# Quantitative frameworks for assessing equity gaps in undergraduate classrooms: comparing learning across traditional/reformed instructional contexts

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Detecting and Addressing BIAS in Data, Humans, and Institutions

Introduction

- **Educational inequity**: the persistent pattern of between-group differences in educational outcomes (NRC 2019)
- **Educational debt**: between-group, education-related disparities produced by decades of historical, economic, sociopolitical and moral decisions and policies
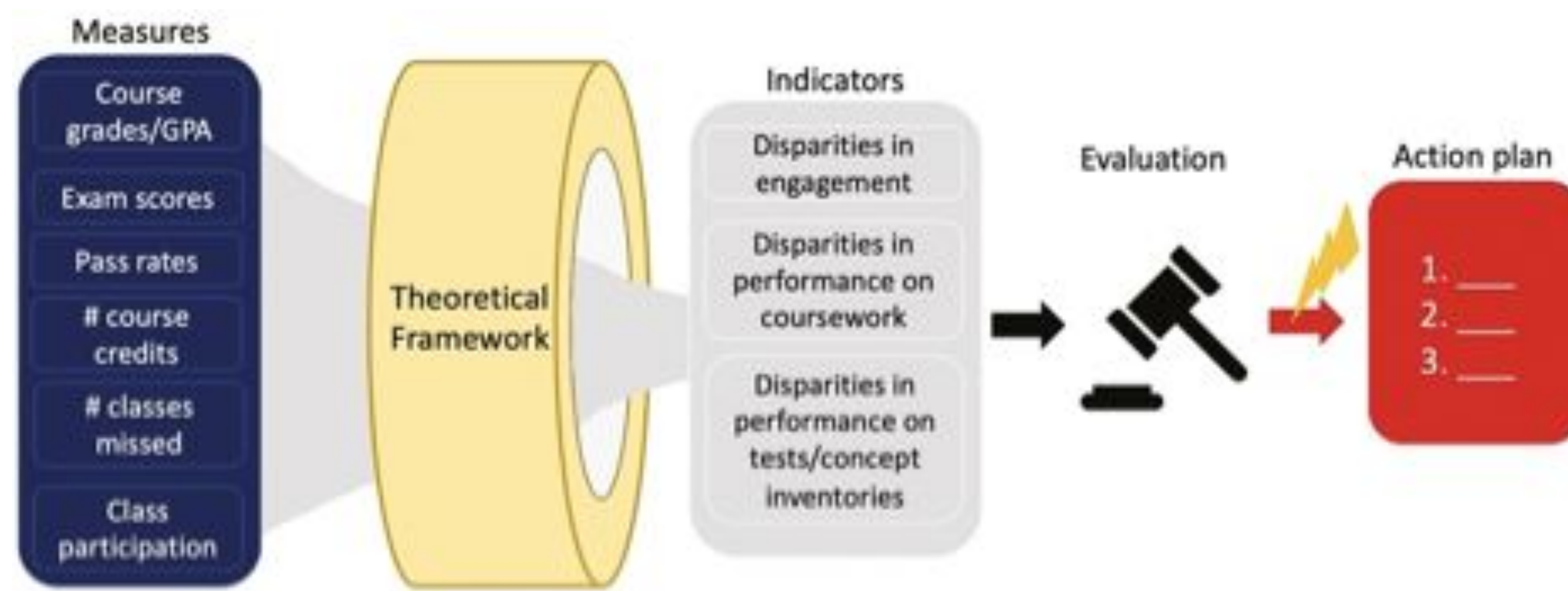
- **Study Objectives.** Use quantitative assessment approaches to apply the *modified educational debt framework* of Sbeglia & Nehm (2024) (itself based on VanDusen et al. (2022) and Ladson-Billings (2006)) to empirically investigate:
  - (a) whether the *same* course taught by instructors using *different* approaches ("traditional" vs. "reform") at the *same* institution differentially impacts students' educational debt patterns.
  - (b) how these educational debt findings compare to the *same* reformed course taught at a *different institution*.
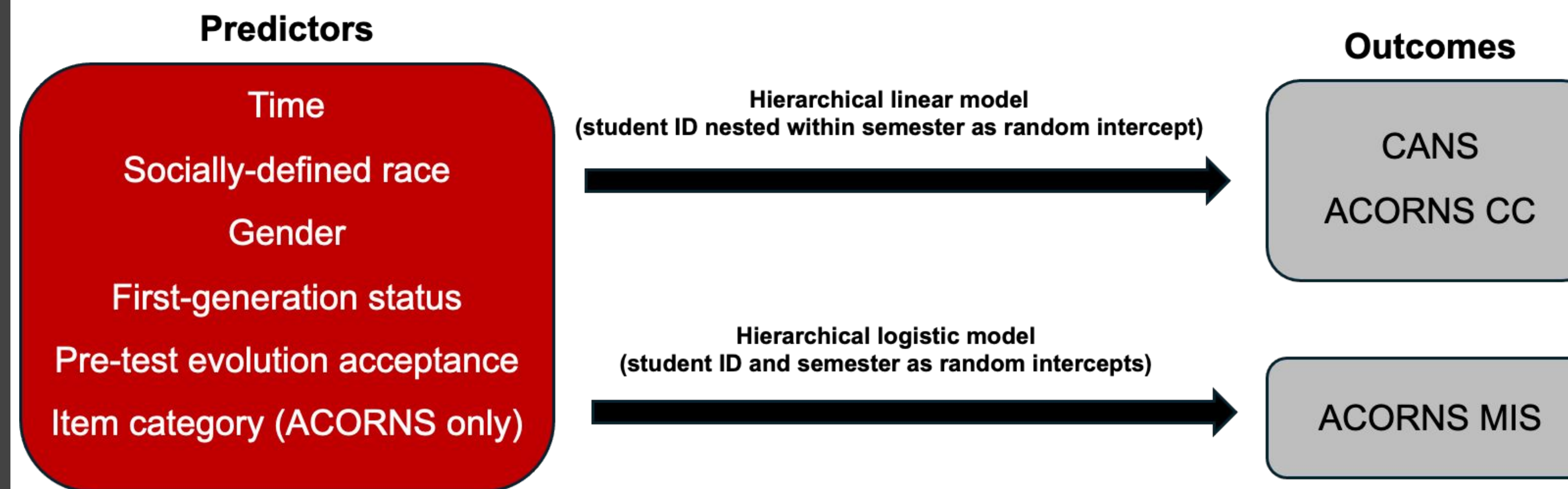
Sample & Instruments

