Computational Heterogeneity in STEM Education

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Orientation

Code and coding as *heterogeneous language*

Attention to Heterogeneity can counter Technocentrism

A story in three parts

- pedagogy
- discipline
- public imaginations of code
Technocentrism

- Device-centred approaches for pedagogy and computational design
- Ignores: teaching, social and institutional infrastructures, cultural histories
- Transparency / universality [of code and devices] as symbolic power
- Recursive methods for ed research: Experience “measured” by being *folded* back onto devices
- Leads to symbolic violence: “misrecognition” of experience, muting and omissions of voices, affect and moral dimensions of experience
Heterogeneity

A necessary counter-world to technocentrism

- Challenge notions of ownership and control
- Center *voices* of learners and teachers
- Unfold computing beyond and away from devices without excluding them
- Offer a necessary *axiological* re-orientation for computing and STEM education
Contexts

A series of studies of various time-scales

- 23 minutes after first “seeing” a computational modeling problem
- 2 weeks in classroom settings
- Year-long studies in classrooms
- 2 years-long studies (same teacher, mostly same students) in classrooms
- Open computational science in public spaces
Part 1: Coding as heterogeneous language in the classroom
Insight 1a: Coding as Perspectival Heterogeneity

Read: Voicing Code in STEM, Chapter 3: Coding as Perspectival Work

Dr. Amy Farris
Assistant Professor
Penn State

- Meaning emerges through negotiating different visuo-spatial and temporal perspectives.
- Ambiguity of computational languages should not be ignored or framed as “misconceptions”.
- Teaching matters.
Insight 1b: *Being with* the user

Read: *Voicing Code in STEM, Chapter 4: Addressivity in Computational Design*

Publicness of experience is about *being with* others. Notions such as "public artifact", "user-centered design", "personal meaningfulness" can still be technocentric.
Insight 1c: Teacher voice and computational heterogeneity

Read: Voicing Code in STEM, Chapter 6: Computational heterogeneity & teacher voice

Dr. Amanda Dickes
Scientist,
Gulf of Maine Research Institute
Insight 1c: Teacher voice and computational heterogeneity

Read: Voicing Code in STEM, Chapter 6: Computational heterogeneity & teacher voice

Image: Figure 6.10

Refinement of step-size measurement convention from socially defined (heel-to-toe) to sociomathematically defined (toe-to-toe)

Dr. Amanda Dickes
Scientist, Gulf of Maine Research Institute

Code and models as circulating references
Emergence of sociomathematical norms
Insight 1c: Teacher voice and computational heterogeneity

Read: Voicing Code in STEM, Chapter 7: Computational heterogeneity & teacher voice

Transformation between circulating references amplified in instruction

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Implications for pedagogy

Code as utterances and intertext

Heterogeneity and transformation of representational genres: Code lives in translation

Teachers voice needs to be centered in system + activity design and classroom work; researchers must listen

Uncertainty and ambiguity play central roles: Recognition takes time
Part 2: Re-Orientations for discipline

Technocentrism as symbolic violence
Symbolic power at the root of symbolic violence

- “a power of constituting the given through utterances, of making people see and believe, of confirming or transforming the vision of the world and, thereby, action on the world and thus the world itself” (Bourdieu, 1991, p. 170).

Symbolic violence as a form of misrecognition

- “Symbolic violence is the coercion which is set up only through the consent that the dominated cannot fail to give to the dominator … when their understanding of the situation and relation can only use instruments of knowledge that they have in common with the dominator, which, being merely the incorporated form of the structure of the relation of domination, make this relation appear as natural; …” (Bourdieu, 1991, p. 170).

“Subjugation inhabits the habitus, deep in the unconscious.” – Burawoy, 2019

Bourdieu, 1991
Burawoy, 2019
Ethnocentrism Simulation

Von Neuman neighborhood

Schelling, 1980
Axelrod & Hammond, 2003
Wilensky, 2005
Two Studies

- Study 1: Pre-service teachers in Southern USA
  - Classroom based; three weeks long; almost all White participants

- Study 2: Post-secondary students in Canada
  - Ongoing
  - Facilitated interviews; <50% White participants; many participants are new immigrants of color
Transitional Othering (Study 1)

Read: Voicing Code in STEM, Chapter 5: Recontextualization & Transitional Othering

Transitional othering: Positioning both the “self” and the “other” in discourse about the simulated agents, without necessarily implicating ourselves, but drawing from our lived experiences.

Involves recontextualizing generalized representations.

Computational social science shows a similar trajectory.
Transitional Othering (Study 1)

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**Transitional othering**: Positioning both the “self” and the “other” in discourse about the simulated agents, without necessarily implicating ourselves, but drawing from our lived experiences.

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Computational social science shows a similar trajectory.
Discourse about forced slavery in terms of the variables used in Axelrod & Hammond’s (2006) model

“...the CD will be plantation owners and those who benefited from slave labor, within the South and then CC would be slaves...it would be slaves because they contributed to other people, as well as themselves. But the energy was not being given as the same rate”

Sengupta, Chokshi, Ozacar, Dutta, Sanyal & Shanahan, 2022 - Language & Symbolic Violence in Computational models of Ethnocentrism - Qualitative Studies in Education
Misrecognition (Study 2): The pain of migration

Migration to the Global North (e.g., US, Canada, Europe) people of color often comes with a sense of loss

The “neutral” gaze of the algorithm omits these affective and embodied experiences

Dennis: Um, Yeah. I don't understand really the traitor one. Um, so, willing to kind of go against our own self and then to work with others?

Facilitator: Yeah, they don't cooperate with their own kind. Let's say...it'll sound racist. Let's say a new immigrant is not contacting with their like with his or her people from his or her background or countries of origin. Like, more engaged with Canadians - ignoring the others. Like, let’s say like not having any relationship with Koreans. But like always Canadians and then trying to, uh, build a life with this strategy.

Dennis I wonder if that's like from pressure to kind of.... Pressure to conform to the society in which your immigrating to? Like, if immigration is higher, then maybe you feel more pressure to become like them. And, kind of maybe you want to distinguish yourself from your origin kind-of-thing?

Facilitator: Yeah, because like we were, like as a newcomer, I can say we were expected to assimilate. Right, language is the first step and then afterwards there's all the cultural things coming with it (as a package).
Re-orientations for Computational Literacies

“Reading” code, challenging the White Gaze: Coding as critical translanguaging

Reimagining computational literacies: Technology, migration, affect and literacies may be deeply intertwined

Simren Trehin, PhD student

Megha Sanyal, PhD student
Countering technocentrism: Axiological re-orientations

Modeling ethical-historical dimensions of disciplined experiences
Implications for discipline

Foundations of computational “discipline(s)” may be entrapped within White Gaze and White Innocence

Analogical mappings between code and lived experiences may be fundamentally oppressive

- {Objects, classes, inheritance} vs. {complex, cultural and political histories}

Universalizing goals of computing and computing ed may be at odds with who is learning

- An argument for fundamental changes to algorithms and code, not “personalized” or “differentiated” instruction
Part 3: Public Imaginations
Axiological anchors for public computing

“Moral undertones” in disciplinary practice (Ducey et al., 2020)

Centering desire and dignity: NOT “broadening participation” (Coding as boundary play, Sengupta & Shanahan, 2017)

Contrapuntal imaginations (Philip & Sengupta, 2021, Journal of the Learning Sciences)
Concluding thoughts

Public imaginations rely on code, but without collapsing experience onto code.

Voice Your Celebration, Canada’s National Music Center, Canada Day, 2018
Concluding thoughts

Public imaginations rely on code, but without collapsing experience onto code, we can use code to create spaces that value our differences and center our dignities.
Concluding thoughts

Heterogeneous images of coding

- Utterances, not artifacts
- centering stories from the margins
- intergenerational interactions
- challenging symbolic violence
- making visible moral undertones

... not an exhaustive list, but an invitation
Thank you

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Discussion prompts

How can computing education change so that moral dimensions of human experience are foregrounded?

How can we work to center teachers in research-practice partnerships?

How can we move away from technocentrism without abandoning code and computational devices?