

# Computational Heterogeneity in STEM Education

Pratim Sengupta  
University of Calgary

Invited Lecture, Raspberry Pi Foundation, University of Cambridge  
7 June, 2022

# 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

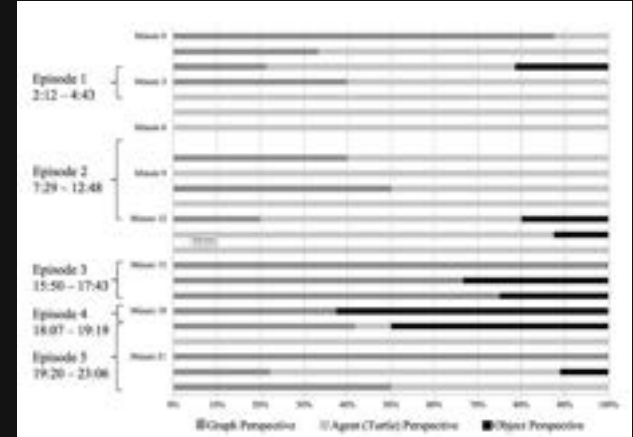
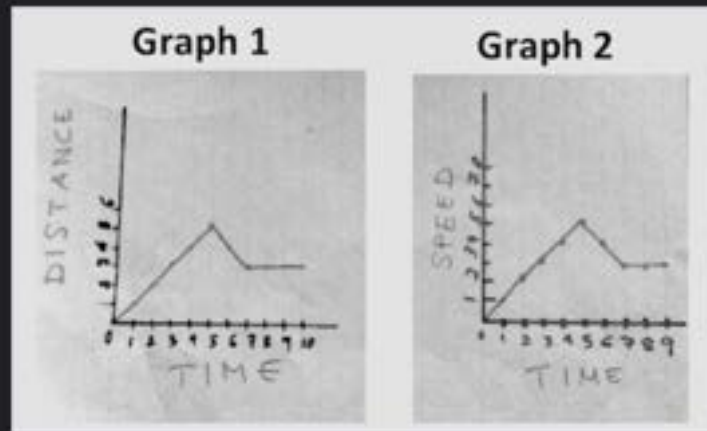
A series of studies of various time-scales

- 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*



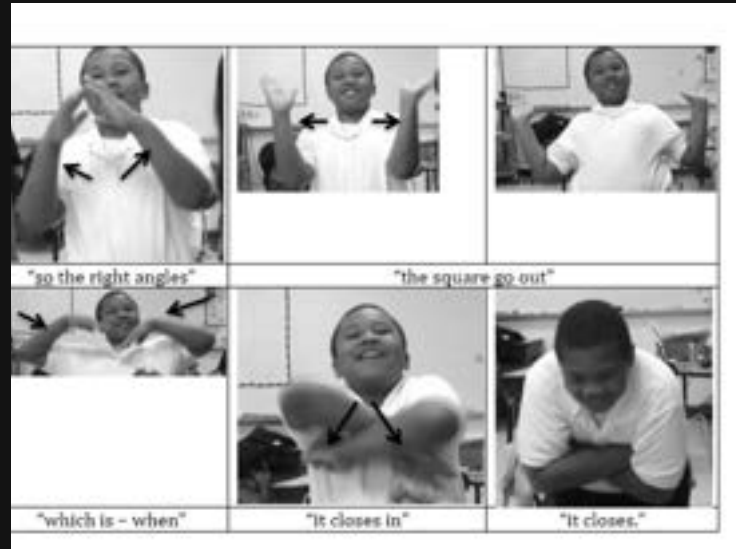
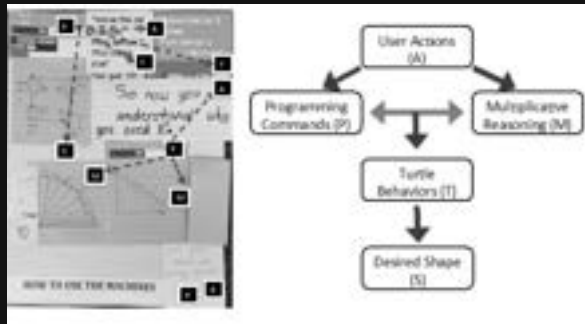
Dr. Amy Farris

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



**Figure 6.8**

Investigations of perimeter and polygons in Emma's classroom. The top-left shows a paper-based representation of the VIMAP shape and graphs, and the top-right shows a multiplication table that demonstrates the multiplicative relationship between the number of sides of a regular polygon and the exterior turn angle of the VIMAP Turtle.