	Current Study Institution	Previous Study Institution
N students	859	~3000
N semesters	6	11
Race	35% underrepresented minoritized identity	18% underrepresented minoritized identity
Gender	74% female	57% female
First-Generation Status	29% first-generation	Not recorded
Prior Biology Preparation	10% with only prior A.P. biology or non-major 100-level biology coursework	33% with no prior college biology
Instructional Context	4 semesters traditional (n = 431 students) 2 semesters reformed (n = 428 students)	11 semesters reformed

Instruments

Item	Description
CANS	24-item multiple choice instrument used to measure evolution knowledge
ACORNS	constructed response instrument that measures three aspects of evolution understanding: •knowledge (i.e., normative ideas) •misconceptions •coherence of knowledge (i.e., consistency across evolution problem types)
I-SEA	24 Likert-scale items that address the topic of acceptance at two evolutionary scales (micro & macroevolution) and among taxa (human & non-human evolution)

Mean outcome scores for each institution at pre-test and post-test
(Institution 1 = Sbeglia & Nehm (2024), Institution 2 = current study)

Measure	Institution 1 Pre	Institution 1 Post	Institution 2 (Traditional) Pre	Institution 2 (Traditional) Post	Institution 2 (Reformed) Pre	Institution 2 (Reformed) Post
CANS	11.24	16.56	10.26	11.25	9.32	13.61
ACORNS CC	0.78	1.94	0.72	0.73	0.64	1.86
ACORNS MIS	0.35	0.11	0.35	0.29	0.36	0.10

Analytical Approach & Results

Predictors

- Time
- Socially-defined race
- Gender
- First-generation status
- Pre-test evolution acceptance
- Item category (ACORNS only)

Hierarchical linear model (student ID nested within semester as random intercept) → **Outcomes**: CANS, ACORNS CC

Hierarchical logistic model (student ID and semester as random intercepts) → ACORNS MIS

Findings

**There was some degree of incoming educational debt for different groups**

Female+gender non-conforming and some URM students had significantly lower evolution understanding at course entry than students from advantaged backgrounds.

There was not a statistically significant difference in evolutionary biology misconceptions (ACORNS MIS) between HEC students and advantaged students.

Reformed semester learning patterns were comparable to Institution 1, & debt pattern maintenance for all Institution 2 semesters was comparable to Institution 1

Previously-studied institution showed more incoming educational debt for HEC student groups than the currently-studied institution.

Reformed semesters of the current institution displayed similarly high magnitudes of overall learning to the previously-studied institution, whereas the **traditional** semesters of the current institution displayed smaller magnitudes of overall learning.
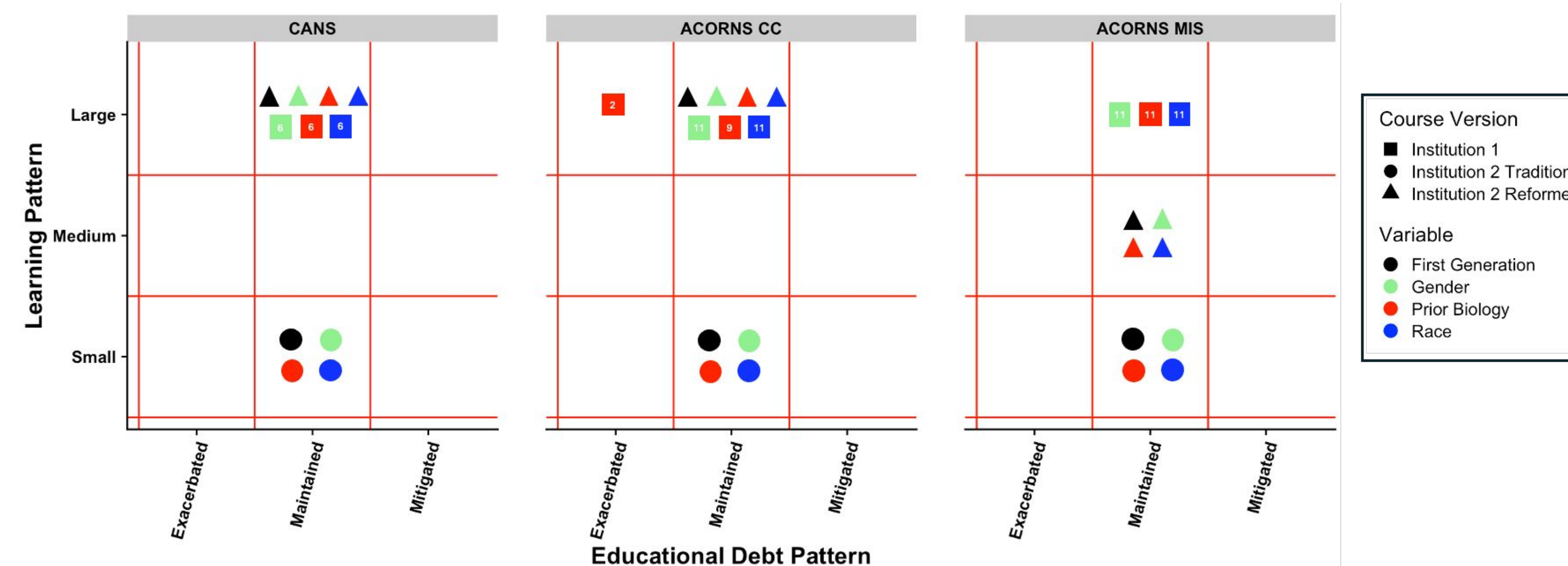
Visualization of the study results in the context of the two-dimensional enhanced educational debt framework. Results are shown for Institution 1 (Sbeglia & Nehm 2024) and the traditional and reformed courses of Institution 2.

Conclusion

- This study showcases the applicability of the enhanced educational debt framework proposed by Sbeglia & Nehm (2024) in using assessment data to **draw quantitative conclusions about equity patterns across course and institution types**.
- Uses a **data-driven** approach on a novel institutional dataset to highlight the framework's potential to generate insights into how instructional reforms impact student learning and patterns of debt mitigation.
- The findings enable educators to critically evaluate whether their students are learning **effectively** and **equitably**.
- The study also highlights that innovative assessment frameworks require assessments capable of robust measurement.

BIAS-NRT Training

This project began in Fall 2023 thanks to Stony Brook's BIAS-NRT interdisciplinary traineeship with students across math and psychology disciplines. The traineeship encourages students in various disciplines to share ideas and interests to create convergent research projects, such as this one. All trainees attend weekly seminars as well as separate affinity groups based on their expertise and collaborations.

Glossary

- **CANS**: Conceptual Assessment of Natural Selection
- **ACORNS**: Assessing Contextual Reasoning about Natural Selection
- **I-SEA**: Inventory of Student Evolution Acceptance
- **URM**: underrepresented minority
- "**Traditional**" **semester**: primarily lecture-based with little active-learning activity
- "**Reformed**" **semester**: substantial portion of course time is active-learning activity as measured by the classroom observation protocol for undergraduate STEM (COPUS) instrument

References: