Innovations in STEM Teaching and Teacher Training and Development

Moderated by:
Dr. Frank A. Gomez
Executive Director, STEM-NET
Office of the Chancellor

https://www2.calstate.edu/impact-of-the-csu/research/stem-net
Innovations in STEM Teaching and Teacher Training and Development

Speakers

Michele Korb, CSU East Bay
Aligning the Science Teacher Education Pathway: A Networked Improvement Community

Hao Yue, San Francisco State
CS4SF: A Scalable Model for Preparing High School Teachers to Provide Rigorous, Inclusive Computer Science Instruction

Kathryn Hayes, CSU East Bay
Equitable Elementary Science Education: Tools for Teacher and District Capacity Building

Ben Ford, Sonoma State
Making Math: Building Authentic Math from Maker Experiences in Upper Elementary Grades
Aligning the Science Teacher Education Pathway: A Networked Improvement Community

Dr. Michele Korb, Professor, Cal State East Bay
Dr. Michelle Sinapuelles, Project Director, Cal State East Bay

This work is supported by grants from the National Science Foundation, A-STEP Project DRL-1908900 ASET Project DRL-1418440. PI: michele.korb@csueastbay.edu

Dr. Michele Korb, Professor
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Project Overview
Step 1: Science Teaching Methods Courses

Step 2: Fieldwork Experiences

Step 3: Induction

Step 4: District Professional Development
The A-STEP Project Focuses on Alignment Across 4 Key Steps of the Science Teacher Education Pathway

**STEP 1: UNIVERSITY SCIENCE TEACHING METHODS COURSES**

The ASET Toolkit is used to foster discussions in the science methods courses of how to design and enact NGSS aligned lessons.

**STEP 2: CREDENTIAL CANDIDATE FIELDWORK EXPERIENCES**

Collaborate with university supervisors and cooperating teachers to implement use of the ASET Toolkit to better align classroom instruction with the goals of NGSS and to facilitate post observation discussions around this alignment.

**STEP 3: INDUCTION PROGRAMS**

Collaborate with district level induction programs and training within the first 3 years of entry into the profession to include use of the ASET Toolkit to bridge the lessons from these credential programs into these district level trainings.

**STEP 4: DISTRICT PROFESSIONAL DEVELOPMENT**

Collaborate with local school districts to implement use of the ASET Toolkit as part of the existing professional development (PD) efforts for inservice science teachers.
Project Activities & Goals
A-STEP Goals

1. Understand how a Networked Improvement Community (NIC) serves as an organizational mechanism of reform for NGSS-alignment across different steps of the identified science teacher education pathway.

2. Understand how the Next Gen ASET Toolkit is used to facilitate discourse to enact NGSS curriculum and instruction within and across different steps of the science teacher education pathway.

3. Strengthen the shared understanding across the NIC of how context shapes individual steps in the teacher pathway and how relationships can be formed to align these steps in a local context.
A-STEP Project Goals – a visual

Unifying Vehicle

Goal 1: NIC as a Mechanism for Reform
Understand how a Networked Improvement Community (NIC) serves as an organizational mechanism of reform for NGSS-alignment across different steps of the identified science teacher education pathway.

Mechanism

Goal 2: ASET Toolkit
Fostering a shared vision and language in pathway

NIC Members

Pathway Partners

PSTs

Goal 2: ASET Toolkit
Understanding of the NGSS

Shared knowledge we are building

Goal 3A/B: Understanding the Pathway

Goal 3A: Characterization of the pathway (Individual and pathway level experiences)

NIC Members

Pathway Partners

PSTs

In-Service Ts

Goal 3B: Alignment of the pathway (needs within and across)

Strengthen the shared understanding across the NIC of how context shapes individual steps in the teacher pathway and how relationships can be formed to align these steps in a local context.
# Monthly NIC Meetings