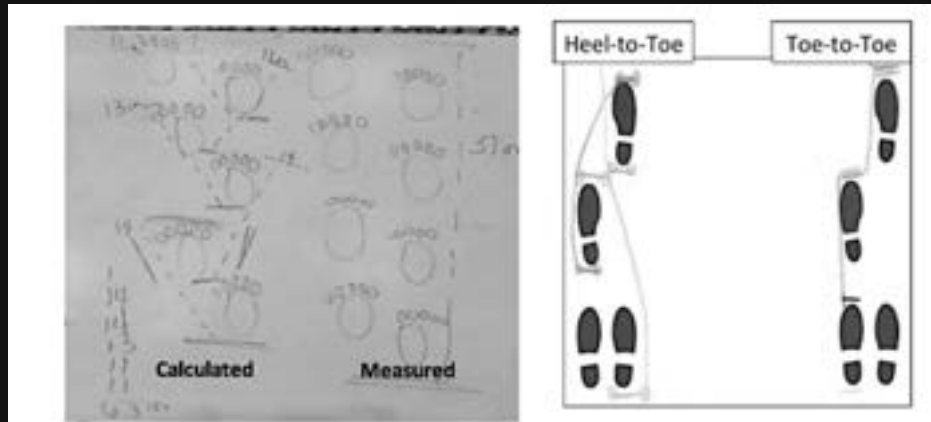
# Insight 1c: Teacher voice and computational heterogeneity

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



Dr. Amanda Dickes

Scientist,  
Gulf of Maine Research Institute



**Figure 6.10**

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

Code and models  
as *circulating*  
*references*

Emergence of  
sociomathematical  
norms

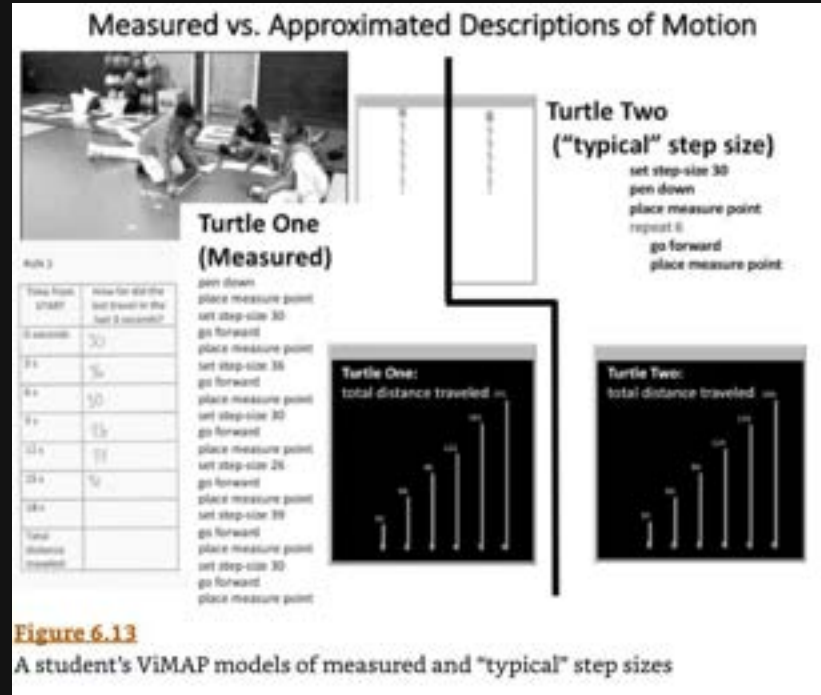
# Insight 1c: Teacher voice and computational heterogeneity

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



Dr. Amy Farris

Assistant Professor  
Penn State



Transformation  
between circulating  
references amplified in  
instruction

# Insight 1c: Teacher voice and computational heterogeneity

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



Dr. Amy Farris

Assistant Professor  
Penn State



Transformation  
of circulating  
references  
amplified in  
instruction

Error is  
recognized as  
central and  
essential to  
modeling

Differences  
valued over  
homogeneity

# 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 Violence as Misrecognition

Bourdieu, 1991

Burawoy, 2019

Symbolic power at the root of symbolic violence

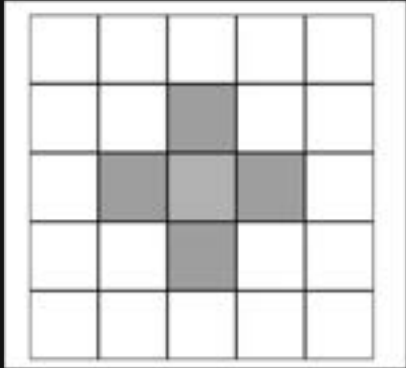
- “a power of constituting the given through utterances, of making people see and believe, of confirming or transforming the vision of the world and, thereby, action on the world and thus the world itself” (Bourdieu, 1991, p. 170).

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

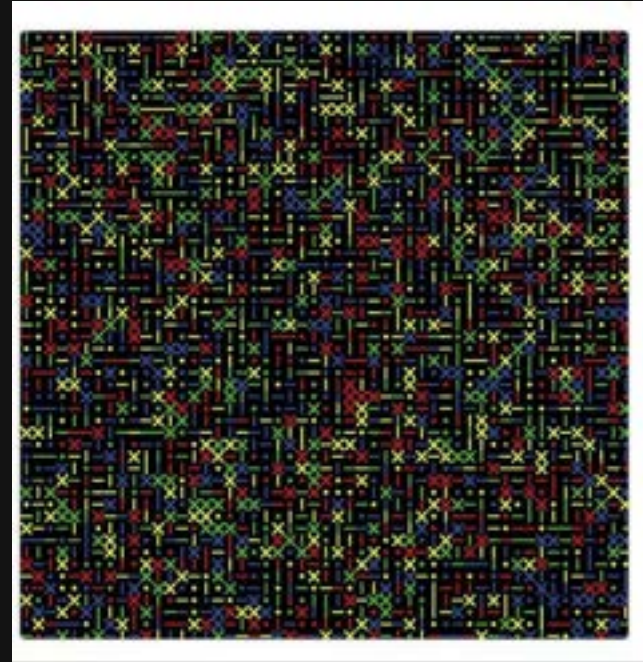
# Ethnocentrism Simulation



Von Neuman  
neighborhood

```
to interact
  ask turtles-on neighbors4
  [
    if color = [color] of myself
    [
      if [cooperate-with-same?] of myself
      [
        ask myself [ set ptr ptr - cost-of-giving ]
        set ptr ptr + gain-of-receiving
      ]
    ]
    if color != [color] of myself
    [
      if [cooperate-with-different?] of myself
      [
        ask myself [ set ptr ptr - cost-of-giving ]
        set ptr ptr + gain-of-receiving
      ]
    ]
  ]
end
```

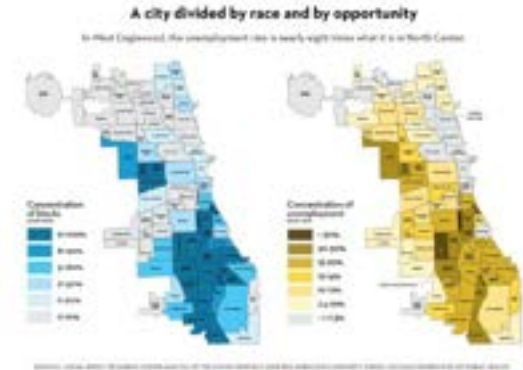
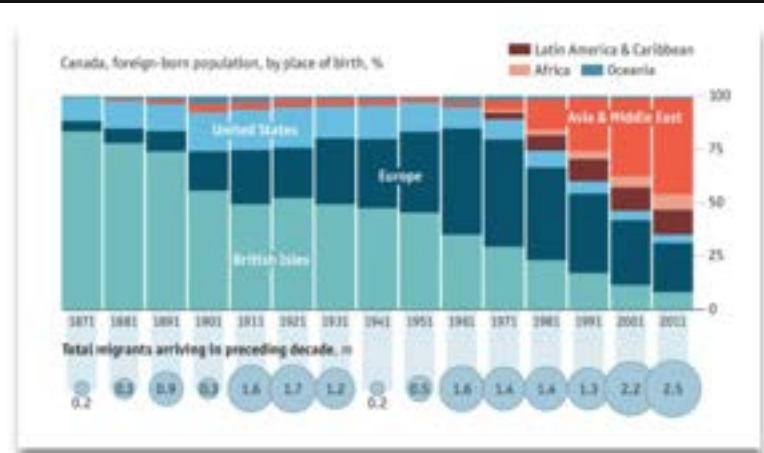
Schelling, 1980  
Axelrod & Hammond, 2003  
Wilensky, 2005





# 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*

"it's important for [students] to have that experience so they can look down on themselves and not just say 'Oh, I'm the blue dot' but also think 'there are the red dots, the green dots' so they can think about this stuff so that they are challenging themselves and thinking about it not just from their normal perspective, so yeah, I think like yeah, find your house, but it's not just about your house at the same time"

*Self: Oh, I'm the blue dot; so yeah, I think like yeah, find your house*

*Other: 'there are the red dots, the green dots'; so yeah, I think like yeah, find your house, but it's not just about your house at the same time"*



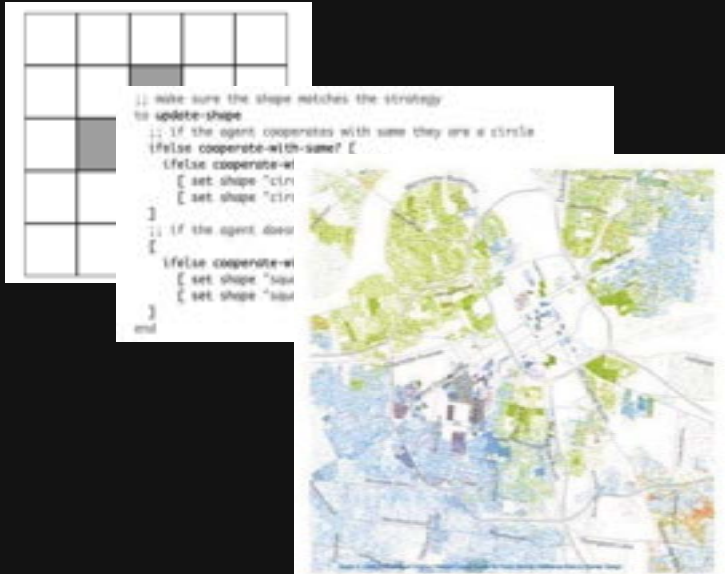
**Transitional othering:** Positioning both the “self” and the “other” in discourse about the simulated agents, without necessarily implicating ourselves, but drawing from our lived experiences

Involves recontextualizing generalized representations

Computational social science shows a similar trajectory

# Transitional Othering (Study 1)

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



```
;; make sure the shape matches the strategy
to update-shape
  ;; if the agent cooperates with same they are a circle
  ifelse cooperate-with-same? [
    ifelse cooperate-w
      [ set shape "ciri
        [ set shape "ciri
  ]
  ;; if the agent does
  [
    ifelse cooperate-w
      [ set shape "sasi
        [ set shape "sasi
  ]
end
```

*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

## MISRECOGNITIONS IN TRANSITIONAL OTHERING

*Sengupta, Chokshi, Ozacar, Dutta, Sanyal & Shanahan, 2022 - Language & Symbolic Violence in Computational models of Ethnocentrism - Qualitative Studies in Education*

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”

# Misrecognition (Study 2): The pain of migration



Apoorve  
Chokshi,  
PhD student

*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*



Basak Helvacı  
Ozacar,  
PhD student

```
;; make sure the shape matches the strategy
to update-shape
  ;; if the agent cooperates with same they are a circle
  ifelse cooperate-with-same? [
    ifelse cooperate-with-different?
      [ set shape "circle" ] ;; filled in circle (altruist)
      [ set shape "circle 2" ] ;; empty circle (ethnocentric)
  ]
  ;; if the agent doesn't cooperate with same they are a square
  [
    ifelse cooperate-with-different?
      [ set shape "square" ] ;; filled in square (cosmopolitan)
      [ set shape "square 2" ] ;; empty square (egalist)
    ]
  ]
end
```

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



Simren  
Trehin,  
PhD student

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



Megha  
Sanyal,  
PhD  
student

# Countering technocentrism: Axiological re-orientations



Santanu Dutta  
PhD Student

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)



## Moral Horizons of Pain

Canmore, Aug & Oct 2021

# 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

*Voice Your Celebration*, Canada's National Music Center, Canada Day, 2018

# 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



Email: [Pratim.sengupta@ucalgary.ca](mailto:Pratim.sengupta@ucalgary.ca)

# 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?