NATIONAL ACADEMIES Sciences Engineering Medicine

Equitable and Effective Teaching in Undergraduate STEM Education: A Framework for Institutions, Educators and Disciplines

Meeting #3

Open Session

July 26, 2023

JULY 2023 UPDATE

Presentations on Observation Protocols and Other Tools for Evaluation of Teaching

- **The EQUIP Observation Tool**
  Dan Reinholz, San Diego State University
- **Classroom Observation Protocol for Undergraduate STEM (COPUS)**
  Michelle Smith, Cornell University
- **Teaching Direct Observation (TDOP)**
  Matthew Hora, University of Wisconsin-Madison

Commentators:

- Ruthmae Sears, University of South Florida
- Jayme Dyer, Durham Technical Community College
- Cassandra Horii, Stanford University

Equitable and Effective Teaching in Undergraduate STEM Education

The EQUIP Observation Tool

Daniel Reinholz, PhD

Associate Professor

Department of Mathematics & Statistics

San Diego State University

San Diego State University

Background

- Extensive research describes equitable and effective STEM learning environments [1-4]
- Theory to practice is the **primary** barrier. [5-6]
- Observation tools can help promote change.
- Use multiple measures and multiple approaches.

Observation Tools

- Designed for a specific purpose.
- Need tools designed to capture equity.
- Generate actionable data that impact practice.
- Use multiple measures.

Social Marker Data

To create equitable classrooms, instructors need data about *who* is participating and *how*, according to student **social markers** (e.g., race, gender, disability, SES).

EQUIP BETA

EMPOWERED TEACHERS, EQUITABLE CLASSROOMS

NIRAL S

EQUIP

EQUIP is a customizable observation tool for tracking patterns in student participation. The goal is simple: to empower teachers in building more equitable classrooms. EQUIP can be used in real-time or with videos of classroom teaching. After completing an observation, EQUIP generates instant analytics that teachers can use to improve their practice.

NSF

NATIONAL ACADEMY of EDUCATION

spencer

CREATE for STEM Institute

Social Marker Analytics*

Discourse Dimensions

- Instructor Question
- Student Talk Type
- Student Talk Length
- Instructor Response

…

Social Markers

- Race
- Gender
- Disability
- Language

…

**Customized to local context and instructor equity goals*

Equity Learning Communities

Overview of Approach

- Social marker data*
- Community learning
- Longitudinal engagement
- Incremental change

Outcomes

- More equitable participation
- Culturally responsive curriculum
- Productive beliefs about students
- Equitable mentoring practices

**EQUIP data are the starting point, but not the ending point.*

Empirically-Validated Approach.

Users: 2500+ and growing

Network: 60+ in the community

Publications: 18 journal articles (my team alone)

Book Projects

- Teaching to Disrupt Hierarchy (*MAA Press*)
- Equity Learning Communities (*Harvard Ed Press?*)

Why EQUIP?

We can talk about equity all day, but…it's a different level to be able to really re-evaluate your practice and step down from that pedestal that we as faculty members like to sit on.

Equitable teaching is more than *what* you do, it's *how* you do it, and *who* you do it for.

Questions & Thank You!

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https://www.equip.ninja/

Acknowledgments
National Science Foundation
Spencer Foundation + National Academy of Education
SDSU Student Affairs and Campus Diversity
MSU CREATE for STEM Institute

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Insights from the Classroom Observation Protocol for Undergraduate STEM (COPUS)

Michelle Smith
Senior Associate Dean for Undergraduate Education College of Arts & Sciences
Ann S. Bowers Professor of Ecology and Evolutionary Biology
Cornell University

Lab members presenting at the Society for the Advancement of Biology Education Research meeting last weekend

Large enrollment STEM course

Are STEM college instructors using lecture or active-learning techniques?

e.g., Freeman *et al*., 2014; Wieman, 2014; Eddy and Hogan, 2017; Ballen *et al*., 2017

STEM Course Observations

Middle and high school teachers observe STEM courses

Asked instructors teaching STEM courses if they would:

- allow middle and high school teachers to observe their courses
- agree to the terms outlined in an informed consent form
- over 75% of the instructors agreed

Teachers conducting classroom observations

58 middle and high school teachers observed:

- 424 STEM class sessions (2 observations per semester)
- 23 different STEM departments

Classroom Observation Protocol for Undergraduate STEM (COPUS)

Adapted from the Teaching Dimensions Observation Protocol (TDOP; Hora *et al.,* 2011)

Classroom Observation Protocol for Undergraduate STEM (COPUS)

1. Students are Doing

- **L** Listening to Instructor/taking notes, etc.
- **Ind** Individual thinking/problem solving. Only mark when an Instructor explicitly asks Students to think about a clicker question or another question/problem on their own.
- **CG** Discuss clicker question in groups of 2 or more students
- **WG** Working in groups on worksheet activity
- **OG** Other assigned group activity, such as responding to Instructor question
- **AnQ** Student answering a question posed by the Instructor with rest of class listening
- **SQ** Student asks question
- **WC** Engaged in whole class discussion by offering explanations, opinion, judgment, etc. to whole class, often facilitated by Instructor
- **Prd** Making a prediction about the outcome of a demo or experiment
- **SP** Presentation by student(s)
- **TQ** Test or quiz
- **W** Waiting
- **O** Other – explain in comments

