SCHELLER TEACHER EDUCATION PROGRAM
education arcade

Teachers with GUTS:

Developing teachers as computational thinkers through supported authentic experiences in computer modeling and simulation

Research Updates

Evidence, Impact & Insights

Teachers with GUTS

Irene A. Lee, ialee@mit.edu
Emma Anderson, eanderso@mit.edu
Ling Hsiao, lingh@mit.edu
Angie Tung, yanchi@mit.edu
Eric Klopfer, klopfer@mit.edu

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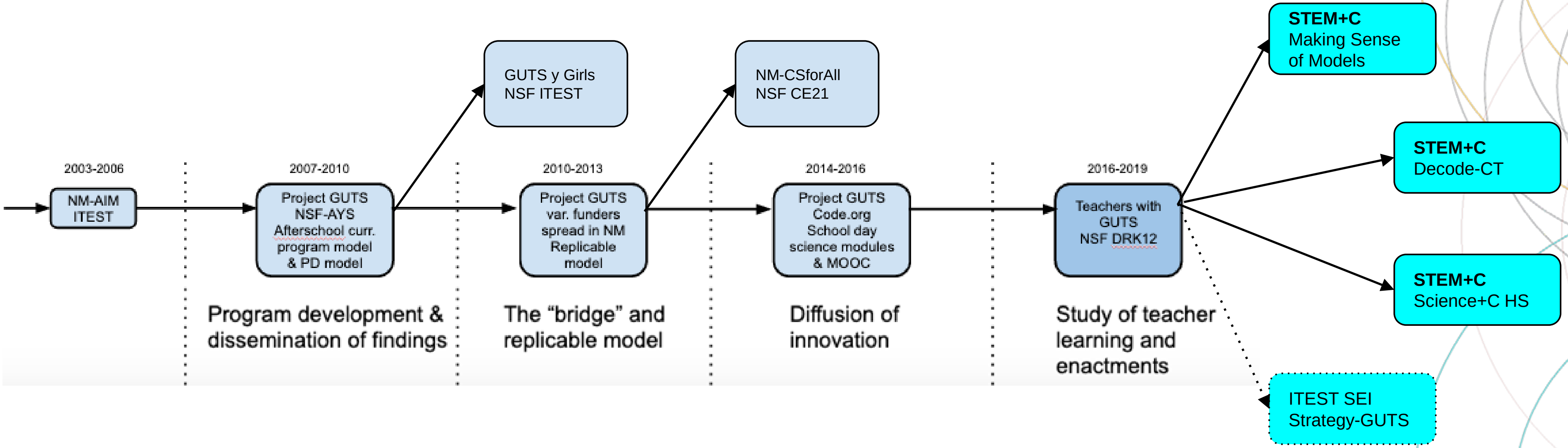
Research Question

How can we enhance the ability of science teachers to provide high quality computational thinking experiences for middle school students in regular school day science classes?

“Computational thinking experiences” are supported through **computer modeling and simulation activities** in science classrooms.

