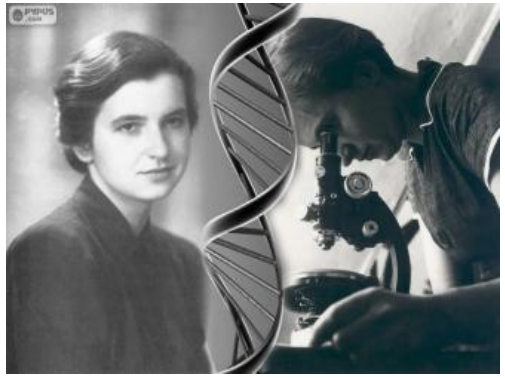
Is the Answer that Simple?

Traditional Laboratory Environments



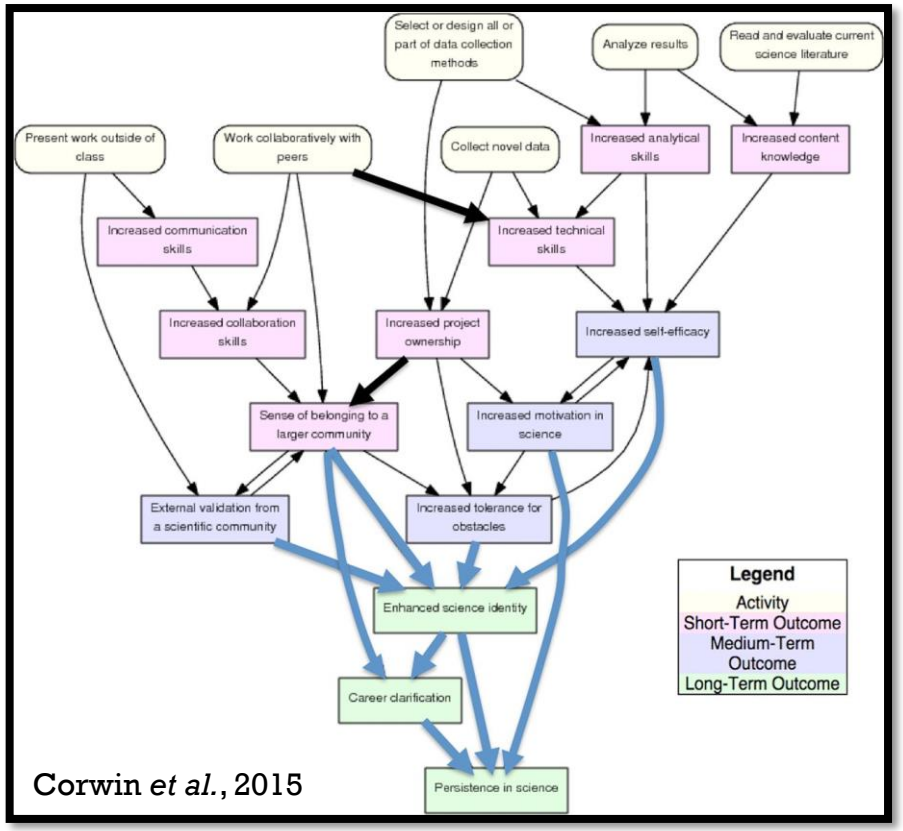
What is a CURE?

- No singular definition exists, though such experiences can often be classified as either (Spell *et al.*, 2014):
  - "Process"-oriented, where the focus is on **experimental design**
  - "Product"-oriented, where the focus is on **novel, publishable outcomes**
- Common features of course-based undergraduate research experiences (CUREs) include (Auchincloss *et al.*, 2014):
  - Use of scientific practices
  - Discovery
  - Broader relevance
  - Collaboration
  - Iteration



CURE Outcomes & Challenges

- **Numerous** potential positive impacts:



Corwin *et al.*, 2015

- Possible challenges and tensions associated with CUREs:
  - Required resources and investment – finances, time, personnel
  - Divergence from standard laboratory format
  - Alignment with required lecture portion of the course
  - Others?
    - _____
    - _____
    - _____
    - _____
    - _____

The Bottom Line: Why CUREs?