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<tr>
<td>August</td>
<td>Review of plans for Year 3 and IRB updates</td>
<td>Planning</td>
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<tr>
<td>September</td>
<td>Presentation by Dan Bedford: Teaching Climate Science</td>
<td>Guest Speaker</td>
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<td>October</td>
<td>Phenomenon &amp; Thinking about big picture goals from this research</td>
<td>Sharing Ideas/Planning</td>
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<tr>
<td>November</td>
<td>Presentation from Weber State: Secondary PD Model</td>
<td>Sharing Pathway Work</td>
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<tr>
<td>December</td>
<td>Spring Plans and Coherence Survey Timing</td>
<td>Planning</td>
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<td>January</td>
<td>Sharing from NIC hub of Fall SIPs Data</td>
<td>Data share from hub</td>
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<td>February</td>
<td>Guest Peter A'Hearn - President, California Association of Science Educators (CASE)</td>
<td>Guest Speaker</td>
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<td>March</td>
<td>Phenomenon Tool: Feedback on Improvements</td>
<td>Sharing Tool Development</td>
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<td>April</td>
<td>Roundtable Paper Share</td>
<td>Sharing Research Progress</td>
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<tr>
<td>May</td>
<td>Pathway partner meeting to share current work and challenges</td>
<td>Sharing Ideas/Guests</td>
</tr>
<tr>
<td>May</td>
<td>Yearly NIC gathering, 2-day in-person/virtual event</td>
<td>Sharing Ideas/Data share from hub</td>
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NIC Member Activities


**KSTA:**


NIC member activities…

• **August 2022** – Biennial Conference on Chemical Education

• **October 2022** – California Science Education Conference
  • Several members have submitted work on how to support new and existing teachers with implementing the NGSS via created curriculum samples or existing curriculum

See our website for many more activities
Preservice Activities

Continued Implementation of ASET Toolkit in Methods Courses

- **Elementary Methods Courses**: 17 Courses across 6 Universities
  (456 PSTs enrolled)
- **Secondary Methods Courses**: 6 Courses across 5 Universities
  (89 PSTs enrolled)

In total we implemented the tools with 545 Pre-Service Teacher’s enrolled in science teaching methods courses Across 8 Universities!
Extended Activities

Implemented the ASET Toolkit in some new courses:

Weber State used them in a course with 11 undergraduate science majors

The STAR program implemented them in their summer seminar as part of the research experience with 15 Pre-Service Teachers and 8 In-Service Teachers

*We sadly lost our induction partner this year, so we are retooling for our last grant year.
Pathway Activities

Continued Implementation of ASET Toolkit in other Pathway Steps

University Supervisors: ASET Tools were integrated into the university supervisor meetings at San Diego State & Sacramento State

Hosted training and professional development sessions:

- PSTs (INDUCTION PATHWAY)
  - Workshop for Trellis scholars and mentor training day (Trellis: CSUEB & SFSU)

- ISTs
  - Held week-long summer PD for secondary teachers and then continued with Fall graduate course meeting during Fall ‘21 (Weber)
  - Series of 4 NGSS workshops with local school district (Fresno)
  - Series of 4 NGSS workshops with Norwalk La Mirada School Teachers (CSULB)
  - PD as part of PIMSER program (UKY)
Some results (there are so many)
And Lessons Learned
Methods Path

Snapshot of Implementation in our Methods Courses

- ASET Tools Used by Grade Level:
  - 57% Elementary Methods
  - 43% Secondary Methods

- ASET Tools Used in Methods Course:
  - 21% 3D Mapping Tool
  - 16% SEP Tool(s)
  - 12% Both the 3D Mapping Tool and SEP Tool(s)
  - 10% Phenomenon Tool
  - 8% All Three: 3D Map, SEP Tools, and Phenomenon Tool
  - 4% Phenomenon Tool and SEP Tools
Snapshot of Implementation in Professional Development

29 Responses: CSU Long Beach, Univ of Kentucky, Trellis, Weber

PD Path
Science Instructional Practices (SIPS) Data Samples (K. Hayes, et al, 2016)

