Embracing Impossibility: Computer Science Education for Tomorrow

Paper abstract:

We posit that any university course at the intersection of society and computing must *explicitly* deal with impossibility. Here by impossible we do not mean something that the students should give up on but rather as something that drives their curiosity, that defines the limits of what they understand as possible.

Any serious attempt to tackle problems at the intersection of society and computing must contend with the impossible nature of the global challenges we now face. Engaging with the likelihood that solutions to major global challenges may be impossible typically leads students down the path of apathy and they tend to give up. The humanities can help. Take, for example, the history of the African diaspora. The descendants of the 12 million enslaved Africans who were forced to cross the Atlantic continue to face an existential threat to their humanity today due to the legacies of oppression. Yet, the history of the African diaspora is full of examples of resistance against oppression in a context of insurmountable odds. Examples such as these can certainly inspire our students today, but we are proposing more than exposure. What we are suggesting is that there is something more profound to be gained by computing students from engagement with Africana Studies. Indeed, we suggest that our students not just learn about these stories, but study and incorporate into their computing education the skills, capacities and dispositions of those who have survived under impossible circumstances. Who better to learn from about how to face insurmountable odds than those who in the face of the denial of their very humanity, continue to struggle to attain the freedom and dignity that should belong to all? Franz Fanon articulated this particular pain when he wrote: "I came into this world anxious to uncover the meaning of things, my soul desirous to be at origin of the world, and here I am an object among other objects [Fanon, 1952]." For black people, the only route to true freedom, to moving from object to subject, is the creation of a fundamentally different imagination of the world. This is increasingly true for all of us as humanity careens toward mutually assured self-destruction taking the rest of the world with us. Perhaps we cannot be saved, but the innovative strategies of survival and flourishing born out of the impossibility of black existence can benefit our computing students and they give form and shape to our digital future.

Exposed to black theory, computing students would learn to make sense of quotes like this one from legendary Afrofuturist jazz composer Sun Ra: "The impossible interests me because everything possible has been done and the world didn't change (Hsu, 2021)." Typically considered a call to "shoot for the stars," Sun Ra's quote can be interpreted otherwise, as encouraging us to think about the need for an onto-epistemic revolution (a change in our sense of being human and in how we know ourselves and think about the world). Indeed, many of the vexing problems of our times *are* impossible to solve in the *current* world. In other words, that which is "impossible" is not possible because it has not yet become *thinkable*. What Ra is saying is that thinking about what is possible in the current world will not lead to changes– to do that we need to think about what is impossible in the current world. Also invoking the impossible in this text *The Fire Next Time*, James Baldwin wrote, "The impossible is the *least* one can demand" (emphasis ours). In higher education, we tend to focus on preparing students for tomorrow's economy. If we are serious about global change, however, we need to prepare our students to think like Baldwin and Ra. They must become convinced that the very *least* they must do is change their notion of the world entirely. What technologies will be built and imagined by students with this perspective?

The above phrasing of thinking about the impossible might seem foreign to a lot of computing students where the overwhelming majority of computing curricula (and indeed how computing degrees are marketed) is solely focused on what is possible. However, this is not inherent to computing. One of the tragedies of how computing is currently taught (including at our institutions) is that it has forgotten the roots of computer science. Indeed, one of the most influential works that gave rise to (modern) computer science is the 1936 paper of Turing where the *main result is an impossibility result:* i.e. there are

problems that computers provably (in a mathematical sense) *cannot solve*. To paraphrase Christos Papadimitriou (we heard this quote attributed to Papadimitriou by Avi Wigderson), computing is unique as a discipline since it was born *aware of its limitations*. Turing's impossibility result did not mean the death of computer science. Indeed, the first few decades of computer science was solely about figuring out what is possible by thinking of impossibility results as setting limits on what is possible. Specifically, computer science was successful by defining computation models and then trying to precisely define what problems could or could not be solved. More pertinent to our discussion of society and computing, computer scientists studied models that were not (known) to be possible in the world as it existed then (e.g. quantum computing theorems are still being proven even though we do not have a quantum computer that in practice has been shown to be better than classical computers). We should clarify that it is not the case that no one is thinking about impossibilities in computing– indeed research in the subfields of computational complexity and programming languages routinely wrestle with the impossible. However, the UG computing curriculum, at least in the US, has moved away from requiring a computational complexity course for their students.

What we are advocating for then is for computing students to unlearn the current "it is all possible with computing" ethos of computing UG education and to be relentlessly exposed to the notion of impossibility in their curriculum from both scientific and humanistic standpoints. As an added advantage, thinking about impossibility in computing (in the traditional context of computational complexity) will inculcate humility in computing students, which is sorely lacking. We posit that exposure to impossibility in the "traditional" computing context will make students more open to wrestling with impossibilities when thinking about problems at the intersection of society and computing *along* with their collaborators from other disciplines.

We tried to implement the above proposal via the Impossible Project framework. The impossible project is an innovative pedagogical approach rooted in Africana Critical theory. It is a project-based curriculum where a group is given the challenge of solving an impossible project. The focus, given the impossibility of success, is not on the result but on the process that the project participants experience. The Impossible Project is meant to seed new forms of collaboration in the interests of global change and increase participants' tolerance for impossibility, as well as their capacity to sustain themselves beyond the point of frustration and disillusionment.

We implemented the Impossible project in a Spring 2024 co-offering of two courses as follows– one in history titled *Rage Against the Machine* (a course on 19th /20th century diasporan black experiences) and one in computer science and engineering titled *ML and Society*. The shared centerpiece of the courses was the semester-long project, where teams of students from both courses came together with the overarching goal to "end white supremacy." In total, we created 7 cross-disciplinary student teams of 3-4 collaborators each (each group had at least one student from each of the two courses). To support the students in their projects, the two courses had lectures that provided students with "tools." These were technical tools in computing and theoretical tools in history. The students had to figure out how to use the tools from both courses to inform the development of their solutions.

Drawing on the African diaspora, students in the history class were exposed to three tools: refusal, undoing and the critical imagination. Students learned the importance of noncompliance. Once they refused to comply, they could progress to productively undoing or unraveling that which holds oppression in place. Once they had unraveled, they moved on to a "freedom dreaming" practice (Kelly, 2002). Engaging the critical imagination, they conjured a better fairer world and imagined what computing technology would look like in and for that world.

The ML and Society lectures considered the tools of causal inference, simulation and impossibilities. For impossibilities, we considered the following `flavors' of impossibility (where the goal is to solve a problem computationally):

- It is impossible to come up with a precise definition of the problem we want to solve
- You can precisely define the problem but it (provably) has no solution (e.g. one can prove that it is impossible in general to simultaneously satisfy three natural definitions of fairness).
- You can precisely define the problem, which does have a solution but it is computationally hard to solve the problem, where here are the flavors of hard
  - It is impossible to solve the problem (this is the category for Turing's result)
  - Computing the solution with current technology is hard/not possible (this is the category for the P vs NP problem)
  - In theory, a solution can be computed but implementing it in the current world is not possible (this is the category for trying to factor numbers using quantum computers).

Where these approaches to impossibility came together was around the notion that it is, in fact, impossible to make computing truly just in our current world. That doesn't mean that we can't make improvements in the lives of many through our current and future technologies, but it means that our computing technologies will always reinforce the world as we know it because they are products of our current world. New tech demands new visions, and truly new visions can only be produced through humanistic approaches to onto epistemic change. To embrace this kind of change, we need to listen to the voices of the most marginalized among us, to those who have long been victimized by the systems that keep the status quo in place. They hold the critical lessons we need. Reconceptualizing computing computing education with Africana Studies and other humanistic disciplines would be a promising start.

To conclude, we would like to share a bit more about the outcomes of our pedagogical experiment. We invite you to review the projects of our students here. You will notice that some final projects centered around computing technologies while others did not, suggesting that a reasonable outcome of a computing-humanities pedagogical project is that tech is *not* the primary solution at all. In the projects where digital technologies were centered, they focused not only on social good but were conceptualized as tools to achieve consistent social good for the building of a justice world. In the [paraphrased] words of one of our students, the goal became not just to "think outside of the box, but to tear it up."

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Dr. Dalia Antonia Caraballo Muller's academic work is motivated by her twin (and intertwined) passions: Afro-Latin American/Latinx intellectual history and educational program development for social and planetary justice. The through line that connects her historical work and her work in educational program building is the concept of "impossibility." She is currently researching African and Afro-descended intellectuals in early 20th century Cuba who thought at the limits of the possible as they staked claims to rights, dignity and equality in a world that denied their full humanity. In her teaching and program building, Dr. Caraballo Muller invites her students to stretch their minds and think at the limits of the possible by engaging in freedom dreaming practices inspired by our ancestors of the African diaspora as they conjure new futures for our ailing world and planet. She currently enjoys the support of a Mozilla Foundation Responsible Computing Challenge grant through which she is exploring justice-centered education in the age of generative AI.