- Though the structure of CUREs varies widely, their primary objective is to engage ***all*** students in ***authentic*** scientific practices
- Previous research suggests that CUREs are effective at…
  - Enhancing students' development of scientific process skills and positive affect within the domain
  - Increasing student interest in conducting rigorous scientific research
  - Improving students' ability to "think like a scientist"
  - Promoting conceptual understanding and assimilation of content knowledge

CUREnet

reu research experiences for undergraduates

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Impacts of CUREs on Student Learning and Affect

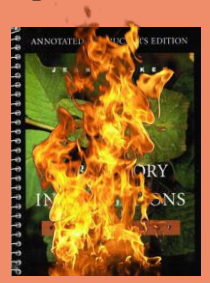
The Principles of Biology "Revolution"

Prior to Spring 2015

Lecture:

- 50-minute sessions
- Three sessions/week
- Single instructor
- Active learning-based curriculum

Laboratory:



Spring 2015 - Present

Lecture:

- 50-minute sessions
- Three sessions/week
- Single instructor
- Active learning-based curriculum

Laboratory:

Research Questions

- What impact does participation in the *Tigriopus* CURE have on students' attitudes and motivation in the biological sciences relative to a matched comparison group who completed the traditional lab?

- How does participation in the *Tigriopus* CURE differentially impact the attitudes and motivation of students from historically underrepresented groups relative to a matched comparison group who completed the traditional lab?

Research Context and CURE Description

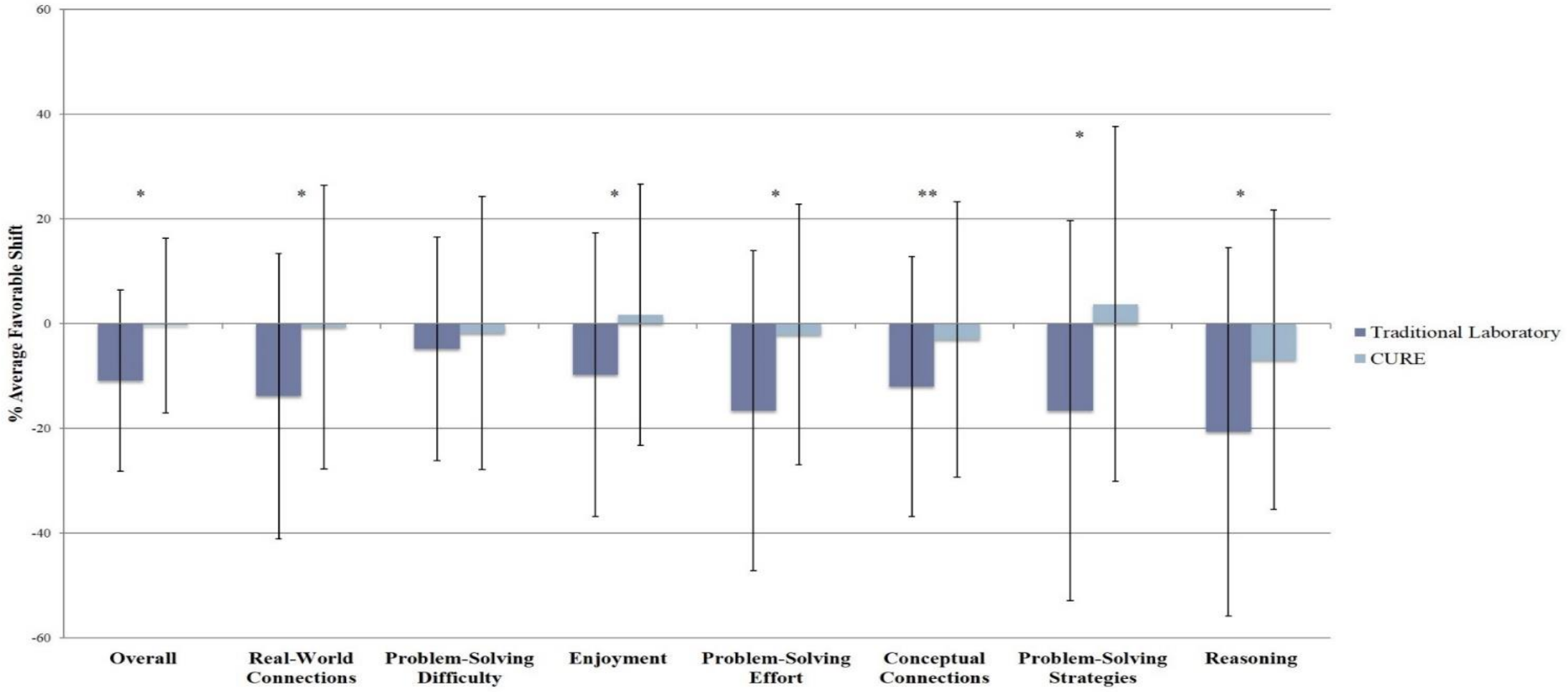
- Implementation of the *Tigriopus* CURE occurred during the Spring 2015 semester in an introductory cell and molecular biology course
- Students worked cooperatively in teams of four to develop and implement novel experiments using the marine copepod *T. californicus* + participated in concomitant supplemental instruction