Measuring engagement in Science and Engineering Practices

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<tr>
<td>All Responses</td>
<td>299</td>
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<td>Elementary</td>
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<td>179</td>
</tr>
<tr>
<td>Secondary</td>
<td>54</td>
<td>50</td>
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Secondary Responses by Campus

One-sided t-test shows most pre/post pair <0.05
One-sided t-test shows Campus pre/post pair >0.05

- Traditional Instruction
- SEP 1 & 3 (Investigation)
- SEP 6 & 7 (Argue & Explain)
- SEP 8 (Discourse and Communication)
- SEP 3, 4, & 5 (Data Collection & Analysis)
- SEP 2 (Modeling)
Coherence Survey
Esther T. Canrinus, Ole Kristian Bergem, Kirsti Klette & Karen Hammerness (2017)

Elementary Responses, N=76
Campus C: Fieldwork, 9 Responses
Campus E: Induction, 67 Responses

I had at least one opportunity to teach a science lesson during my fieldwork experience

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<th></th>
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<th>Campus E</th>
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<tr>
<td>Yes</td>
<td>100%</td>
<td>91%</td>
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<tr>
<td>No</td>
<td>0%</td>
<td>9%</td>
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Were the science lessons you observed during your fieldwork experience aligned with the expectations of the NGSS?

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<th>Campus E</th>
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<tr>
<td>Yes</td>
<td>89%</td>
<td>66.7%</td>
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<tr>
<td>No</td>
<td>11%</td>
<td>13.6%</td>
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<tr>
<td>Didn’t observe any science lesson</td>
<td>0%</td>
<td>19.7%</td>
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Coherence Survey

Were the lessons you observed during your fieldwork experience aligned with the expectations of the current state standards in your content area (Common Core, NGSS, etc.)?

Secondary Science Responses, N(science)=40
Campus A: Fieldwork, 4 Responses
Campus B: Fieldwork, 13 Responses
Campus D: Induction, 11 Responses
Campus E: Induction, 12 Responses

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<tr>
<th></th>
<th>Campus A</th>
<th>Campus B</th>
<th>Campus D</th>
<th>Campus E</th>
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<tbody>
<tr>
<td>Yes</td>
<td>100%</td>
<td>85%</td>
<td>73%</td>
<td>73%</td>
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<td>0%</td>
<td>15%</td>
<td>27%</td>
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</table>

Secondary General Responses, N(non-science)=51
Campus A: Fieldwork, 8 Responses
Campus D: Induction, 7 Responses
Campus E: Induction, 36 Responses

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<th>Campus D</th>
<th>Campus E</th>
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<tr>
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<td>87.5%</td>
<td>86%</td>
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<tr>
<td>No</td>
<td>12.5%</td>
<td>14%</td>
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Meetings with Partners

Elementary
- Difficult to find teachers teaching science in Elementary for pre-service teachers to observe
- Elementary have hired STEM teacher and classroom teachers have “handed off” science teaching to them
- Many have switched to Mystery Science (curriculum) and has seen more teachers teaching science with it on a digital format.
- Include supervisors in the training more often
- Compensate teachers and mentors

Secondary
- Making headway in NGSS has been difficult in general.
- revert to comfort zone (lecture) - protecting their practice.
- Burnout is pervasive. More so this year than any other year.
Partner Feedback

What change they would like to see:

National patterns is to spend more time in math and ELA. **How do we engage school leadership to foster a different culture of learning and approaching science.**

Administration and principals are so important in this process. They can move the needle at their school sites. **How do we engage leadership in this process?**

**How do we discuss assessment?** This drives teaching

**Need to create Institutional continuity** - Supervisors have an “in-between role” around supporting teachers. Majority of science teachers don’t use NGSS as much as they need to - providing support for PSTs and CTs is a huge challenge.
Next steps & Long-Term Plans

- Videos for mentor and supervisor training
- Release “Phenomenon tool”
- Integrate partner feedback into next project
- Increase focus on supporting current NGSS curriculum
- “Dig into” coherence results
- Publications and presentation
- Collaborations
  - Nationally
  - State-wide (California Association of Science Educators): preservice support/ board representation for IHE
- Next NSF project!!
Thank You
Questions?

