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Eglash, R. (2021). Computing for generative justice: decolonizing the circular economy. In Understanding Computing Education (Vol 2): Equity, Diversity and Inclusion. Proceedings of the Raspberry Pi Foundation Research Seminars.

Available at: rpf.io/seminar-proceedings-vol-2

Computing for generative justice: decolonizing the circular economy

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We are often told, quite rightly, that the only hope for a sustainable future is to transition to an economy that is circular. We envision discarded products recycled, carbon exhaust reutilized, waste heat warming houses, and so on: the “industrial symbiosis” touted by corporate giants and government research agencies. But these formulations often fail to address the underlying problem. There is no reason to think that more environmentally sustainable technologies will avoid the low paid work and poverty the current technology creates. Current trends in neuromarketing, spyware, gamification and related technologies are dedicated to increasing consumption of things we do not need. Microplastics--which are emitted just as much by recycling as any other plastic process--are now found in the placentas of unborn babies. We are seeing an increase in “voluntary segregation” created by real estate costs, patrolled by militarized law enforcement and fueling a rising tide of racialized nationalism. But this need not be the case. A decolonial or *generative* economy could bring the circular flow to all forms of value exchange: to ecological value; to labor value; and to social value. Enabling the next generation to view STEM through this lens, and effect this transition, requires a different approach to knowledge; and a shift in the kinds of computational tools we provide.

Some forms of knowledge are purely social, subjective and personal. What I think is the best tasting food is not necessarily what you think. Other forms are more objective: if I add in a bit of coloring to oil, water and alcohol, and pour them into a glass cylinder, they will eventually settle into their respective density layers. No human has to be present; they will sort themselves on their own, surely a good sign of objective facts. But knowledge *systems* are far more complex than isolated facts, and involve the combination of social and objective understandings. Consider, for example, the history of Euler’s formula for polyhedra (figure 1). We know it to be Vertices - Edges + Faces = 2. But it is actually a history of counter-examples. Hessel pointed out that a hollow inside a cube is an exception; Möbius did the same for two pyramids joined at a vertex. Each time the math community had a

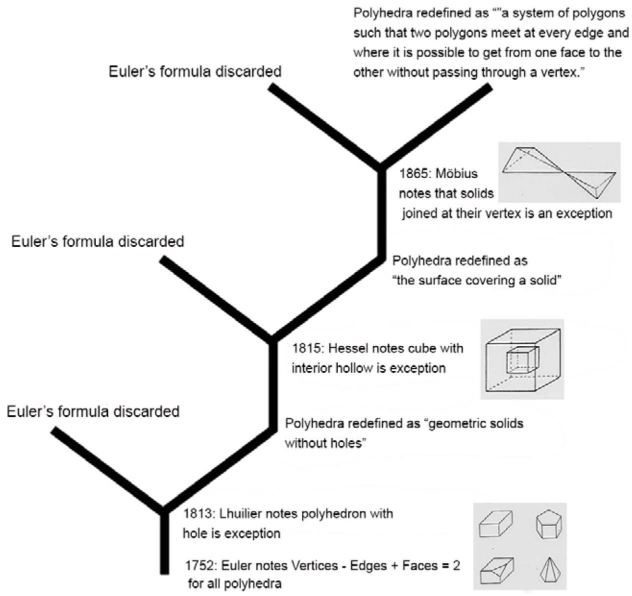
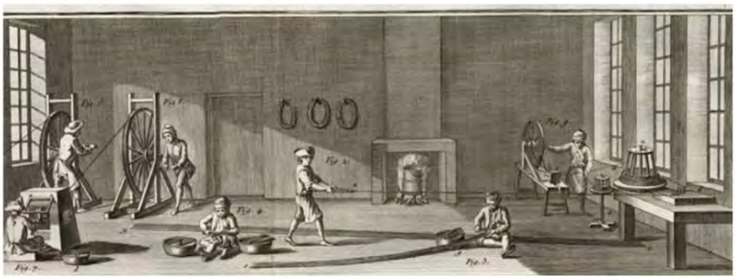
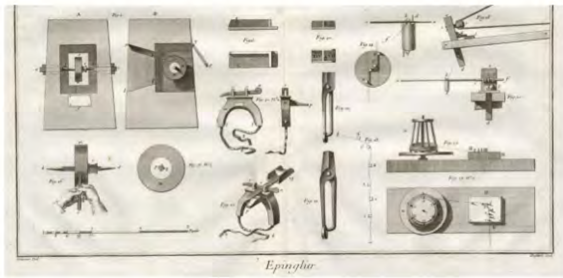


Figure 1. The evolution of Euler’s formula for polyhedra, with controversies and branch points.

Europe: Extractive Economy and Extractive STEM Co-Evolve





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

Figure 2. The co-evolution of Europe’s labor extraction and its STEM foundations.
Illustration: Designed by Goussier, engraved by Defehrt (1762); file author unknown, Public domain, via Wikimedia Commons.

debate. Each debate is a potential *branch point* in the evolution of Euler’s formula; a path to mathematics we do not have, but could just as easily have adopted. It became a positive feedback loop: the more it was defended, the harder it became to dislodge it, even though the definitions had to become increasingly baroque. Perhaps some day we will encounter aliens and see the math resulting from a different branch point.

But we don't need to venture into space for that; we have different knowledge systems right here in earth’s cultural traditions. They too have branch points at which they began to differ. Europe’s early knowledge systems were strongly influenced by Greek, Roman and other empires. A positive feedback loop between wealth extraction, technology development, and military power set Europe on a trajectory as surely as did the feedback loop for Euler’s defense. Industrialization in the modern era amplified this tendency. Figure 2 shows how the kinds of deskilling of labor celebrated in Adam Smith’s

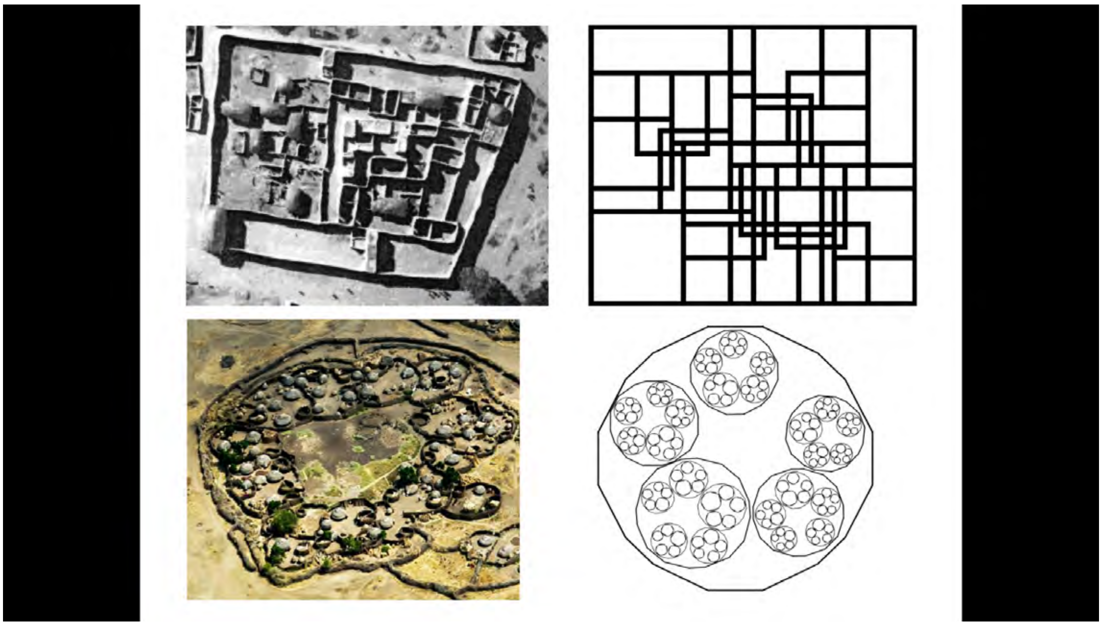


Figure 3. Fractal architecture in Africa.

Wealth of Nations stimulated the development of technology for this purpose. Conversely, when physicists used the term “efficiency” to define maximum work for minimum effort, it was embraced by the business world (Smith in particular declared that in a static economy, workers should be paid wages that keep them on the edge of starvation, since no population growth is required until more factories need to be filled). Charles Babbage specifically cites Smith in his description of the first computer: the deskilling of human labor was the perfect model for separating functions like memory, math and output. Conversely, Babbage envisioned computers as the ultimate technology for replacing high wage artisans with low paid, deskilled drudge labor. While factories focused on labor value extraction, farms, fisheries and the like developed STEM for ecological value extraction, degrading soil, air and water. Deforestation and deskilling might seem like different processes--one devastating to nature, the other to culture--but they are ultimately the result of the same knowledge system: extractive STEM.

Indigenous knowledge systems took a different branch point, that of generative STEM. In nature, value is generated in cycles: biomolecules like the Krebs cycle; organisms like the reproductive cycle; entire environments in the ecosystem cycles. Indigenous cultures utilized these circular flows, in many cases enhancing nature’s productivity rather than harming it. Far from the colonial view of ignorant “children of the forest”, Indigenous knowledge reflected sophisticated understandings and techniques for maintaining circular flows of value, without extraction. Because it has a radically different basis, it is hard to recognize Indigenous STEM when we see it.

Figure 3 shows some examples of fractal architectures in Africa. They are not created by a single master-mind imposing their structure on the masses; the top-down model celebrated in works such as Ayn Rand’s “Atlas Shrugged” or the USSR’s Stalinist urban planning. Rather, they evolve bottom-up, growing in adaptive response to local needs: goals that Western

Figure 4. Top: the roof of a church in Ethiopia; its nonlinear staircase; an African symbol for recursion. Bottom: fractal simulation for an Ethiopian cross; the cross in metal and cloth.

architectural sciences have barely conceived. Africa's recursive fractal forms can be found in textiles, sculpture, and myriad symbolic forms; in practical crafts from windscreens to winnowing baskets; and in the structural flows of restorative justice, ecological sustainability and egalitarian relationships traditional to these cultures (figure 4). Space does not permit more detail here, but more can be found in Eglash (1999) and my TED talk.

Africans could not bring their physical artifacts across the middle passage, but cornrow hairstyles were one of the fractal traditions that survived and flourished. Figure 5 shows one of our efforts to "translate" those recursive traditions into contemporary STEM education practices in the US. The process is similar when we work with Native American, Latinx, and low income groups of all ethnicities. We begin by interviewing artisans, elders, anyone who represents that traditional approach, both to make sure we have permission, and to ensure we are representing the tradition respectfully and accurately. We then translate their concepts into a set of online apps called Culturally Situated Design Tools, or CSDT for short (csdt.org). Students use those tools to learn what we call "heritage algorithms" (Bennett 2016). At first they are simply simulating the originals. They then use them creatively to generate their own innovations. The next step is to facilitate physical rendering of the designs, using laser cutters and other digital fabrication. This creates two opportunities.

First, it opens the involvement of adult artisans. In the case of figure 5, it inspired local braiding shop owners to get involved. They suggested a focus on the pH damage in commercial hair

Figure 5. The generative cycle using a cornrows simulation tool at csdt.org.

products, so that became a new CSDT. It also inspired new entrepreneurial activity, with one student producing and marketing her own organic, pH neutral hair product. And that is the second opportunity: offering the chance to create healthier, more sustainable and more just versions of STEM. In Ghana this generative cycle showed statistically significant improvement for students in controlled comparisons to their current approach (Babbitt et al., 2015). But we also created new opportunities for STEM activities, such as solar production of Ghanaian fabric dye, mushroom foam replacement for plastics, and intergenerational collaborations between youth using laser cutters and elders with sewing machines[9] In our most recent project, we developed AI that can distinguish between factory fakes and hand-made fabrics (Robinson et al 2020). Machine learning of this sort is not limited to the microscale; by networking these small artisanal operations into larger cooperatives (our example[10]) and those into macroscale ecosystems, one can imagine a more just, sustainable and equitable role for STEM in sustaining an entire artisanal economy (Eglash et al 2019).

Conclusion

These generative STEM examples all utilize the Indigenous circular structure: starting with local knowledge; translating that into STEM equivalents; facilitating their creative use both virtually and as physical renderings; and bringing that value back to the community. They range from US inner city applications, to Native American, Latin American, and African communities (Eglash et al 2020). At this point they are merely "proof of concept", but I hope they offer a vision for the kinds of change that need to occur.

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[9] https://generativejustice.org/projects/
[10] https://africanfuturist.org/

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