Methods

- Participants (n = 125) included students enrolled in an introductory cell and molecular biology CURE, as well as a matched comparison group (n = 125) who had not participated in the CURE
- No mediating effect due to graduate teaching assistant instructor was observed ($F(108,1680) = 0.97$; $p = 0.575$; Wilk's $\Lambda = 0.64$)
- Survey Measures:

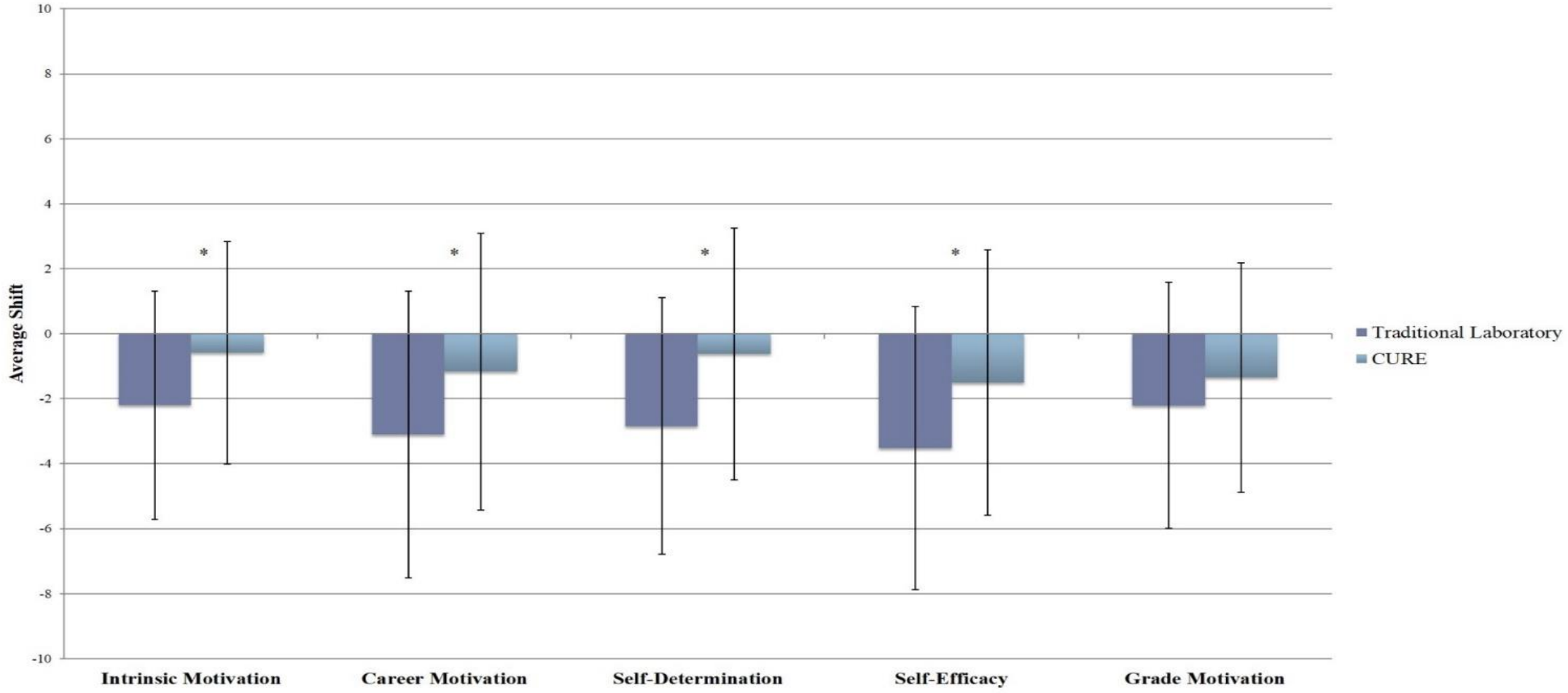
CONSTRUCT	INSTRUMENT
Attitudes	CLASS-Bio (Semsar *et al.*, 2011)
Motivation	BMQ (Glynn *et al.*, 2011)