2. Instructor is Doing

- **Lec** Lecturing (presenting content, deriving mathematical results, presenting a problem solution, etc.)
- **RtW** Real-time writing on board, doc. projector, etc. (often checked off along with Lec)
- **FUp** Follow-up/feedback on clicker question or activity to entire class
- **PQ** Posing non-clicker question to students (non-rhetorical)
- **CQ** Asking a clicker question (mark the entire time the Instructor is using a clicker question, not just when first asked)
- **AnQ** Listening to and answering student questions with entire class listening
- **MG** Moving through class guiding ongoing student work during active learning task
- **1o1** One-on-one extended discussion with one or a few individuals, not paying attention to the rest of the class (can be along with MG or AnQ)
- **D/V** Showing or conducting a demo, experiment, simulation, video, or animation
- **Adm** Administration (assign homework, return tests, etc.)
- **W** Waiting
- **O** Other – explain in comments

Smith *et al.,* 2013

Adapted from Teaching Dimensions Observation Protocol (TDOP; Hora *et al.,* 2011)

COPUS Form

	1. Students doing													2. Instructor doing										
min	L	Ind	CG	WG	OG	AnQ	SQ	WC	Prd	SP	T/Q	W	O	Lec	RtW	Fup	PQ	CQ	AnQ	MG	1o1	D/V	Adm	W	O
0-2			X															X		X					
2-4																									
4-6																									

Students doing: **L**-Listening; **Ind**-Individual work; **CG**-Clicker Q discussion; **WG**-Worksheet group work; **OG**-Other group work; **AnQ**-Answer Q; **SQ**-Student Q; **WC**-Whole class discuss; **Prd**-Predicting the outcome of a demo or experiment; **SP**-Student present; **TQ**-Test/quiz; **W**-Waiting; **O**-Other

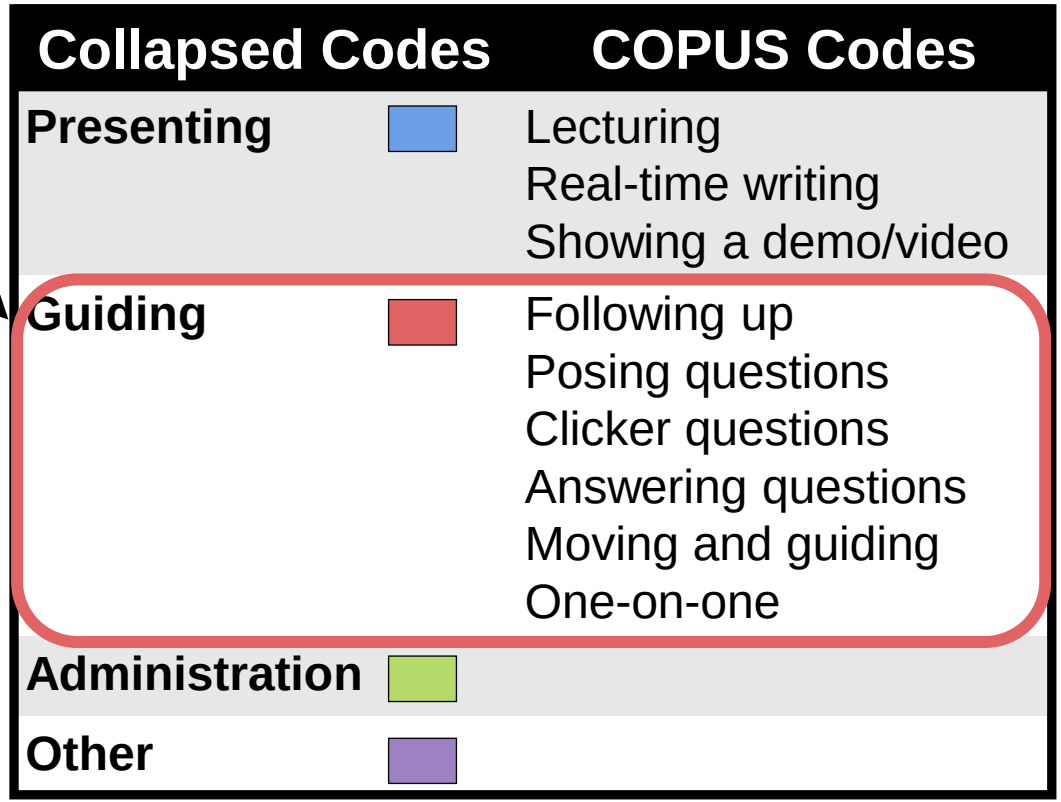
Instructor doing: **Lec**-Lecturing; **RtW**-Real time writing; **FUp**-Follow-up; **PQ**-Pose Q; **CQ**-Clicker Q **AnQ**-Answer Q; **MG**-Moving through the classroom; **1o1**-One-on-one discussion with student; **D/V**-Conducting a demo or experiment; **Adm**-Administration; **W**-Waiting; **O**-Other

