Iteration 1 (in-school)

Iteration 2 (in-school)

Iteration 3 (at-home)

Embedding Computational Thinking in School Science: Designs of an Automated-Greenhouse Project with Young Adolescents

David W. Jackson

Boston College & "Mills City Public Schools"

Doctoral Candidate &

"Out-of-School-Time Coordinator"

Yihong Cheng

BC & "MCPS"

Doctoral Student &

"Out-of-School-Time Co-Advisor"

Innovations in Urban Science Education

University of Colorado Boulder

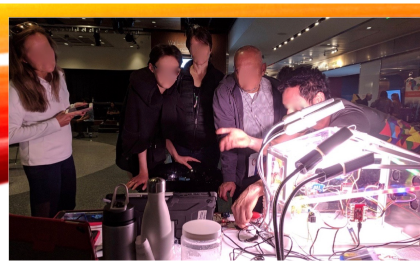
Iowa State University

Department of Materials Science and Engineering

College Bound

NSF

DRL #1814001



RESEARCH APPROACH

	2018 & 2019: In-school-time (IST)	2020: Out-of-school-time (OST)
what & why	CS4All [Computer Science for All] (***what***): many **why's**... (Vogel, Santo, & Ching, 2017; Voogt et al., 2015)	
where	**required school** courses, including STEM (Voogt et al., 2015; Weintrop et al., 2016)	**homes & community**, and connections with school (Bevan et al., 2010; Moll et al., 1992)
who	students, in small groups	youth, in family-units
when	during the school day	anytime!
how	student **engagement** in computational **practices** (Denning, 2017; Fredricks et al., 2016)	**funds of knowledge** (Moll et al., 1992); **engagement | interest** (Järvelä & Renninger, 2014)
Re-search ?'s	In **five classrooms** of a required 8th grade science course, how does participation in an **automated smart-greenhouse project** with integrated computation influence students' **social | affective engagement**?	In **ten households** across **three cities** in the northeast US, how does participation in an **automated hydroponics project** with integrated computation influence youths' computational **engagement and interest**?

METHODS

- Methodology
  - DBR: cultural psychology approach (Bell, 2004)
  - Phenomenological: understand lived experiences (Creswell, 2013)

- Setting & participants
  - "Mills City": **pluralistic** (Paris, 2012) urban-ring city in US northeast
  - Iteration #1: one school; ~200 students and 2 teachers
  - Iteration #2: two schools; ~400 students and 5 teachers
  - Iteration #3: three cities; ~10 households, *esp. those marginalized by inequitable systems and institutions* *(Cho et al., 2013)*

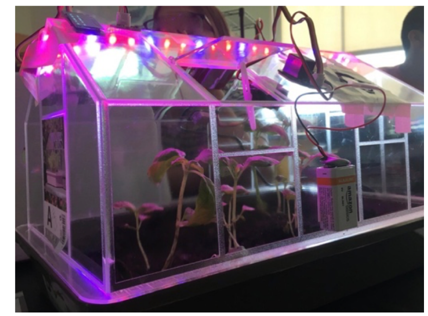
- Data generation
  - Pre- & post-surveys (~90% matched)
  - Pre- & post-interviews (~6 students per teacher, per year)
  - Video and audio recording (~6-10 groups at each school)

- Data analysis
  - t-tests of means: computational experience, confidence, and interest
  - Coding: Process, emotion, & *in vivo* (Miles, Huberman, & Saldaña, 2014)
  - Data from video: "whole-to-part" method (Erickson, 2006)
  - Convergence: CAQDAS [Dedoose] as aid (Creswell & Plano Clark, 2018)

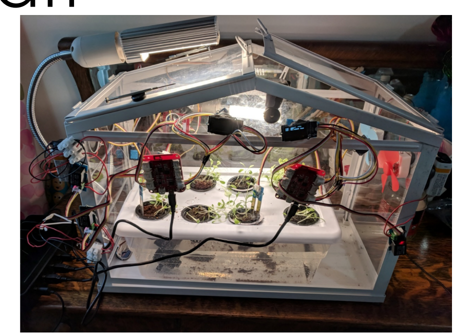
FINDINGS

Per *Social Infrastructure Framework* (Bielaczyc, 2006, 2013)