Students' Attitudes in the Biological Sciences



* $p < 0.001$; ** $p < 0.01$

Students' Motivation in the Biological Sciences



* $p < 0.001$

Underrepresented Populations

	Trad._Fem.	CURE_Fem.	Trad._URM	CURE_URM
Real-World Connections	-13.92 (3.04)	0.48 (3.05)*	-12.34 (3.19)	-0.93 (3.20)*
Problem-Solving Difficulty	-3.69 (2.41)	-2.61 (2.94)	-5.52 (2.53)	-1.65 (3.08)
Enjoyment	-8.47 (3.04)	2.92 (2.76)*	-9.56 (3.19)	-0.01 (2.90)*
Problem-Solving Effort	-16.91 (3.45)	-2.02 (2.74)*	-16.98 (3.62)	-1.82 (2.82)*
Conceptual Connections	-12.40 (2.80)	-3.75 (2.94)*	-12.36 (2.94)	-0.89 (3.09)*
Problem-Solving Strategies	-18.33 (4.08)	4.38 (3.79)*	-16.25 (4.29)	4.86 (3.98)*
Reasoning	-21.67 (3.97)	-6.83 (3.21)*	-18.51 (4.17)	-6.50 (3.37)*
Intrinsic Motivation	-2.21 (0.39)	-0.38 (0.38)*	-2.01 (0.41)	-0.97 (0.40)
Career Motivation	-3.24 (0.50)	-0.73 (0.47)*	-3.06 (0.52)	-1.23 (0.50)*
Self-Determination	-2.73 (0.44)	-0.57 (0.43)*	-3.16 (0.46)	-0.46 (0.46)*
Self-Efficacy	-3.58 (0.49)	-1.33 (0.46)*	-3.30 (0.52)	-1.29 (0.48)*
Grade Motivation	-2.25 (0.43)	-1.10 (0.39)	-2.38 (0.45)	-1.10 (0.40)

Contextual Information

- Females (n = 90)
- URM (n = 86)
- *$p < 0.004$

Scaffolding Student Learning
PRIOR *to the CURE*

Research Foundations Courses (RFCs)

- Pre-requisite for entrance into a CURE (freshmen/sophomores)
- Adoption of active learning techniques
- UTEP RFC Structure:

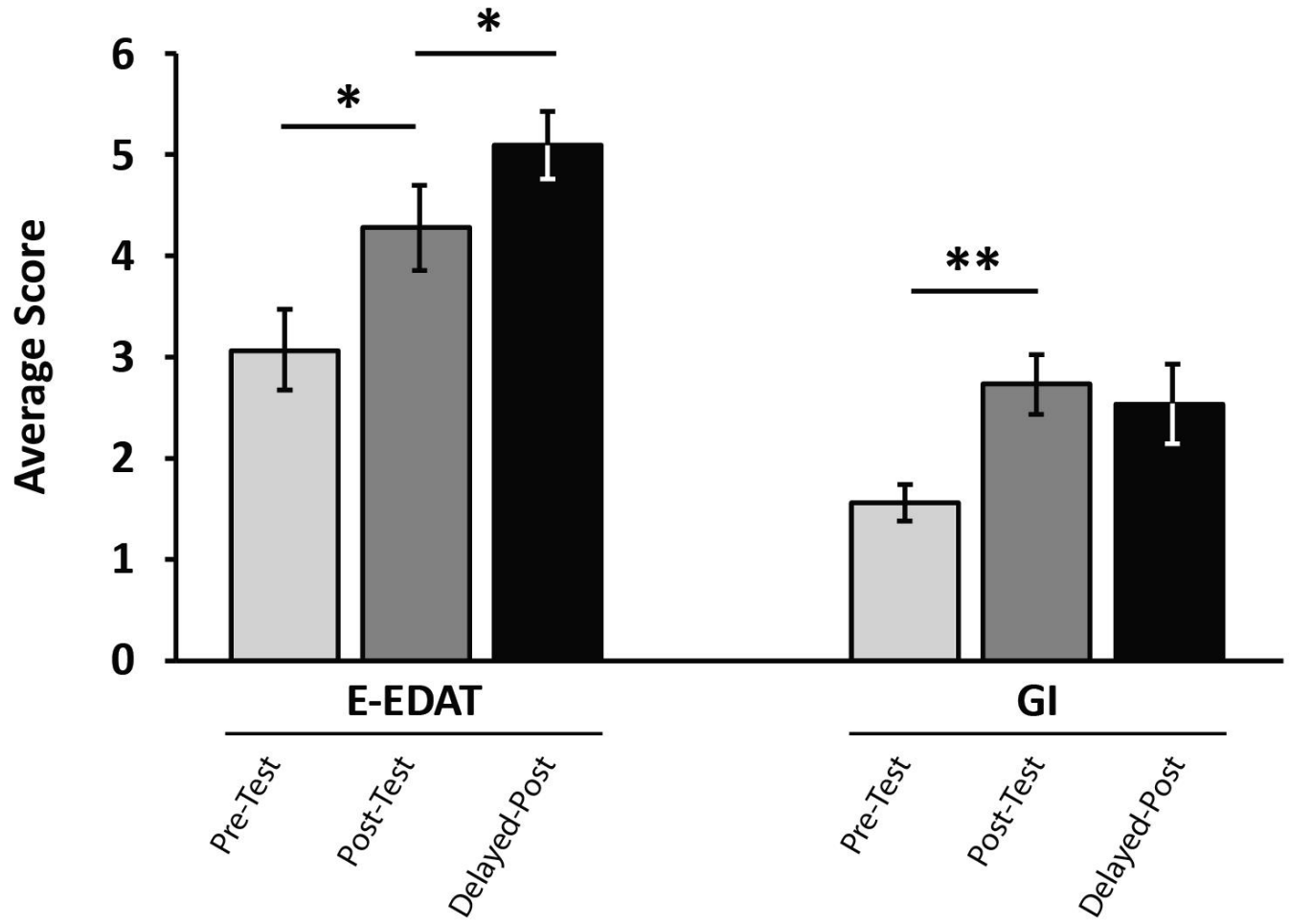
Enhancing Quantitative Reasoning Skills

- Development of quantitative reasoning skills is integral for professional *and* personal decision-making (Speth *et al.*, 2010; Goldstein & Flynn, 2011)
- Students often perceive themselves to be poor quantitative reasoners and scientific researchers (Hester *et al.*, 2014)
- Recent CUREs have adopted a focus on quantitative skills (e.g., Makarevitch *et al.*, 2015), but what about smaller-scale curricular approaches?