Contact us!

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Visit our website! https://www.nextgenaset.org
CS4SF: A Scalable Model for Preparing High School Teachers to Provide Rigorous, Inclusive Computer Science Instruction

Hao Yue – San Francisco State University

Collaborators: Brian Beatty, Ilmi Yoon, Jingyi Wang, and Patricia Donohue

This project is supported by the National Science Foundation under No.1837699 and 1837552.

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Project Overview

• Providing **CS education** for **K-12 students** is now a national priority

• High school teachers need better preparation and support regarding **CS content knowledge and pedagogical knowledge and practices** to provide inclusive instruction for diverse student populations

• **CS4SF** is a design-based implementation research-practitioner partnership (RPP) to create and validate a transferable, scalable model for preparing and supporting high school CS teachers

**CS4SF: A Scalable Model for Preparing High School Teachers to Provide Rigorous, Inclusive Computer Science Instruction**
Activities

- Create and offer new **CS supplementary authorization program (SA)** to increase authorized high school CS teachers in California
- Establish an **Instructional Assistant (IA) Program** to provide in-classroom support for high school CS teachers and students
- Create **Professional Learning Community (PLC)** for high school CS teachers that provides continuous professional learning on CS curricula and inclusive pedagogical strategies
Results

- 103 teachers (61% women, 36% from URGs) have enrolled in the CS SA program. 53 have completed it, and 25 have received their authorization from the state.
- Trained 100+ Instructional Assistants (55% female and 50% URGs) who provided 7000+ hours of classroom support.
- PLC meet monthly and is regularly attended by 20+ SFUSD full-time high school CS teachers. On average, 95% reported the meetings were useful.
- Impacted and supported 5000+ high school students.
Lessons Learned

- K-12 CS teacher training and development research needs an **interdisciplinary team**
- **Start small. Build and run a pilot program first.**
- **Hear the school districts’ need**
- Teachers love in-person meetings for short-term PD, but prefer **online format** for long-term PD
- **Financial support** (tuition waiver, stipend, etc.) are critical for some teachers to join the PD
Next Steps/Long-Term Plans

- Collaborate with other CSUs and school districts to scale this effective, evidence-based model to other areas in California
- Adapt this model to prepare and support K-8 CS teachers
Summary

• Introduce our NSF-funded project on Preparing High School CS Teachers to Provide Rigorous, Inclusive CS Instruction through effective activities such as CS supplementary authorization program, Instructional Assistant program, and Professional Learning Community.

• We have a dream that all the children will one day live in a nation where they all have opportunity to participate and learn CS in their schools.
CS4SF: A Scalable Model for Preparing High School Teachers to Provide Rigorous, Inclusive Computer Science Instruction

Questions?

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Equitable Elementary Science Education:
Tools for Teacher and District Capacity Building

Dr. Kathryn Hayes, PI
CSU East Bay

Grant: Science Communities of Practice Partnership (SCOPP)

These materials were developed by project staff as part of the NSF Discovery Research K12 (DRK12) Science Communities of Partnership Project (SCOPP). Award Number: 1813012;

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Kenya Taylor Undergrad Researcher
Aa'ishah Riaz Undergrad Researcher
Jessica Gladstone Postdoc Researcher

Equitable Elementary Science Education: Tools for Teacher and District Capacity Building
Equitable Elementary Science Education: Tools for Teacher and District Capacity Building

Thanks always to our teachers
EQUITABLE ELEMENTARY SCIENCE EDUCATION: TOOLS FOR TEACHER AND DISTRICT CAPACITY BUILDING

Project Overview
NGSS Requires Shifting the Learners Experience

Teacher sharing their knowledge

Students engaged in equitable sense-making

“Learning About” vs. “Figuring Out”
Equitable Elementary Science Education: Tools for Teacher and District Capacity Building

Theory of Change

SCOPP Professional Learning Model

Full treatment

Intensive PD

3 RCoPs

Partial treatment

Science Content + Pedagogy

District Leadership Teams

Lesson study

Instructional Innovation

Context

Shifts in Organizational Practice

Ownership
- Internalization
- Agency
- Commitment

Shifts in Instructional Practice
How do we facilitate meaningful and sustainable improvement in science instruction while simultaneously building capacity within districts to support such instructional change?
Asset-based Student Work Analysis Protocol

- **Purpose:** Shift teacher analysis of student work from a numerical evaluation to understanding how students conceptualize science phenomena, and the assets and experiences they use. It can be used during a process such as lesson study.