Project GUTS history



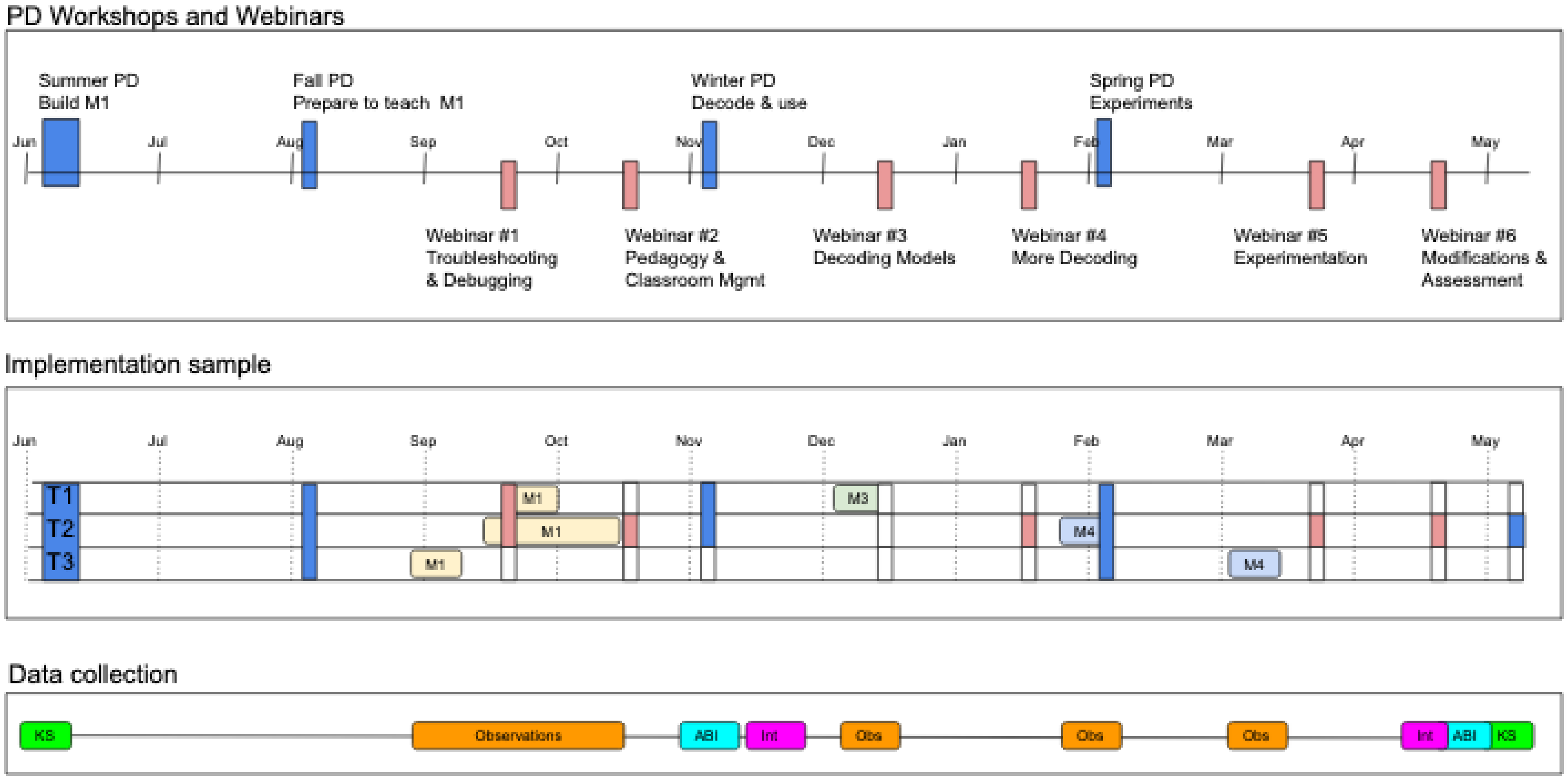
Computational Thinking

Formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent

(Cuny, Snyder & Wing, 2011)

Computational Thinking (CT)	Operationalized In Computer Modeling & Simulation context as...
ABSTRACTION →	What should I include?
AUTOMATION →	How will I encode processes?
AUTOMATION →	How will I use the model for experimentation?
ANALYSIS →	What data will I collect from runs?
ANALYSIS →	What do that data tell me?
ANALYSIS →	In what ways is the model valid?

Intervention & data collection timeline



TwiG Research Sites, Subjects & Staff

Cohorts 1, 2, & 3

- 48 Teachers
- 3 Facilitators

Research Team:

- 3 FIs
- Grad stud.
- Statistician

Cohort 3

- 12 Teachers & 2 admins.
- 2 Facilitators

Research Team:

- 3 FIs
- Reg. partner

Research Team:

- PI, co-PI
- 2 researchers
- Proj. mgr.