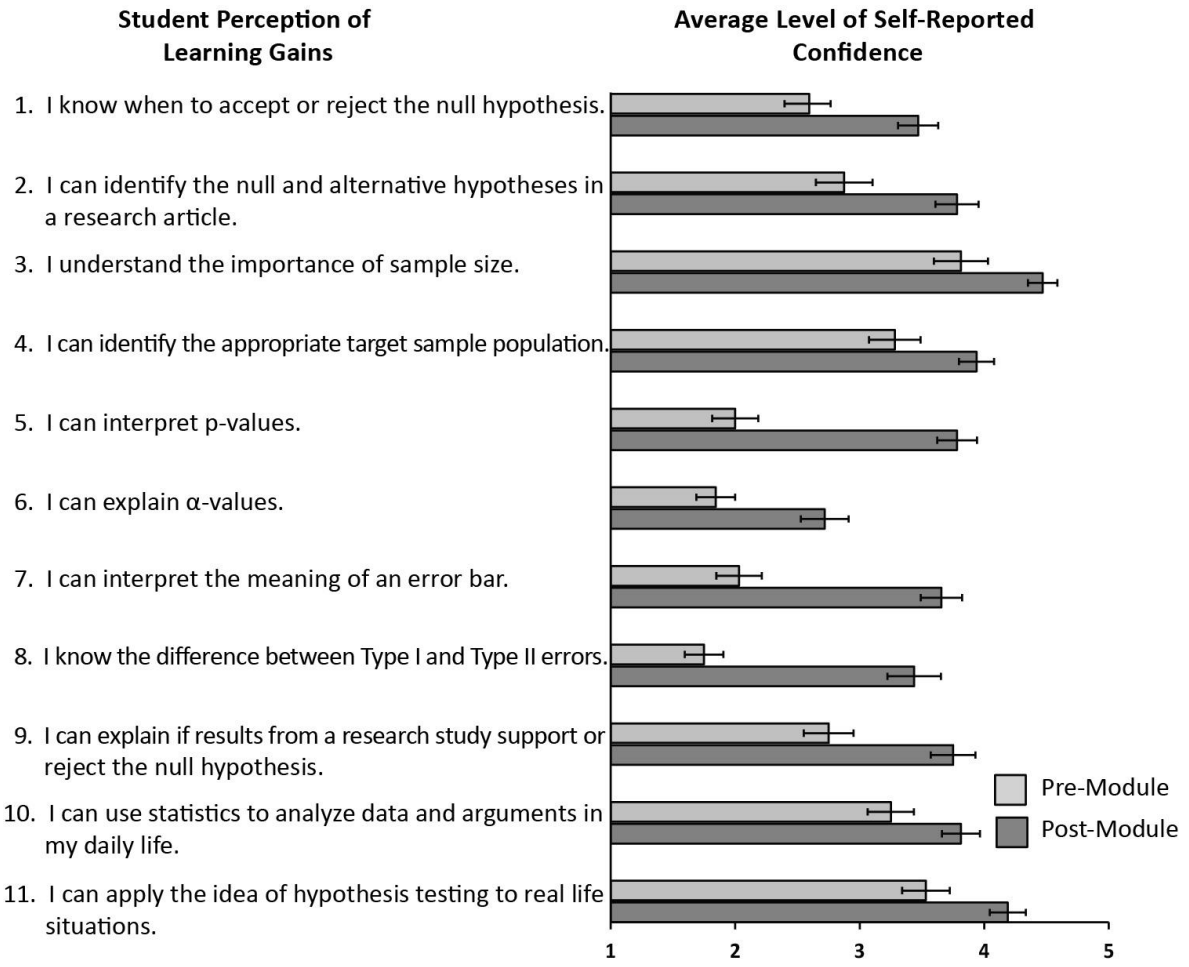
Statistics Module – Curriculum/Evaluation

- Two-session module (160 min. of total instruction)
- Activities consisted of:
  - Formal lecture
  - Interactive "height" exercise
  - Dissection of a peer-reviewed manuscript
- Participants' (n = 32) experimental design and graphical interpretation abilities were assessed using the E-EDAT and GI, respectively. Affective data were also collected.