Smith *et al.,* 2013

Adapted from Teaching Dimensions Observation Protocol (TDOP; Hora *et al.,* 2011)

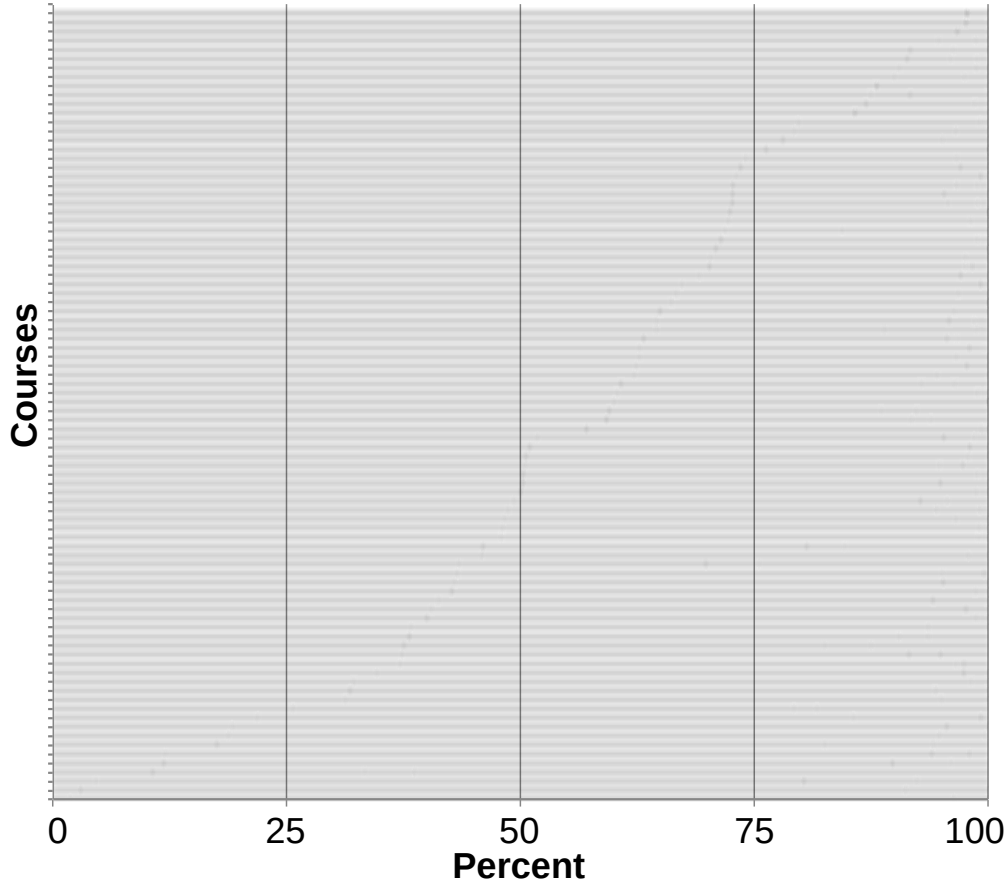
Instructor Collapsed Codes

Active-Learning Techniques



Collapsed Codes	COPUS Codes
Presenting	Lecturing Real-time writing Showing a demo/video
Guiding	Following up Posing questions Clicker questions Answering questions Moving and guiding One-on-one
Administration	
Other	

Instructors Use a Range of Instructional Practices



Collapsed Codes	COPUS Codes
Presenting	Lecturing Real-time writing Showing a demo/video
Guiding	Following up Posing questions Clicker questions Answering questions Moving and guiding One-on-one
Administration	
Other	

Smith *et al.*, 2014

NSF WIDER Grant

How do the Observation Data Impact Instructors?

Professional development workshops are aligned with instructor needs

Campus-wide professional development session

Year-long Faculty Learning Communities (Cox, 2004; Cox, 2016)

-Groups of STEM instructors observe each other and provide feedback

-Added data (e.g., Instructor Talk observation protocol, student survey data)

