Computing for Generative Justice: decolonizing the circular economy

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Some knowledge is socially constructed:

Which is the most delicious food? There is no universal, objective answer.

Some knowledge is objective:

Which of these liquids has the greatest density? You don't even need a human, the liquids will sort themselves.
Knowledge systems: both objective AND socially constructed aspects. Example: the history of Euler’s law

1752: Euler proposes relation of Vertices, Edges, and Faces: \( V - E + F = 2 \). Polyhedra are defined as "a solid whose faces are polygons."

1815: Hessel’s cube with a cubic hollow inside does not satisfy Euler's theorem. A fight! Euler wins. Polyhedra redefined: "a surface made up of polygonal faces."

1865: Mobius notes that two pyramids joined at the vertex also defies Euler's theorem. A fight! Euler wins. Polyhedra redefined as "a system of polygons such that two polygons meet at every edge and where it is possible to get from one face to the other without passing through a vertex."

Each branch point is a math we could have pursued (but did not!)

- Euler's formula discarded.
- Polyhedra redefined as "a system of polygons such that two polygons meet at every edge and where it is possible to get from one face to the other without passing through a vertex."
- 1865: Möbius notes two pyramids joined at the vertex also defies Euler's formula.
- 1815: Hessel notes that a cube with a cubic hollow inside does not satisfy Euler's formula.
- 1813: Lhuilier notes that a polygon with a hole going through it does not satisfy Euler's formula.
- 1752: Euler proposes relation of Vertices, Edges, and Faces: \[ V - E + F = 2. \] Polyhedra are defined as "a solid whose faces are polygons."

Pickering: each branch point is a “mangle” of human and non-human agency
Branch points in cultural evolution

Obviously this is an over-simplification -- the branches are entangled.

There is no “primitive” knowledge, just branch points where knowledge systems diverged.

What was Europe’s branch point of divergence?
Europe: Extractive Economy and Extractive STEM Co-Evolve

<table>
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<tr>
<th>Economics</th>
<th>Science and Technology</th>
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<tbody>
<tr>
<td>Skilled employees demand high pay. Break into little tasks: “deskilling”</td>
<td>Physics: Efficiency metaphor defines relation of energy to work: extracting maximum work for minimum effort.</td>
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<tr>
<td>Borrows term “efficiency” from physics: deskilling is just following Nature’s laws</td>
<td>Engineering: defines: tool design driven by Smith’s deskill goals</td>
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<tr>
<td>Competition in technology requires business advances in accounting and logistics for extraction</td>
<td>Computing: Charles Babbage cites Adam Smith’s pin factory as model for computer</td>
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Europe: Extractive Economy and Extractive STEM Co-Evolve

“Poor people? Well, that’s just part of nature. You cannot argue with the laws of physics!”

European economies of extraction inspired the kinds of science and technology that serve that purpose.

If you believe that is the only kind of science possible, then optimizing for the extraction of value from workers seems like an inevitable law of the universe. BUT IT’S NOT
Western knowledge’s branch took a wrong turn in seeking the *extraction of value*

Extracting ecological value from pollution and overharvesting

Extracting labor value from low paid, unfulfilling jobs

Extracting social value by colonizing our landscape, physically and online
Both capitalism and communism: extraction of value

Nature, labor and society are self-generating sources of value
But their value is extracted; alienated from its source.
Nature does not extract value, it circulates it

Biomolecules: autocatalysis

Organisms: autopoiesis

Ecosystems: sympoiesis

At every scale, the power of life is due to self-generation

Erwin Schrödinger: “negative entropy”

Indigenous traditions also used this recursive loop of circulating value
Nature uses fractal geometry, because of its bottom-up emergence.
Fractals are patterns that repeat at many scales, typically created by a “bottom-up” cycle.
Africans are using bottom-up organization, and creating fractal forms as a result.
I was often told fractals in African architecture must be unintentional—but evidence shows otherwise.
The recursion--shapes within shapes--is used to symbolize ancestral relations and other spiritual meanings.
Recursive scaling is a conscious theme in African design.
Heritage Algorithms: African case includes intentional cycles of nonlinear scaling
Africa’s fractal heritage in the Americas

Architecture could not be brought along, but the concepts of recursion and nonlinearity came via cornrow braiding, quilting, growing traditions, making traditions, spiritual concepts and so on.
Not just symbolic: cycles of unalienated value flow form the traditional generative economy.
Western STEM was created for value extraction. Indigenous STEM’s goal is to **prevent** extraction, and nurture cyclic generation.

We have trouble recognizing Indigenous STEM: because we are blind to generative technologies...
Ethnocomputing uses simulations to translate Indigenous Knowledge to a heritage algorithm.
CSDTs: indigenous ethnocomputing

Virtual Beadloom

Adinkra Grapher

Precolombian Pyramids

African Fractals

Anishinaabe Arcs

Navajo Weaver
CSDTs allow creative exploration with heritage algorithms
Fractal Simulations of African Design in Pre-College Computing Education


• 10th grade computer science class, two sections.
• About 75% minority, over 50% female.
• Control class has 6 days on fractal instruction websites with java applets.
• Intervention class has 6 days on the African fractals website.

• Post-test shows higher scores in intervention group;
• statistically significant at .001 level
The WRONG way to think about culture-based STEM education
How to bring Indigenous and vernacular knowledge into education without reduction to the service of hegemony?

CSDT development process

1. Work with artisans, elders, others to ensure we have a basis for collaboration and “cultural permission” (not just a matter of copyright!)

2. Interview artisans and research cultural background to understand the knowledge system from their point of view (“emic” not “etic”).

3. Translate their practices and concepts into equivalents in STEM (weaving algorithms, geometric transforms, power law scaling, anti-aliasing, context free grammars, etc.).

4. Embed these concepts in a “design tool” applet that allows students to simulate the original designs and create their own innovations
How to bring Indigenous and vernacular knowledge into education without reduction to the service of hegemony?

CSDT deployment process

1. Students need anti-primitivist cultural, historical background. Examples: graffiti is not just vandalism; cornrows are not just fashion; beadwork is not just decoration.

2. Students need anti-primitivist STEM representations; eg heritage algorithms

3. Students need anti-essentialist frameworks: the freedom to allow hybridity, exploration, expression, agency.

4. Teachers need the flexibility to make curricular connections that emerge naturally from the intrinsically motivated activities of students

5. Communities need a generation of youth that can see how education contributes to local empowerment.
hybridity, not purity

we start with Indigenous tradition, but leave room for exploration
CSDT pedagogy: the inverted funnel of expanding agency in Generative STEM

Level 1: simulating original artifact from community
Level 2: creative exploration of heritage algorithms
Level 3: Creative physical renders
Level 4: Creative Community contributions
The Generative Cycle in Albany

Practical applications benefit braiding shops and inspire more student interest

Development of testing kits for hair product pH

Cornrows simulations for STEM

3D printed mannequin heads to increase customers
Ecological value flow between humans and non-humans is one Indigenous strategy for preventing extraction.

Native American use of arc geometry is a relationship with trees.
Results from educational workshops

“I believe my design represents the two worlds I come from. One being of my Native heritage and the other of the technology era. With the completion of my structure I was able to combine two worlds and accumulate an interest in engineering... This project has taught me that I can provide and give back for my people while incorporating important traditions and teachings to create a productive environment”
Unalienated value forms are often embodied relations between human and nonhuman collaborators.

Bézier worked at French automaker Citroën. Wood spline became computer graphics spline. The same curve family created in Anishinaabe tradition.
The Generative Cycle in Anishinaabe culture

NMU Center for Native American Studies investigates Indigenous knowledge and practices

Students develop ideas for how STEM can contribute to indigenous communities

Physical rendering and discovery learning

Students learn Heritage algorithms
Embodying labor value is another Indigenous strategy for preventing extraction.

Generative economy is maximizing the visibility of labor, to ensure ethical flows of value. Capitalism ensures invisibility by converting value to numbers, masking injustice.

Craft complexity is labor value made visible.
AI in Kente Authentication

Putting it to work:

Youth learning STEM through CSDTs; learning digital fabrication in collaboration with elders.

Traditional artists working with youth to bring new techniques into their product line.

Inter-generational STEM learning puts Africa’s heritage into the future.

[https://africanfuturist.org/](https://africanfuturist.org/)
For more on applications:
https://generativejustice.org/projects/