Program Evaluation:

- Evaluator

Teacher and Student Voices:

Teacher perspectives, experiences, and learning from:

- Professional development offerings
- Implementing the Project GUTS modules
- Using StarLogo Nova for modeling and simulation
- Development of CT practices for science instruction

Student perspectives, experiences and learning from:

- Classroom activities using StarLogo Nova
- Classroom activities in curricular lessons

Teacher voices captured in data from:

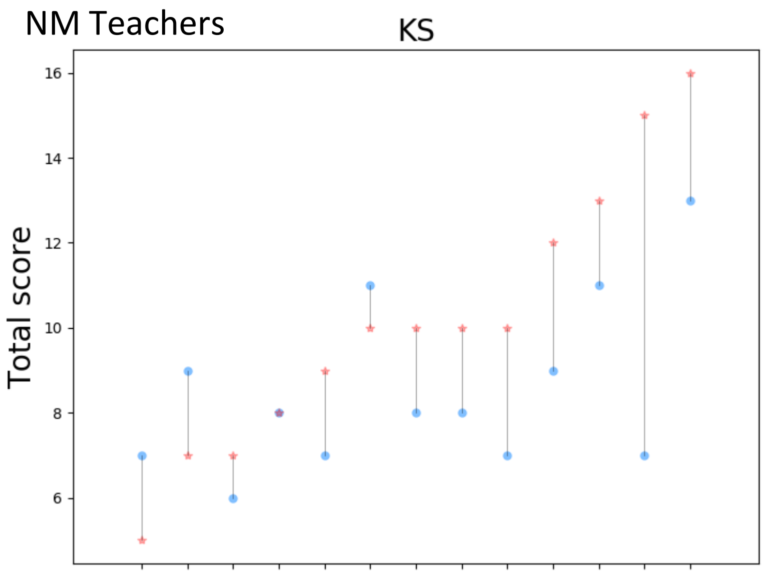
- Teacher surveys: (#pre-; #post-)
  - Attitudes, Interest, Awareness: 60; 42
  - Knowledge & Skills: 62; 38
  - Resources, Models, Tools: 57; 36
- Teacher Interviews
  - Artifact-Based Interviews: 34
  - Fall Cohort 3 Interviews: 18
  - Spring Cohort 3 Interviews: 14
- Classroom observations:
  - 142 reports / 28 classrooms in C2 & C3

Student voices captured in data from:

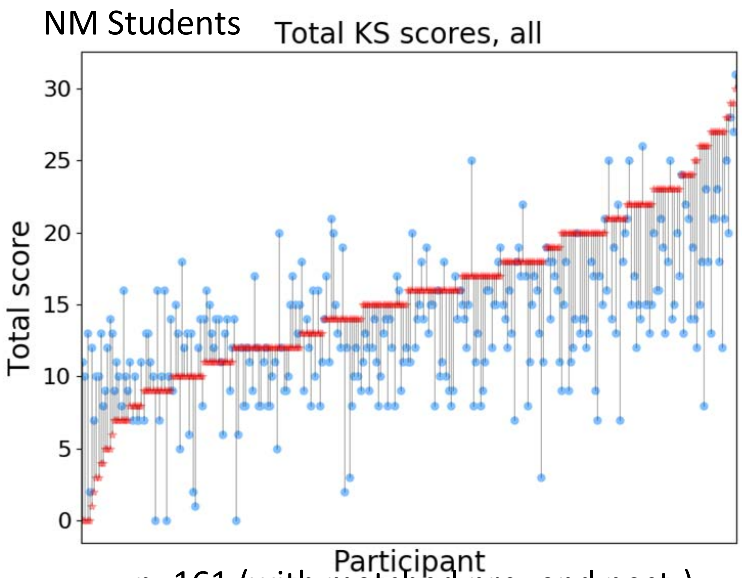
- Student surveys: (#pre-; #post)
  - Knowledge & Skills surveys: 1956; 576
  - End of module surveys: 726 responses
- Student Focus Group Interviews
  - 4 focus groups
- Classroom observations:
  - 142 reports / 28 classrooms in C2 & C3

KS Surveys – Cohort 3 teachers and students

Change in Knowledge and Skills; Pre- (in blue) to post- (in red) scores.