1. Spring 2018 #1: Sequential S-E-C Practices
    1. students: Groups of two **"Technicians"**
    2. teachers: **Co-**instructors
    3. planned learning: **simplicity**



2. Spring 2019 #2: Stress → Interactions → Engagement
    1. students: Groups of four **"Parents"**
    2. teachers: **Lead** instructor w/ support staff
    3. planned learning: **flexibility**



CONNECTIONS TO LITERATURE

1. Self-efficacy theory (Bandura, 1993; Schunk & DiBenedetto, 2016)
   1. Finer-grained data generation...
   2. ...in more diverse settings (esp. racial/ethnic & socioeconomic)

2. Social interdependence theory (Johnson & Johnson, 2009)...
   1. The combination of software, hardware, and plants promoted **positive interdependence** within and between groups.
   2. Stress and frustration sometimes impeded **promotive interaction,** but **social dynamics** and project characteristics helped to stimulate engagement.

3. Social infrastructure framework (Bielaczyc, 2006, 2013)
   1. Identify the most salient *design considerations*...
   2. ...to better understand research-practice *trajectories of change*

FUTURE WORK

Iteration #3: Summer 2020 (“LEaFS”)*

- socio-techno-spatial: Indoor two-tier hydroponics system
- participation structures
  - Engages the whole family
  - Training **high-school mentors**
- “outside world”:
  - Community Cookbook
  - Cooking & Gardening 🔁 Electronics & Programming

*again, per *Social Infrastructure Framework* of Bielaczyc (2006, 2013)

"SHOULDERS" WE'RE STANDING ON/WITH (REFERENCES)

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THANKS!
WHAT QUESTIONS DO YOU HAVE?

david.jackson@bc.edu | @Jackson_DavidW
yihong.cheng@bc.edu

<EXTRA SLIDES START HERE>

…BUT FIRST, POSITIONALITY:

- Carrying *my own* "invisible knapsack"… (McIntosh, 1992)
- …recognizing the value of diversity and social justice for people of both marginalized and privileged groups (Goodman, 2001)

- "**engineer**-turned-**educator**-with-a-**research**-habit"

- Working **with** the "Mills City" community(/context) (Pollock, 2008)
  - Resident June 2010 – June 2019
  - "Out-of-school time coordinator" 4+ years
  - Urban ring (suburban | urban)
  - Cultural and linguistic diversity; gentrification; immigration

THEORETICAL ORIENTATIONS

broadly: **dialectical pluralism** (Johnson, R.B., 2017)...
...especially pragmatism & social constructivism...
...with an eye towards **critical dialectical pluralism** (Onwuegbuzie & Frels, 2013

By iteration:

1. **self-efficacy theory** (Bandura, 1993)
2. **social interdependence theory** (Johnson, D.W., & Johnson, R.T., 2009)
3. **funds of knowledge** (Moll et al., 1992)

