Integrating Computational Thinking, Engineering Design, and Environmental Science through Smart Greenhouses

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Rationale and Goals

- **Economic, social, literacy, civic, technological, educational, and personal needs** for teaching Computational Thinking (CT) and computer science (Vogel et al., 2017)...
- ...but access to CT and computer science is **inequitable** (Voogt et al. 2017)...
- ...and **embedding CT** in disciplines of STEM has proven difficult (Denning, 2017)...
- ...so, we need to better understand how to embed CT in **required classes, including science and engineering.**

Research Questions

1. What **tensions**, if any, do eighth-graders in a **required environmental science class** experience when engaging **in practices of computation, engineering, and science** during a smart-greenhouse project?

2. What **design conjectures**, if any, can be made for learning environments that **embed computational thinking practices** outside of computer science coursework?

Conceptual Framework

- **NGSS Science and Engineering Practices** (SEPs; NGSS Lead States, 2013)
- **Mass. Digital Literacy and Computer Science practices** (DLCS; MA DESE, 2016)
- **self-efficacy theory** (Bandura, 1993, 2006)
- **scaffolding** (Reiser & Tabak, 2014)
- **student engagement** (Fredricks et al., 2016)

Designed Intervention

Day	Topic(s)
N/A	*Professional development (~5 hr.)*
1	Unit launch
2-3	Light
4-6	Temperature & humidity
7-10	Engineering design

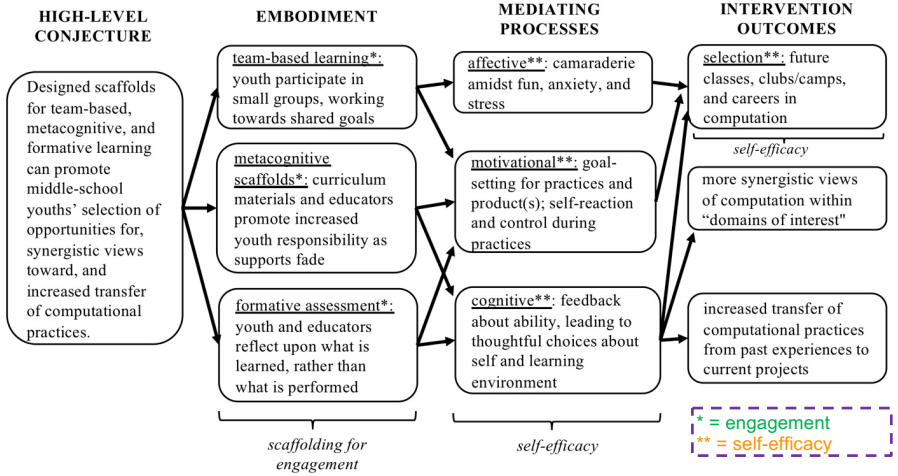
Version 1: growthings.netlify.com (lead: Paul Xu)
Version 2: email Dave for a link (lead: Mike)

Results

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

Discussion: Educational Design



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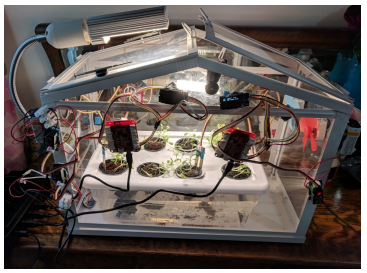

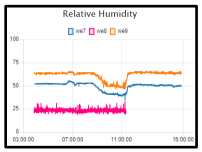

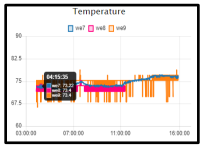

Discussion: Significance

- Embeds CT in STEM disciplines, specifically with smart/automated greenhouses
- Shows differences & similarities for computation/sci./engineering
- Culturally-relevant CT
- Access for ALL students

Future Work

- Educational Design
  - * greenhouse: two microcontrollers --> more sensors & actuators
  - * grouping: two groups/greenhouse --> inter-group collaboration
- Practices
  - * NGSS: focus on analyzing and interpreting data
  - * CT: focus on analysis and abstraction
- Research
  - * focus on student engagement (shorter-term)
  - * emphasize connections to prior experience with coding

Partners

*"Mills City" Public Schools
*Dr. David Blustein & colleagues
*Dr. Belle Liang & colleagues

References available upon request

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