Change in total scores:
Mean = 1.615
Sign test: $p = 0.145$
Signed rank: $p = 0.019$

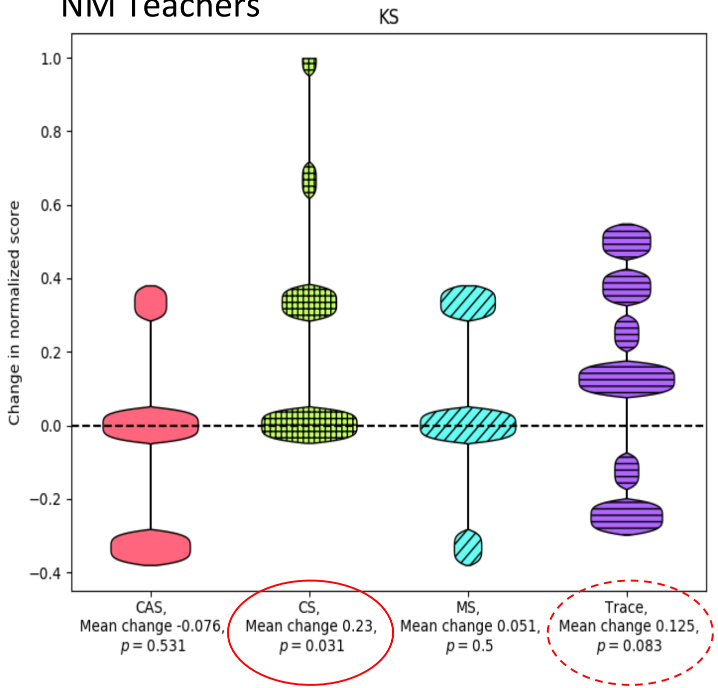


n=161 (with matched pre- and post-)
Change in total scores:
Mean = 2.213;
Sign test: p = 5E-9;
Signed rank p = 1E-10

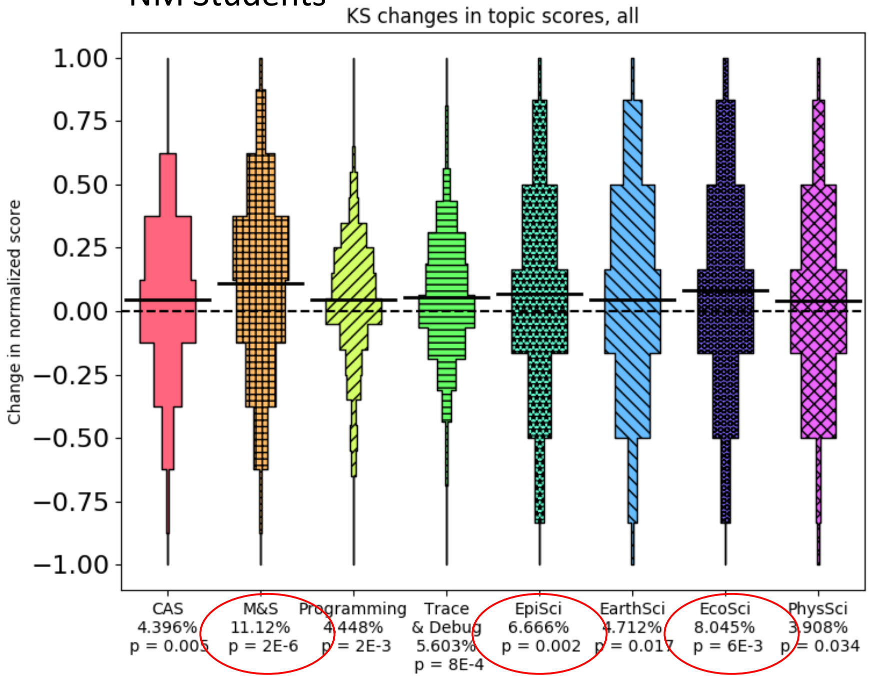
Growth in KS Survey – Cohort 3

Where did change in Knowledge and Skills (pre to post scores)