CONCEPTUAL FRAMEWORK

Student engagement

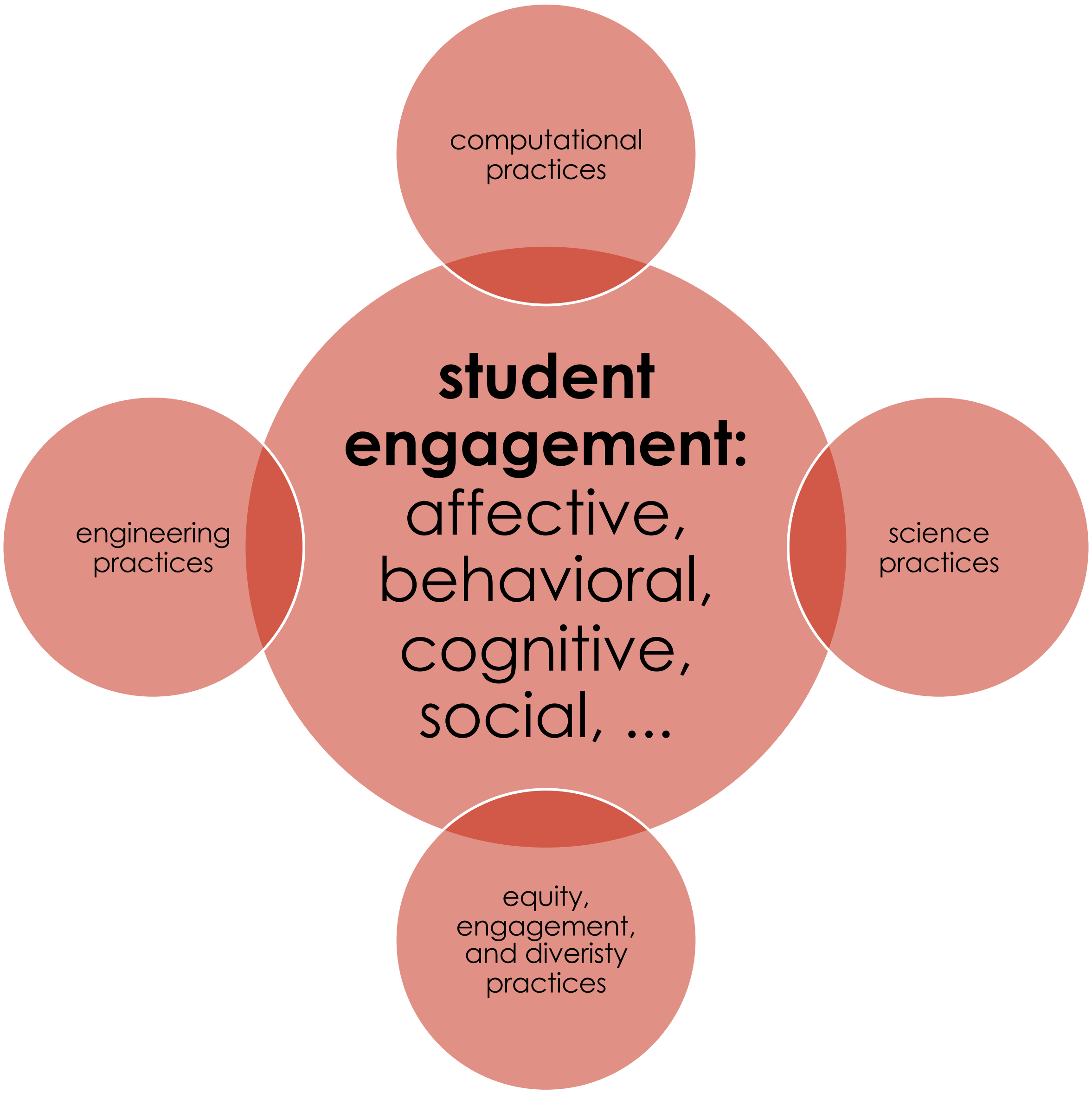
*Fredricks et al. (2016): social | {emotional, behavioral, & cognitive}
*Gresalfi & Barab (2011): procedural, conceptual, consequential, critical
*Sinha et al (2015): social, behavioral, cognitive, conceptual-to-consequential
*Pekrun & Linnenbrink-Garcia (2012): soc.-behav., cog.-behav., cog., behav., & motivational

computational practices (CSTA, 2017), especially
Collaborating ..., Testing and Refining..., and Communicating...

SEPs + EEDPs (NGSS Lead States, 2013; Rodriguez, 2015), especially...

- **Using** mathematics and computational thinking
- Designing solutions (for engineering)
- Obtaining, evaluating, and communicating information

CONCEPTUAL FRAMEWORK

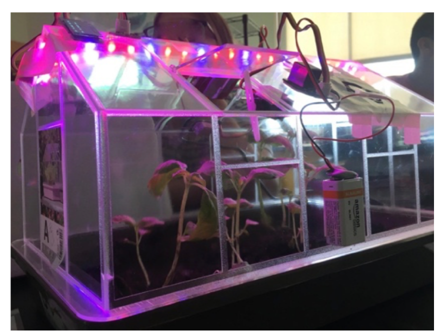


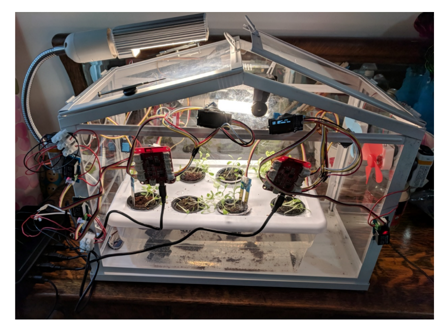
SETTING + PARTICIPANTS

- "Mills City": urban-ring city in Massachusetts

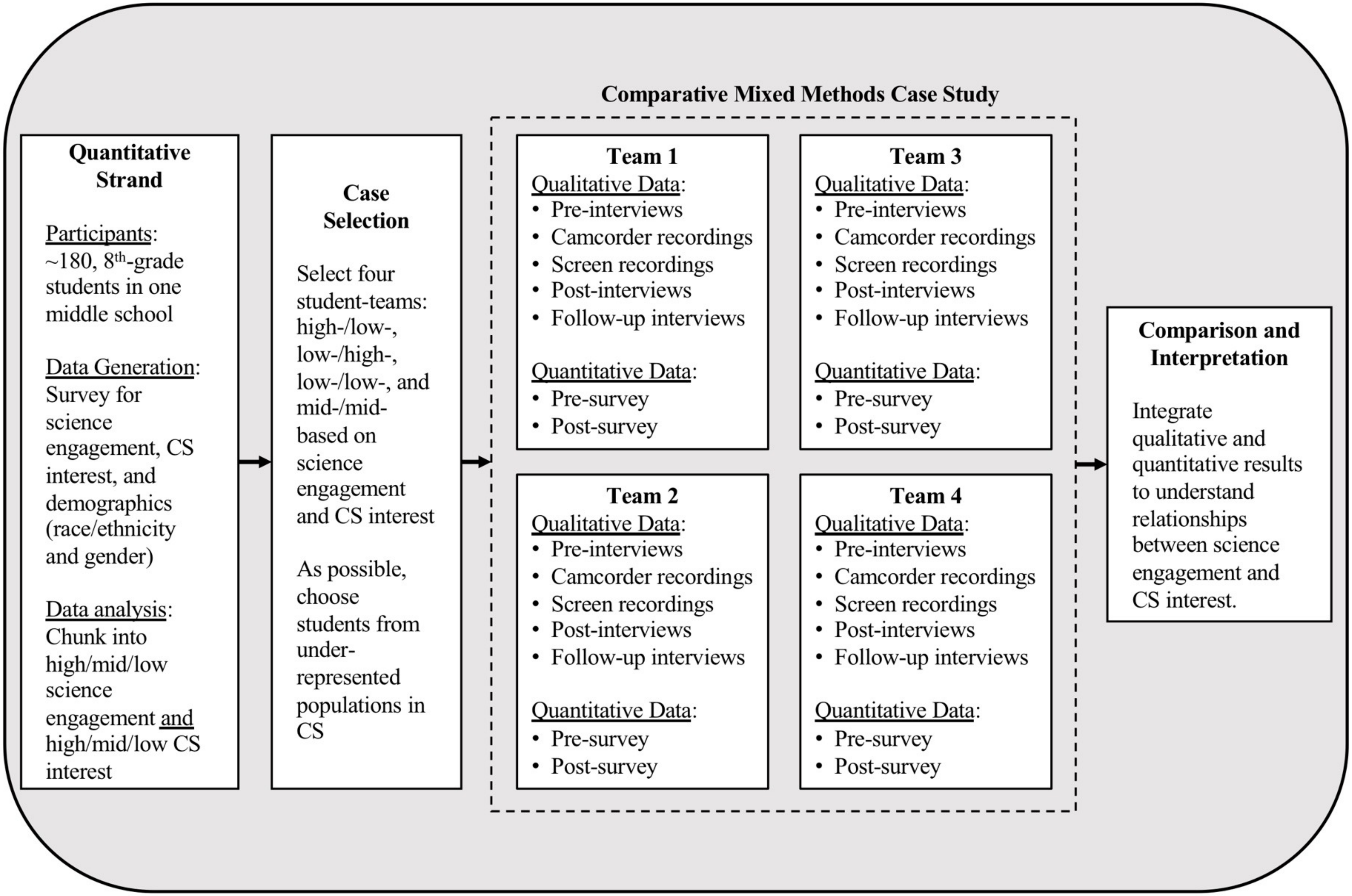
	2018	2019
Class-periods (~55 min.)	13	14
Students	~200	~400
MCUs/greenhouse	1	2
Students/greenhouse	2-3	4-5
Schools	1	2
Teachers	2	5
Participant-researchers	2 / class	1 / class
Topics	Intro, light, temp. & hum., eng. design	<same> + soil moisture

Version 1: growthings.netlify.com (lead: Paul Xu)
Version 2: email Dave for a link (lead: Mike)





RESEARCH DESIGN

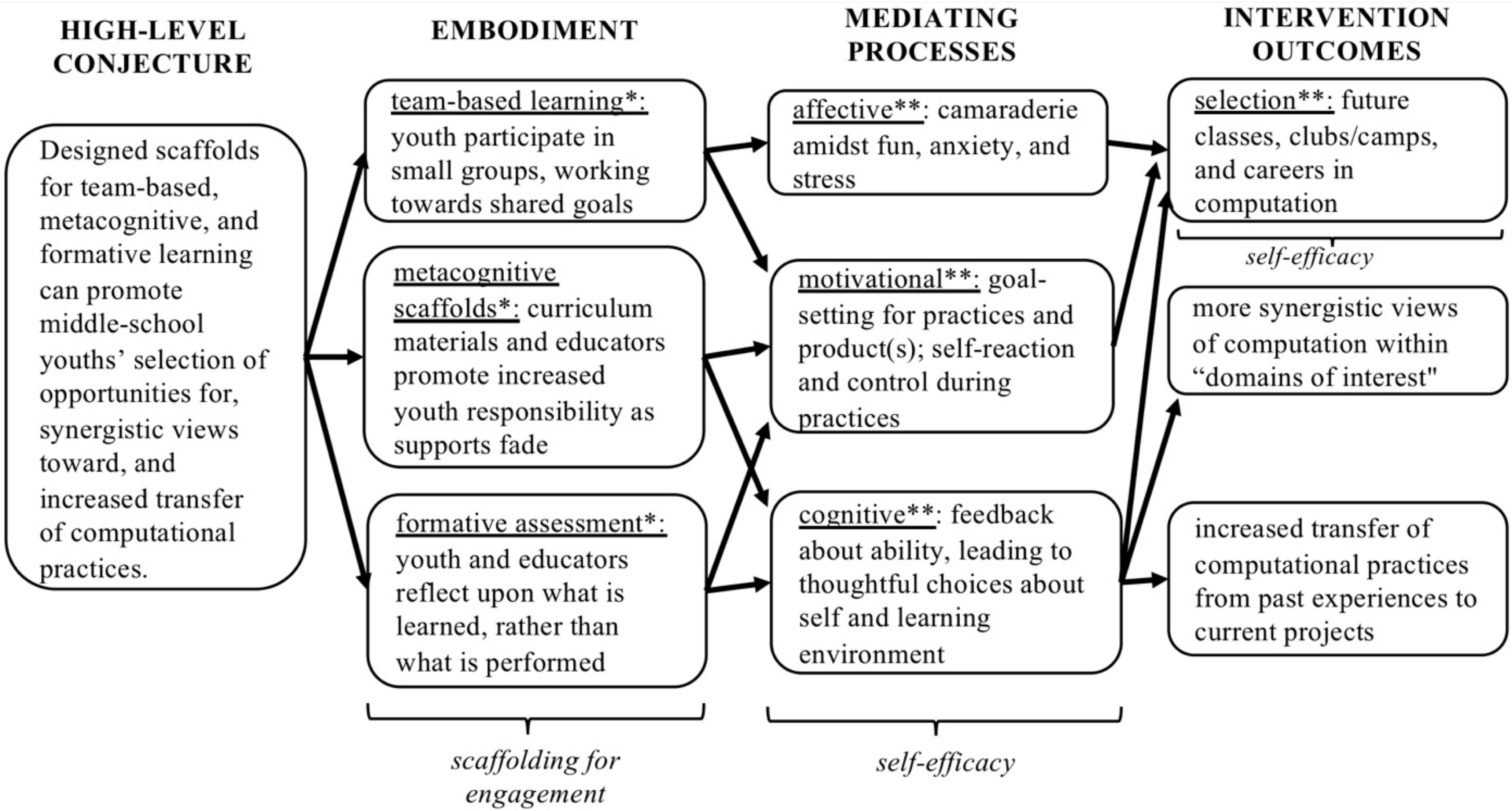


FINDINGS FROM ITERATION 1

Tensions in student practices, from variable- and case-based analyses

Tension	Clara & Gabriella [more engaged & simultaneous]	Faith & Taylor [more disaffected & sequential]
1. engagement disaffection	• Laughing about errors • Focus on aesthetics • Checking each other's work • Helping peers	• Playing with materials • Providing emotional support • Stress about grades and tests
2. sequential practices simultaneous practices	• Disciplines initially siloed • Ended with "different mixes", ~"10 minutes [at a time]"	• Worked in parallel • Connected engineering with science, but not computing
3. prior experience present transfer	• Previous experience in grade 6 & club • Minimal use of TA • Rapidity of coding, at expense of consistency with science	• Previous experience in grade 6 only • Frequent use of TA • Quickness to claim broken items, rather than troubleshooting

IMPLICATIONS FROM ITERATION 1



(PRELIMINARY) FINDINGS FROM ITERATION **2**

Through a lens of social interdependence theory (Johnson & Johnson, 2009)…

1. The combination of software, hardware, and plants promoted **positive interdependence** within and between groups.
2. Stress and frustration sometimes impeded **promotive interaction**, but **social dynamics** and project characteristics helped to stimulate engagement.

IMPLICATIONS FROM ITERATION **2**

*Maintain high-interest elements
    *Culturally-relevant plants
    *Hydroponic growing

*Promote individual accountability
    *Smaller groups...
    *...and/or clearer scaffolds

FUTURE WORK

- Transition to **BBC micro:bits** (block AND text-based)

- Focus on **student engagement** #PhDone ☺

- **Expand** to "Western US" high-school, Massachusetts high-school, Massachusetts OST (grades 7-12)…
- …¿and beyond?

VERBOSE SCHEDULE

Table 1: *Outline of smart-greenhouse curriculum intervention*

Days	Topics	Focal practices per CSTA (2017)*
1	Introduction to the project	Recognizing & Defining Computational Problems; Fostering an Inclusive Learning Environment
2	Introduction to coding	Testing & Refining Computational Artifacts; Collaborating Around Computing
3-7	Light (color/s & duration)	Developing and Using Abstractions
8-11	Temperature & humidity (fans + servos with arm attachment)	Developing and Using Abstractions
12	Soil moisture (includes pump)	Developing and Using Abstractions
13-14	Final adjustments & troubleshooting	Testing & Refining Computational Artifacts
15	Showcase	Communicating About Computing

**Days 3-14 implicitly involved Creating Computational Artifacts, without express emphasis.*

OBSERVATION PROTOCOL (OLD)

Appendix 4: Observation Protocol: *Smart Greenhouses* 2019 (**Take a photo of every version of the design!**)

Teammates' Names____ **Observer name**__________________ **Date** __________

RQ1. When integrating CT into a required environmental science course, how do computational practices promote or inhibit student engagement?
RQ2. What is student engagement in computation? (a) How is it similar to student engagement in math and science? (b) How is it different?

Time	*Notes on student engagement (affective, behavioral, cognitive, social, ...)*	*Notes on* ***disciplinary practices*** *(computation, engineering, science)*	*Notes on* ***equity, engagement, and diversity*** *practices*	Other notes about the **team** (~2-3 students)	Other notes about the **full class** (~20-25 students)

Reflection *(continue notes and/or reflection on the next page/s if needed)*:

- In what way(s), if any, did computational practices seem to **promote** student engagement?

- In what way(s), if any, did computational practices seem to **restrict** student engagement?

QUESTIONS FOR YOU:

- What’s your advice for engaging families remotely?
- What related literature can you recommend?
- What improvements can you suggest for our design?
- Want to correspond later? ☺

david.jackson@bc.edu | @Jackson_DavidW
yihong.cheng@bc.edu