Instructors discuss their COPUS data with a staff member

-68% of observed instructors discussed their results

-Results used in tenure and promotion applications

NSF WIDER Grant

COPUS Does *Not* Measure Everything

Additional observation protocols were developed

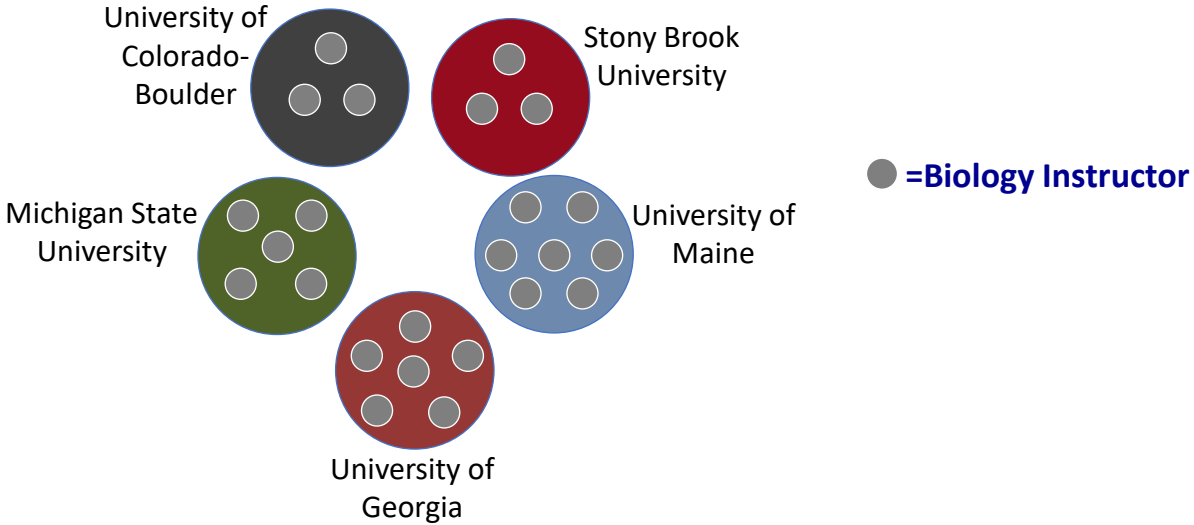
- Laboratory Observation Protocol for Undergraduate STEM (LOPUS; Velasco *et al*., 2016)
- Online COPUS (O-COPUS; Pusey *et al*., 2023)

Students in a lab course

Teaching an online evolution course (at the same time as middle school band)

Observation Data Often Need to be Paired with Additional Data

1. Collected biology assessment data in large enrollment courses at five institutions
2. Instructors collaborated on developing an Open Educational Resource (OER) using Backwards Design
3. Measured student learning
4. Used COPUS data to determine if collaborative lesson development influences teaching practices



Stop Codon Questions

The following DNA sequence occurs near the middle of the coding region of a gene.

DNA 5' A A T G A A T G G* G A G C C T G A A G G A 3'

There is a G to A base change at the position marked with an asterisk. Consequently, a codon normally encoding an amino acid becomes a stop codon.

1. How will this alteration influence DNA replication?

"Since during DNA replication only one nucleotide is read at a time, the mutation will have no effect on DNA replication."

"This will cause the DNA replication to stop"

Correct
Incorrect

2. How will this alteration influence transcription?

"This won't influence transcription because RNA polymerase doesn't read codons."

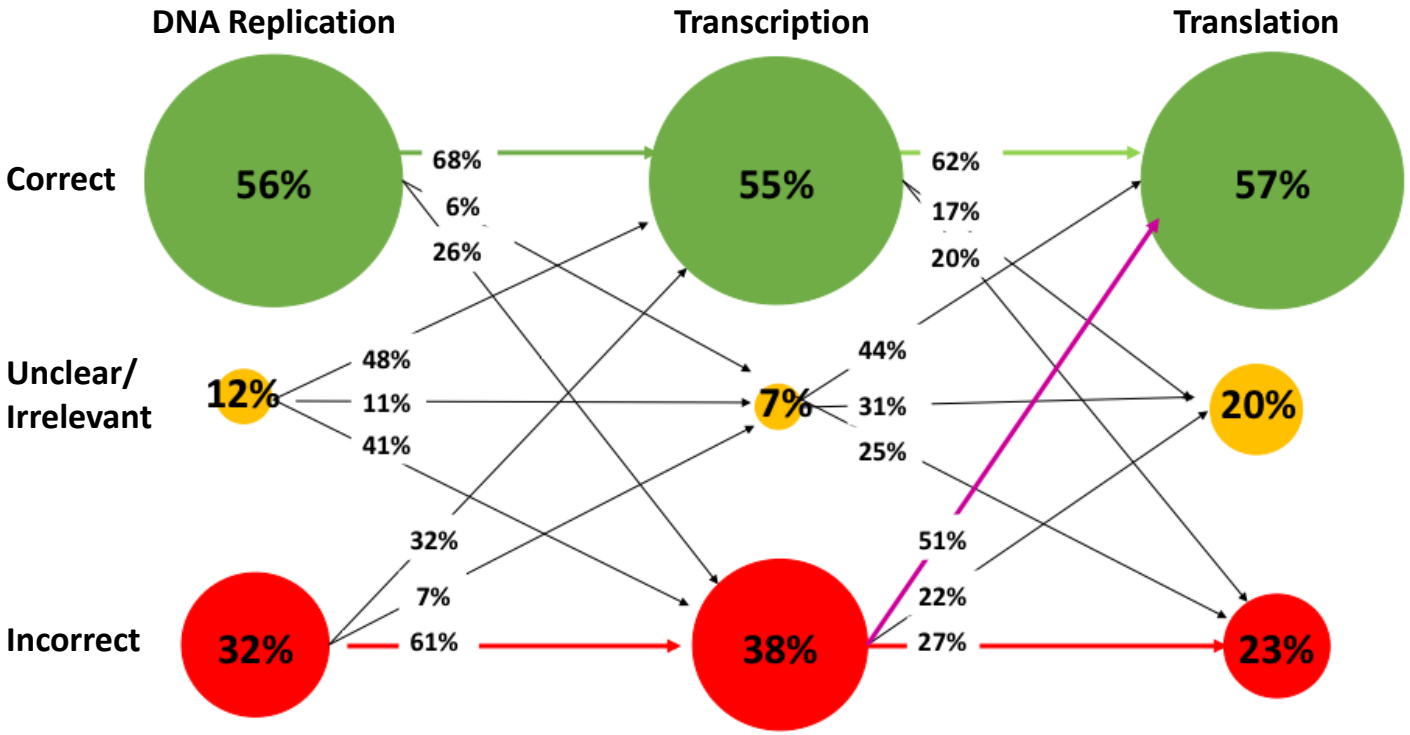
"The newly added stop codon will inhibit the rest of the chain from being transcribed into RNA."