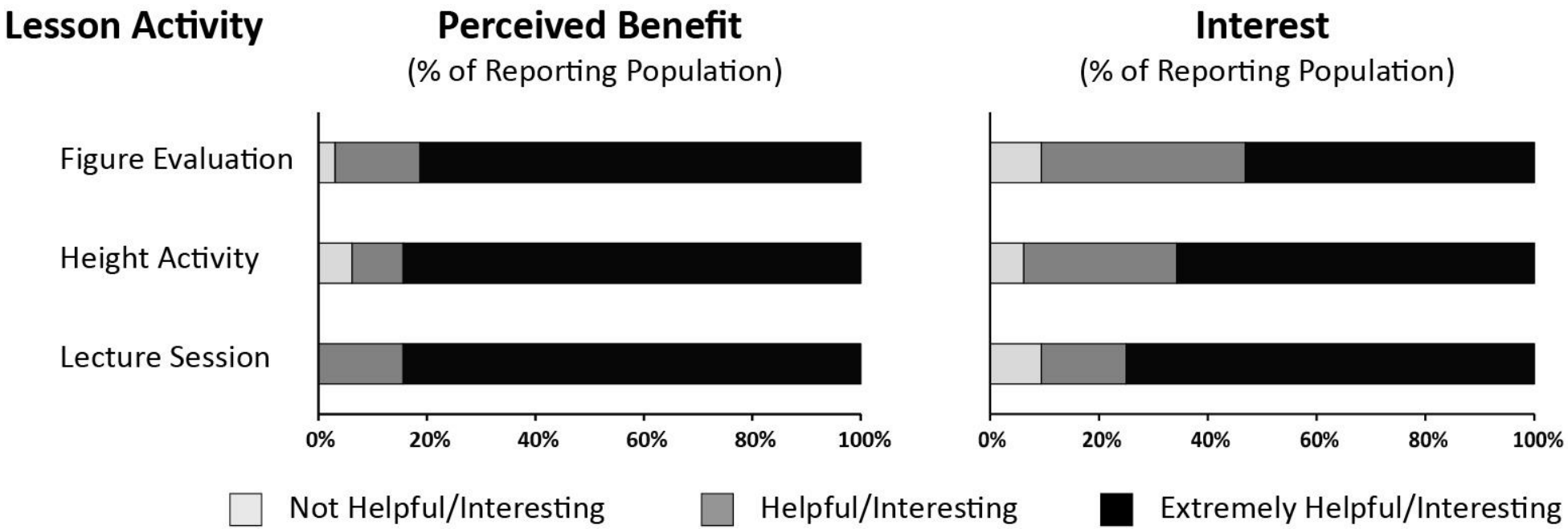
Statistics Module – Cognitive Outcomes



Statistics Module – Affective Outcomes



Statistics Module – Affective Outcomes



Conclusions and Future Directions

- Student engagement in CUREs directly impacts their attitudes and motivation in the discipline (Olimpo *et al.*, 2016)
- These outcomes are also observed among individuals who are historically underrepresented in the STEM fields
- Curricular exercises that target critical skills required for effective engagement in authentic research promote student learning and affect (Olimpo *et al.*, 2018; Marsan *et al.*, 2016)
- Contextual features impacting student/faculty outcomes in CUREs + national scalability of the *Tigriopus* CURE

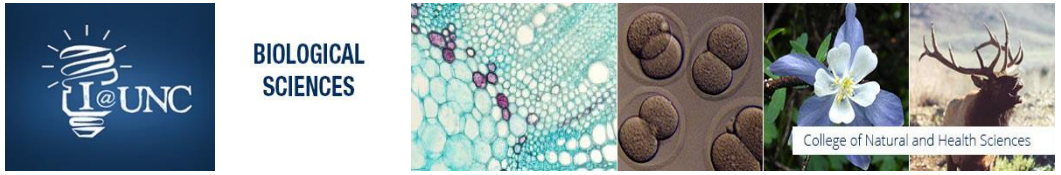
Acknowledgments

Dr. Ginger Fisher

Dr. Lauryn Benedict

Dr. Scott Franklin

Dr. Sue Ellen DeChenne



Acknowledgments

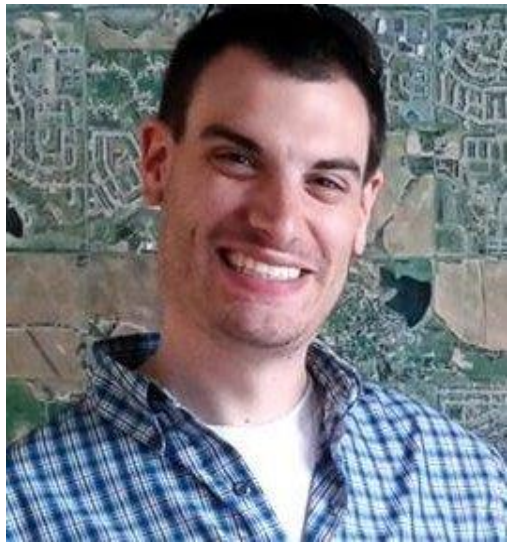
Univ. of Northern Colorado

- Susan Keenan, Ph.D.
- Lacy Cleveland, Ph.D.
- Thomas McCabe, Ph.D.
- Mr. Ryan Pevey
- Ms. Cindy Budde
- GTAs and Student Participants

Univ. of Texas at El Paso

- Lourdes Echegoyen, Ph.D.
- Steven Aley, Ph.D.
- Student Participants

Contact Information



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