- **Research:**
  - Completed three rounds of design research, resulting in revisions to the protocol and theory development.
  - Presented at STEM, CSTA and NSTA.
With facilitation, teachers:

1. Discuss the learning goals of the lesson; based on these goals, they decide a portion of the work sample to be evaluated
2. Review student work samples, describing how students are making sense of the concepts and processes of the task, as well as the knowledge and experiences students are drawing on
3. Share and discuss emergent patterns in student understanding
4. Use individual work samples to demonstrate how and why a particular student might conceptualize science ideas
5. Reflect on needed instruction and feedback and revisions to the assignment or lesson
Asset-based Student Work Analysis Protocol

Findings

- Teachers tended to focus more on student conceptualization of science ideas when using the protocol.
- The protocol yielded an asset-based conceptualization:
  - Less sorting, labeling, students, and more connecting with students empathetically.
- Allowed teachers to revise their instructional practice to further support student learning.
Instructional Innovator Continuums

- **Purpose**: Development of administrator understanding of instructional shifts needed for equitable NGSS-based science instruction, and building capacity to support such shifts.
- **Research**:
  - Four rounds of development and expert feedback completed.
  - Instructional Innovator's Toolkit includes 1) pre-observation plan, 2) Observation Continuums for Discourse and Sensemaking, and 3) post-observation debrief.
  - Presented at CSTA.
Instructional Innovator Continuum Protocol

Pre Meeting with the teacher to get context of learning experience and teachers goals

Leaders at all levels of the system debrief the observation and develop next steps for building capacity

Facilitated observation of learning followed by application of the instructional innovator continuums

Equitable Elementary Science Education: Tools for Teacher and District Capacity Building
### Component 1: Equitable Discourse

Who is **initiating** the conversation? Who has **authority** in the conversation? **How many students** are participating? What **knowledges and experiences** are being valued? Do students have **choice** in how they participate in discourse?

|----------------------------|--------------------------------|--------------------------------|-----------------------------|
| Discourse opportunities are directed by the teacher. | Discourse opportunities are mostly directed by the teacher.  
  • Teacher initiates whole group and partner discussions with protocols to ensure equity of voice (e.g. equity sticks) | Diverse discourse opportunities are evident.  
  • Teacher intervenes frequently to reinforce norms, and ensure equity of voice  
  • Students are encouraged to build off each other's ideas | Equitable discourse culture is well established  
  • Teacher makes shifts to original plan to follow through with student ideas/contributions |
| Everyday experiences and vocabulary are not brought into the scientific discourse. | Teacher permits students to use everyday language to explain science concepts, but prioritizes academic language. | Teacher and students are beginning to integrate everyday language with scientific language | Teacher and students use home, everyday, and academic language fluently during scientific discourse. |
| Scientific vocabulary is frontloaded | | Teacher and students elevate and value diverse and historically marginalized student ideas during discourse. | |
Instructional Innovator Continuum Protocol

Findings

- Administrators see a new approach to instruction, and discuss shifting their evaluation practices.
- Administrators discuss how to support all teachers in making these shifts.
- Science becomes centered.
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<th>Data Collection</th>
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<td>Kathryn/Kristi</td>
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Lessons Learned

• In the proposal, develop a coherent through line
  • Create a theory of change, define how it works, and support it with the literature
  • Theory, methods, and argument should align
  • Define your main constructs, and use the same words every time

• Cultivate a relationship with site and district administrators. This supports
  • Recruitment and research
  • Science education

• Equity should be front and center
Questions?