NM Teachers

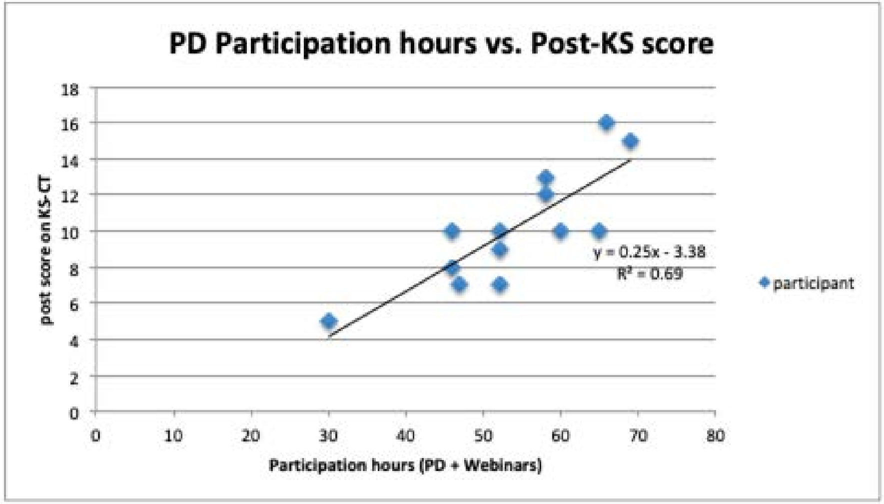


NM Students

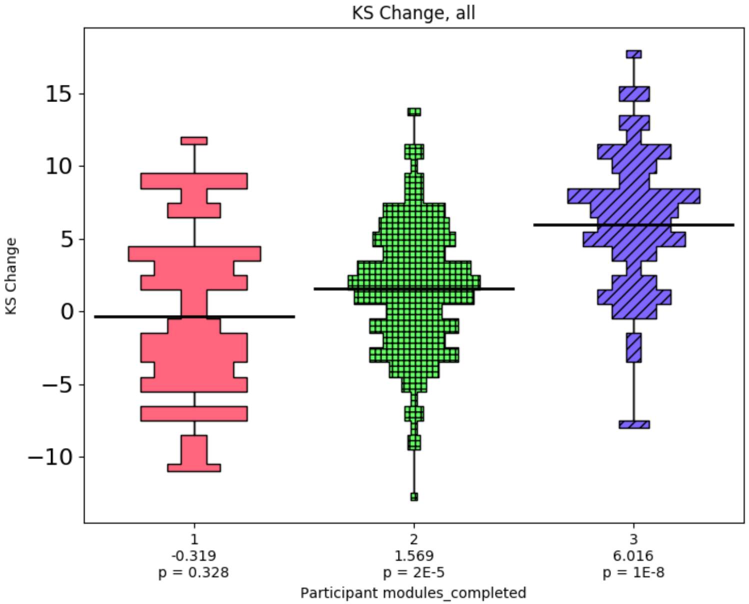


Dosage response in KS scores

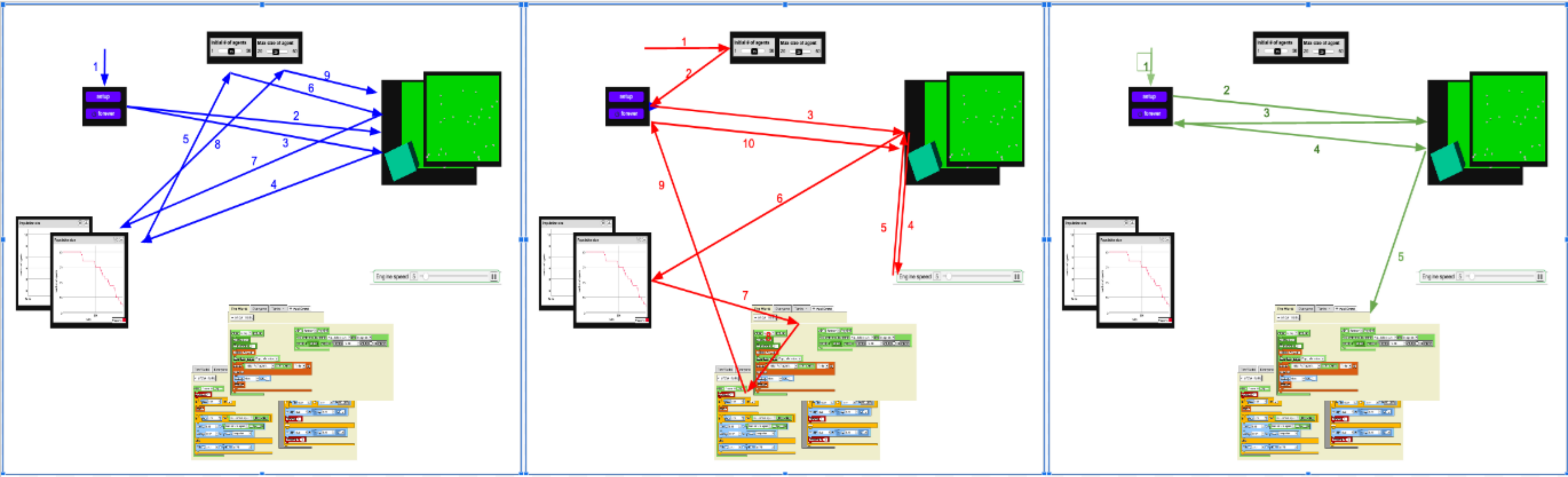
NM Teachers



NM Students



CT in Action: How teachers used agent based modeling to support mechanistic reasoning



Ling Hsiao, Irene Lee, and Eric Klopfer wrote about how science teachers use agent-based modeling tools to support mechanistic reasoning. British Journal of Education Technology (2019)

Findings: three types of enactments

We observed a variety of enactments of the Project GUTS CS in Science curriculum.

In particular, there were three approaches:

- Coding centric (emphasized learning to program)
- Modeling centric (emphasized abstractions and assumptions in models)
- Experimentation centric (emphasized using models as experimental testbeds)

In progress: case studies of enactments

Teacher's:

A. belief about fit with school curriculum,
B. beliefs in students' capabilities,
C. preparation in CT, and
D. epistemic views of science

CASES:

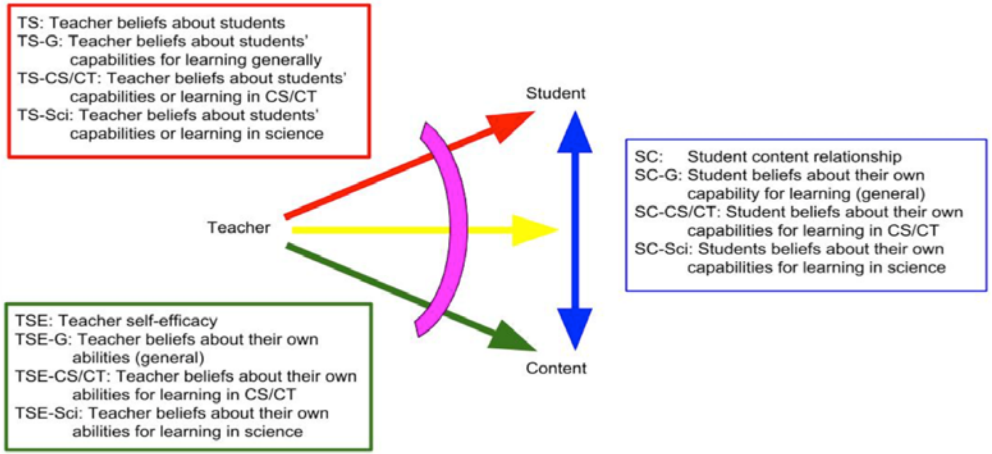
- Coding centric (T1)
- Modeling centric (T2)
- Experimentation centric (T3)

How did the different enactments impact student learning?

May help us answer "what's the best approach given limited class time?"

Barriers to implementation

Paige Prescott presented findings from Cohort 1 on Teacher self-efficacy & beliefs in student capabilities as mediating factors in the enactment of Project GUTS' CS in Science curriculum. (SIGCSE 2019)



Supporting Productive Failure

Exploring Teachers' Instructional Choices for Promoting Productive Failure (AERA 2019)

Kapur (2008) defined productive failure as "engaging students in solving complex, ill-structured problems without the provision of support structures" (p. 379).

1. How do teachers help students work through moments of challenge when completing a Project GUTS CS in Science lesson?
2. How do teachers reflect on their own practice and how does this impact their instruction to help students move beyond 'failure' and to understanding how to address challenges?

Emma Anderson presenting at AERA

What KS-CT is necessary to integrate CT in Science?

Chapter in preparation: "Teachers' knowledge and skills in computational thinking and their enactment of a CT-rich curriculum within science classrooms" for the book "Preparing Teachers to Teach Computer Science,"

Both teachers start with low-mid range of CT knowledge and skills. (7 out of 17 pts)

Teacher A (large KS-CT gains, +8 pts) Teacher B (small KS-CT gains, +1 pt)
Focused on *coding* Focused on *modeling*
Built the base chemical reaction model Big picture of modeling w/ limited coding
Linking chemical equation to code. Connected the model to real world
Very little discussion of abstraction. Discussed abstraction in the model daily
Emphasis was on stages of reaction. Emphasis on concept of conservation of mass
+ Intensive coding experience **+strong thinking about models and why use them**

Moving forward:

Findings that piqued our interest in mechanistic reasoning:

1) BJET paper - Only when observations of the simulation were combined with examining code did “Level 3” mechanistic explanations emerge (describing “why something happened”).

1) Teacher cases - Teacher with weaker understanding of coding and small gains in KS-CT, provided an exemplary integration of CT without emphasis on coding.

NEW QUESTIONS:

Can teachers and student read and decode models without learning to write models?

1) Is reading code a distinct skill from writing code?
2) Is decoding a model a distinct skill from creating a model?
3) Can decoding models for mechanism be taught without teaching how to write code?
4) Can analysis and scientific uses of models be taught in classrooms without teaching programming?

New STEM+C projects:

MIT's Making Sense of Models, NSF STEM+C #1934126, PI Lee / Co-PI Klopfer

Audience: 6th grade teachers & students in regular school day math and science classes

Q: Does learning to encode processes when formulating problem solutions in math class lead to the ability to decode similar processes when encountered in models within science class?

AMNH's Decoding Urban Ecosystems, NSF STEM+C #1934039, PI Gupta / Co-PI Lee

Audience: middle school students, Out of School Time programs

Q: Does learning to decode for mechanisms in scientific models lead to better understanding of complex systems phenomena?

EDC's Computational Science Pathway Option for MA HS Students, NSF STEM+C #1934112, PI Malyn-Smith / Co-PIs Lee & DeMallie

Audience: high school teachers & students in regular school day science classes

Q: *How do science+C classes impact student science learning? (quasi-experimental study)*

Q: Can teachers and students learn to decode and analyze models for mechanisms *without* extensive instruction on how to create models?