3. How will this alteration influence translation?

"Translation will be halted prematurely as the ribosome reads the stop codon."

"Translation is unaffected by this alteration."

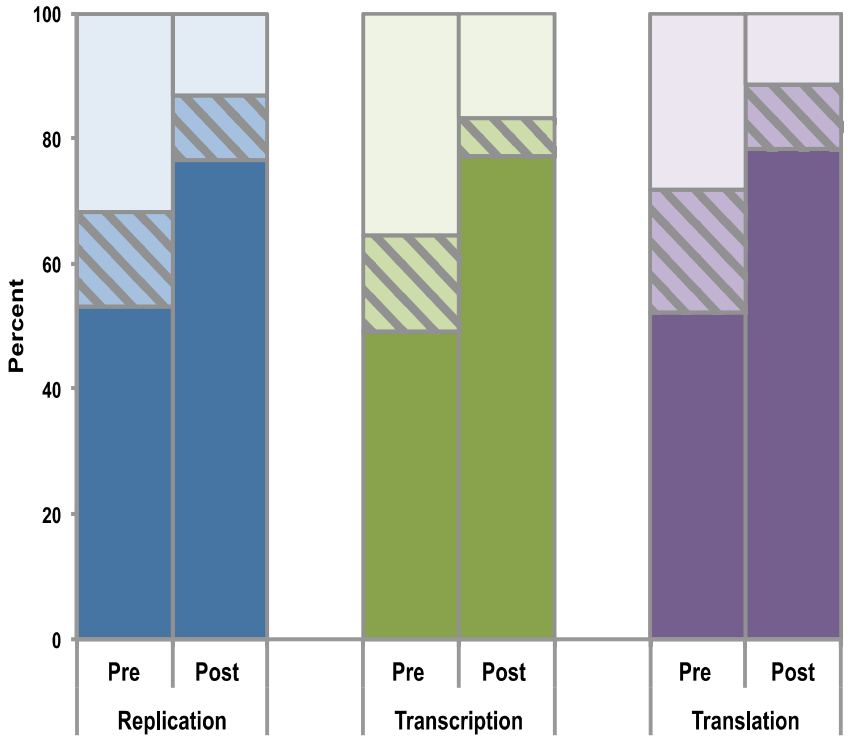
Students Have Mixed Models



Prevost *et al.*, 2016

n=1043 students

Students Show Improvement as Instructors Revise the Lesson



Light color=incorrect
Hashed= irrelevant/unclear
Dark color= correct

n=1184 students

Pre=day before lesson
Post=~one week after the lesson

Pelletreau *et al.* 2016

NSF TUES III and WIDER Grants

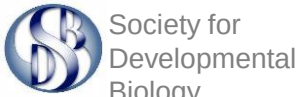
Instructors Collaboratively Published the Active-Learning Lesson

Home » Courses » A clicker-based case study that untangles student thinking about the processes in the central dogma

A clicker-based case study that untangles student thinking about the processes in the central dogma

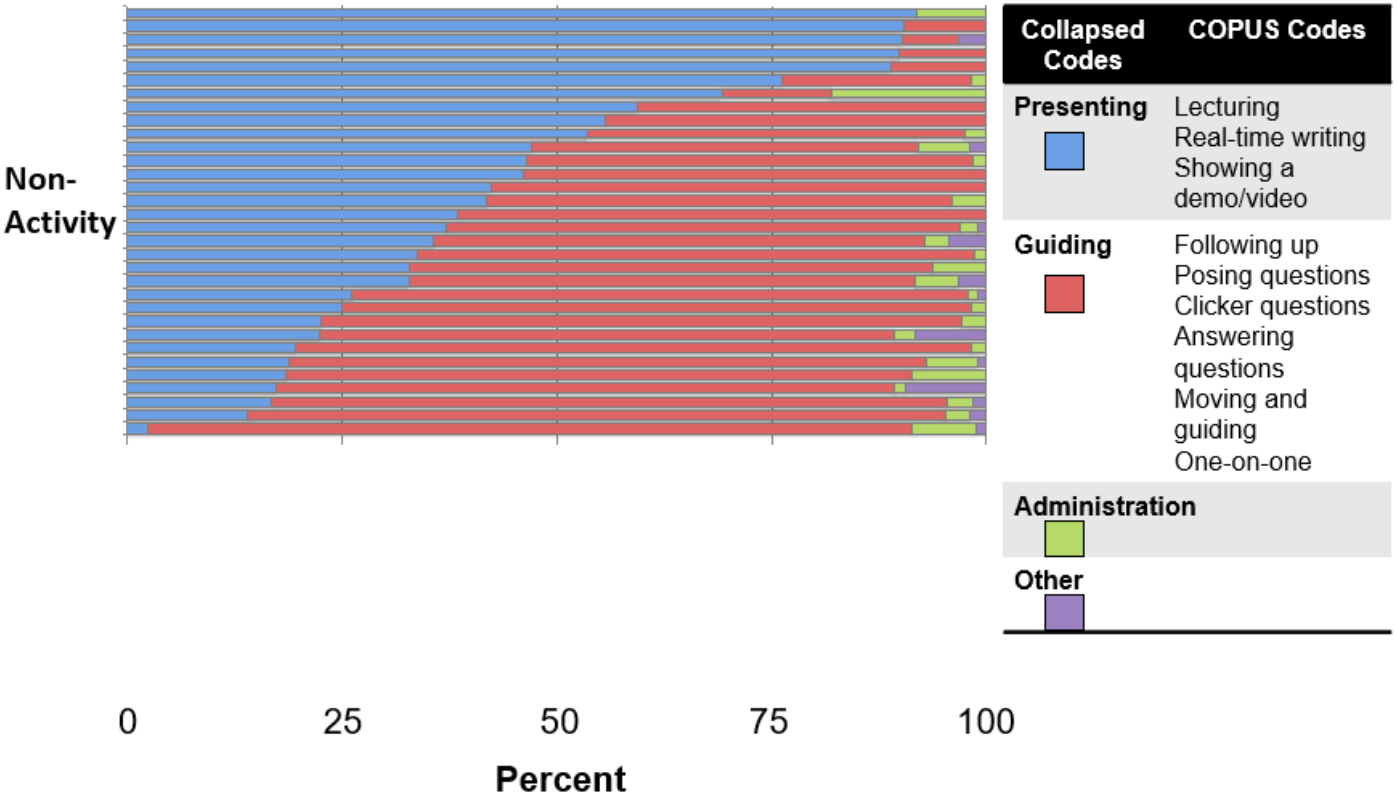
Karen Nicole Pelletreau, University of Maine | Tessa Andrews, University of Georgia | Norris Armstrong, University of Georgia | Mary A Bedell, University of Georgia | Farahad Dastoor, University of Maine | Neta Dean, Stony Brook University | Susan Erster, Stony Brook University | Cori Fata-Hartley, Michigan State University | Nancy Guild, University of Colorado Boulder | Hamish Greig, University of Maine | David Hall, University of Georgia | Jennifer K Knight, University of Colorado Boulder | Donna Koslowsky, Michigan State University | Paula Lemons, University of Georgia | Jennifer Martin, University of Colorado Boulder | Jill McCourt, University of Georgia | John Merrill, Michigan State University | Rosa Moscarella, Michigan State University | Ross Nehm, Stony Brook University | Robert Northington, University of Maine | Brian Olsen, University of Maine | Luanna Prevost, University of South Florida | Jon Stolzfus, Michigan State University | Mark Urban-Lurain, Michigan State University | Michelle K. Smith, University of Maine

Introductory Biology | Genetics



NSF TUES III and WIDER Grants

Collaboratively Designed Activities Can Impact Instructor Teaching Practices



Pelletreau *et al.* 2018

NSF TUES III and WIDER Grants

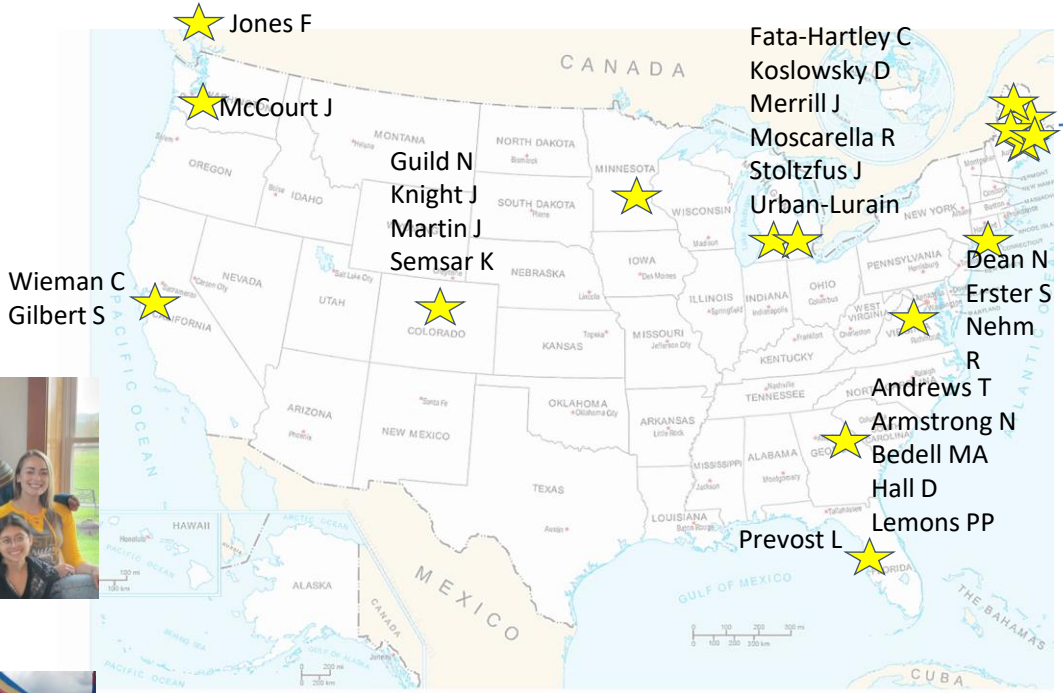
Observation Protocol Development: Take Away Lessons

- Consider innovative ways to collect observation data

- Important to think about how to share data with instructors and design multiple opportunities for support

- Only possible to measure a subset of variables
  - Additional instruments may be needed
  - Consider combining different data sets to answer questions

Acknowledgements



Smith Lab

Spring 2023

Summer 2023

Baker E
Barboza T
Bates T
Benoit M
Borges K
Boyle S
Brackett V
Connors E
Dastoor F
Driscoll L
Freudenverger W
Ford A
Greig H
Haas M
Hanley L
Hayes K
Haynes E
Jergenson T
Johnson C
Johnson D
Johnston J
Jones EH
Kumpa W
Lewis M
LaComb-Burby L
Mannette J
Martin N
Matthews L
Nelson P
Nickerson R
Northington R
Novak N
Olsen BJ
Page J
Pelletier P
Pelletreau K
Prentiss N
Priest K
Roe JL
Shelton M
Smith G
Smyth-Handley E
Sorenson D
Staples J
Stetzer MR
Stevens J
Stevick N
White T
Witick M
Vinson E

Commentary

- Ruthmae Sears, University of South Florida
- Jayme Dyer, Durham Technical Community College
- Cassandra Horii, Stanford University

Overview of Literature on Equitable Teaching

Equity Based Teaching Collective

- Corbin Campbell, American University
- Brian McGowan, American University
- Milagros Castillo-Montoya, University of Connecticut
- Bryan Dewsbury, Florida International University

Equity-Based Teaching Collective

Presentation to the committee on *Equitable and Effective Teaching in Undergraduate STEM Education: A Framework for Institutions, Educators, and Disciplines*
Board on Science Education at the National Academies

July 26, 2023

Presentation Agenda

- Revisiting Our Purpose
- Revisiting Our EBT Framework
- Emergent Thoughts
- Landscape Analysis
- Research Synthesis: Emergent Insights
- Critical Questions to Consider
- Q&A

Purpose: Develop Policy Playbook for EBT

- To provide an organizational framework for understanding the complex roles of different stakeholders and levers in the improvement of college teaching to address systemic barriers that prevent equitable student outcomes.

- To articulate how different stakeholders (i.e., faculty, academic leaders, state agencies, disciplinary and higher education associations, and funders) can interact to produce improvements in equity-based teaching and equitable outcomes for Black, Latinx, and Indigenous students and students from low-income backgrounds.

- To highlight the resource structure and funding necessary to turn policy recommendations into practice in key gateway courses.

EBTC Emergent Thoughts on Where Equity-Based Teaching Needs to Go…

Institutional Transformation is Necessary

- Disrupt centrality of Eurocentric epistemologies, policies, and practices
- Revise policies and practices to meaningfully integrates non-dominant epistemologies about teaching and learning

Meaningful Engagement of Communities is Essential

- Students' communities are key to their learning
- Reciprocal relationships with student communities are essential in and outside of the classroom.

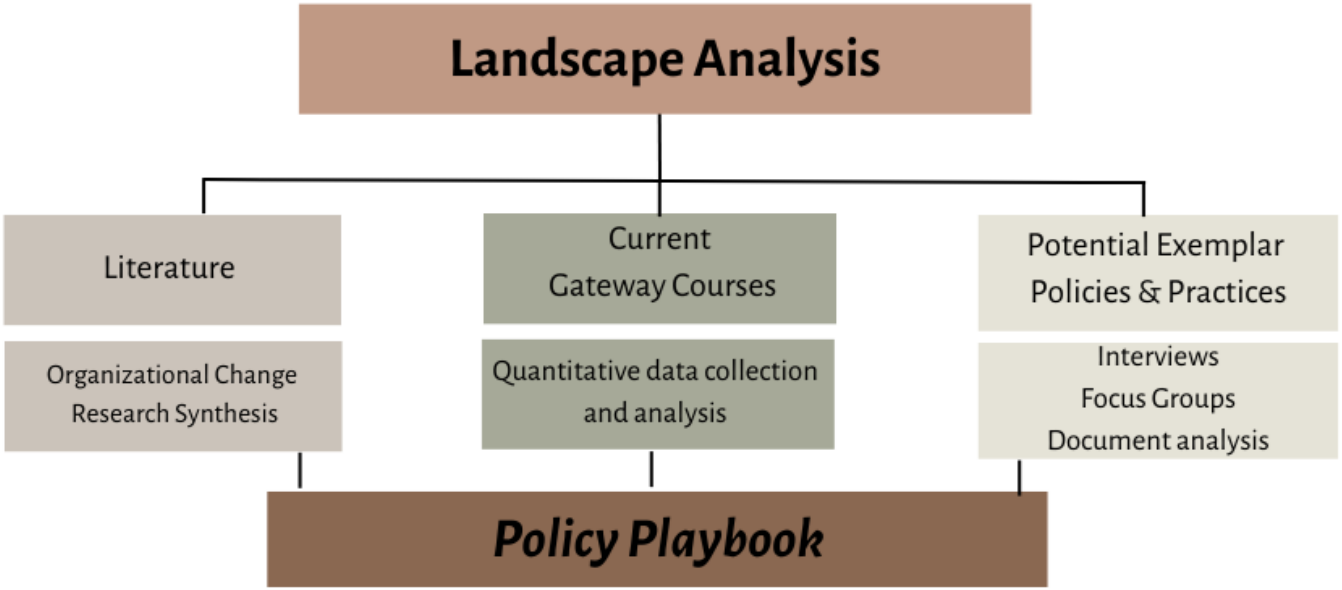
Contexts Matter

- Geopolitical and institutional contexts inevitably shape teaching conceptions and practices
- EBT calls for educators to be intentional about the context of when, where, and who they are teaching

Expand Purpose of Education to Include Liberation/Sovereignty

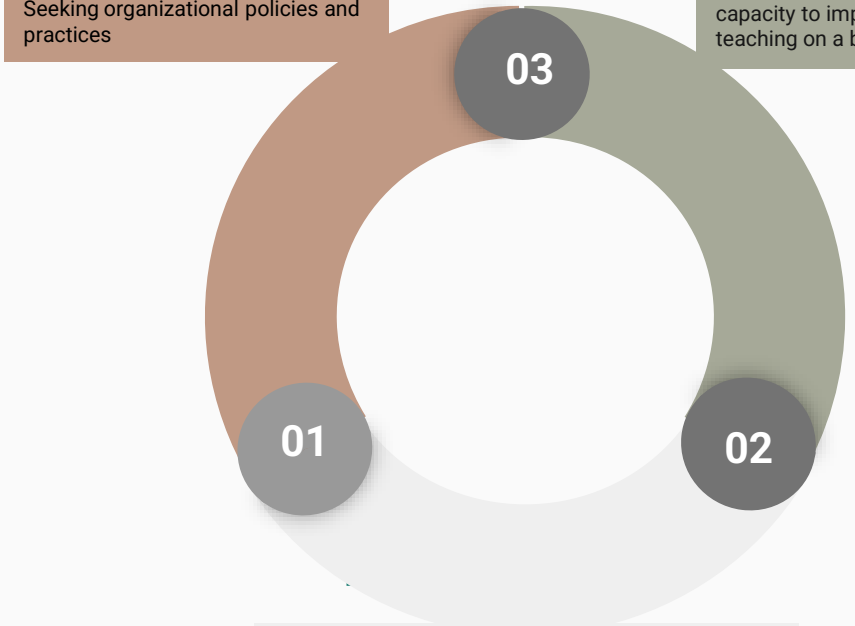
- Traditional student outcomes (e.g., critical thinking) are important, but not enough
- Key outcome for BLI students is self-actualization and revitalizing/sustaining their communities.

Equity-Based Teaching Collective
Phase 1A Methodology: Landscape Analysis



Research Synthesis

Examining scholarly literature for frameworks, organizational practices, policies, and uses of educational technology for broad-scale improvement of equity-based teaching.



Literature Search & Abstract Screening

Systematic database search
Peer-reviewed
2012-2022
Seeking organizational policies and practices

Full-text Screening & Data Extraction

Inclusion/ exclusion screening. Extraction of study characteristics, design. Qualitative descriptions of frameworks, policies, practices, and technologies

Analyze

Evaluate and offer recommendations about which frameworks, organizational practices, organizational policies, and uses of technology might have the capacity to improve equity-based teaching on a broad scale.

Emergent Findings from Organizational Literature Synthesis

About 60% of the interventions we have identified from the literature are focused on changing and developing individual faculty.

Other types of organizational change (structures, policies, external systems) were present but much less prevalent in the literature.

Interventions are mostly practice-driven, not policy-driven, thus not necessarily linked to formal, written institutional commitments.

Critical Questions to Consider

When thinking about equity, how far are you willing to go to ***transform*** STEM education?

What does working toward ***decolonizing*** STEM education need to look like to advance equity?

What does **"freedom dreaming"** look like for STEM education? *What constraints need to be removed?*

What **investments** do stakeholders need to make to support work toward decolonizing and transforming STEM education?

Equity in Undergraduate STEM Education

- Ebony McGee, Johns Hopkins University

Designing Accessible Learning Experiences

- Luis Perez, CAST
- Carol Hurney, Colby College
- Flower Darby, University of Missouri
- Suzanne Wakim, Butte College