Contact Information:

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Email: Kathryn.hayes@csueastbay.edu
Make Math REAL
Building Authentic Math from Maker Experiences in Upper Elementary Grades

Ben Ford
Sonoma State University

Joint with: Rajeev Virmani and Kathy Morris (SSU), Harold Asturias, Karen Mayfield-Ingram, and Rena Dorph (Lawrence Hall of Science, UC Berkeley), and a host of teacher co-developers

Ben Ford, Professor
Sonoma State University, Department of Mathematics and Statistics
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Funding provided through award numbers DRL-1850372 (SSU) and DRL-1850367 (UCB)
Make Math REAL: Realize Equity to Activate Learners

GOALS

1. refine a model for Maker Learning Cycles that build from authentic maker experiences to deep engagement in and learning of core grade-level mathematics content;

2. develop 4 examples of such MLCs in each of grades 4 and 5; and

3. generate and evaluate evidence about aspects of these MLCs that contribute to opportunity to engage in mathematics and to STEM activation for students and specifically for emerging multilingual learners.
Make Math REAL: Realize Equity to Activate Learners

HYPOTHESES

1. authentic maker experiences provide opportunities for deeper engagement and inquiry for emerging multilingual learners, change teachers’ perceptions of these learners’ capacities, and prime student STEM activation in the dimensions of fascination, competency beliefs, and innovation stance (see definitions in Theoretical Framework).

2. these maker projects position students’ mathematics learning within meaningful contexts that enable deeper engagement and thus greater success, leading in turn to more persistence in STEM pursuits.
Make Math REAL: Realize Equity to Activate Learners

DESIGN and DEVELOPMENT

Year 1 (2019–2020/2022): Four teams draft and pilot Maker Learning Cycles (SSU 4th & 5th; LHS 4th & 5th)

- Each team: University facilitator + 3 classroom teachers

Year 2 (2022–23)

- Revise MLCs based on pilot feedback; add language supports and strategies
- Field test revised cycles
- Student Activation and Teacher Learning Research data collection
- Final revision, Research analysis, publication
What is a Maker Learning Cycle?

Making something REAL: authentic Maker project

Making Math REAL: 2+ Math follow-on lessons

Making it all come together (Cycle Finale)
- Fermi Problem OR Revisiting Making OR Where Else in the World?
Making Enables Powerful Math Learning

Maker community principles

• Access for everyone, learning from each other
• Authenticity
• No pre-teaching beyond familiarity with tools/materials

These lead to:

• Math learning principles, e.g.
  • Authenticity: Math for a purpose
• Language development principles
  • Communication for a purpose
Make Math REAL Research

Student Activation in STEM

- A state composed of dispositions, practices, and knowledge that enables success in proximal science, technology, engineering, art, and mathematics learning experiences.
- Main question: Do MLCs lead to increased STEM activation for emerging multilingual learners?
  - activationlab.org

Teacher noticing of emerging multilingual learners’ assets

- Surveys, interviews, classroom observation
Results & Lessons Learned

2022–23 is primary research data year for both student and teacher research

2021–22 student data: high engagement relative to non-MLC math time

Teacher practice

• Giving access for productive struggle is hard
• Allowing for productive struggle (resisting urge to “help”) is hard
• Radical paradigm shift like Maker principles can help
Questions?

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Next Steps/Closing Remarks

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https://www2.calstate.edu/impact-of-the-csu/research/stem-net
Webcast Feedback Survey

Please take a few moments to tell us about your webcast experience.

Use the QR Scan Code to download it
Virtual Research Café 10.0
Date: Wednesday, September 21, 2022
Time: 11 AM-12 PM
Register Here
Join our CSU STEM-NET Community listserv

csustemnet@lists.calstate.edu

Begin a Conversation with Colleagues and Join our Private CSU STEM-NET Facebook Group

https://www.facebook.com/groups/2629611737269292
THANK YOU FOR JOINING US TODAY!
For more information about STEM-NET visit our website: