Rethinking Computer Science Education:
Bringing Public Interest Technology into Undergraduate and Postdoctoral Training
FINAL REPORT

Goals and Objectives Achieved:

The purpose of this project was to build institutional capacity to expand the public interest technology (PIT) pipeline at undergraduate and post-PhD levels. Our goals were to:

1) To serve as a bridge across communities by hiring a postdoctoral fellow with a computer or data science background and interests in data ethics, social and racial justice, and governance. We aimed to provide training to equip them for a PIT position in academia, industry, civil society, or government. The postdoc will last two years.
2) Rethink the computer science (CS) curriculum for University of Michigan's (UM) undergraduate program, the largest in the country, with an emphasis on social justice and racial equity.

Postdoctoral Training

We advanced both of these goals. In the fall of 2020, we began an international search for a postdoctoral fellow, and then hired Johanna Okerlund, who had just completed her PhD in Human-Computer Interaction at the University of North Carolina, Charlotte. We hired Johanna because we thought that she would serve as a perfect bridge between computer scientists and experts in social science, ethics, and public policy. First, Dr. Okerlund received both formal and informal training. During the Winter 2021 semester, she audited three courses in science and technology policy, science and technology studies, and values and ethics: politics and policy in government algorithms. She also began working with the Ford School of Public Policy Science, Technology, and Public Policy (STPP) Program's Technology Assessment Project (TAP), which launched an analysis of the ethical, social, equity, and environmental implications of large language models, a form of artificial intelligence. Johanna's work with the TAP embodied the bridge building that we had hoped to foster through the PIT-UN grant: she provided technical expertise, while developing skills to analyze the implications of emerging technology. And at the same time, I learned how to mentor a postdoctoral fellow with a technical background who sought to develop PIT skills.

Rethinking the CS Curriculum

In her first few months as a postdoctoral fellow, Johanna also conducted extensive research focused on reimagining the computer science curriculum. She did a systematic assessment of how other universities around the world are trying to bring ethics, equity, and justice concerns into science and engineering education and analyzed University of Michigan's computer science curriculum to understand where and how ethics, equity, and justice concerns might be included. In light of this research, Dr. Okerlund concluded that ethics, equity, and justice concerns had to be incorporated into the introductory computer science course (101) in addition to more specialized treatment throughout the curriculum. *This was a crucial insight: she realized that if discussions of equity and justice in computer science were focused on specific technologies (e.g. facial recognition, biased hiring platforms) then students would likely dismiss*

them as not relevant to their chosen career path. But if students learned how ethics, equity, and justice considerations needed to be baked into the foundations of technology development, that would increase the likelihood that they might listen and learn. She then developed a series of lessons and assignments for the 101 course that integrate ethics and justice topics with technical content. A few examples: CS projects sometimes ask students to write code that sorts a list of songs to practice CS concepts of iteration and branching. These assignments could instead ask students to iterate through a list of job applicants and make decisions about who to interview, which would invite the opportunity to discuss how iteration and automation are likely to impose a narrow set of criteria that miss out on nuance and variation. She also left CS instructors with prompts to help students confront their own value system and practice how to draw on different values when designing algorithms.

As Dr. Okerlund conducted her research, she mentored seven undergraduate and graduate students in CS and related disciplines who helped develop the set of lessons and assignments. She also provided them with semi-structured training, about how to think about ethics and justice as they related to CS, drawing from the courses she audited. Many of the students had a general interest in ethics and justice but not much formal training. Through readings and discussions, she helped them follow their interests and deepen their understanding of the issues that play. Some of the students had already been active advocates that there should be more social factors discussed in their degree program and we expect that these students will continue to discuss and advocate for these topics at University of Michigan.

Throughout this period, Johanna worked with faculty colleagues in computer and data science, to gauge their interests, priorities, and knowledge about transforming University of Michigan's computer science curriculum. She met with a number of professors, and many were enthusiastic about the project (helping to establish closer linkages across the university). She also arranged to teach the introductory computer science course (101) in Winter and Spring 2022, implementing some of the lessons she learned through her research and essentially, reimagining the course to center equity and justice concerns.

Disseminating Results and Engaging the Broader Community

As Dr. Okerlund's postdoctoral fellowship came to a close in Winter 2022, we published the Technology Assessment Project's report on large language models. Given her important contributions to it, I asked her to be the first author, and our findings were covered in *Nature*. We also organized a panel entitled "Cultivating Socially Responsible Engineers: The Role of Universities and Public Policy" at the University of Michigan in March 2022 to mark the end of Johanna's fellowship. We brought together an interdisciplinary group of leading thinkers on the issue from the University of Michigan and beyond, including Dr. Okerlund, Amy Ko (Professor, Information School, University of Washington), Tim McKay (Associate Dean for Undergraduate Education and Arthur F. Thurnau Professor Physics, Astronomy, and Education, University of Michigan), and José Zayas-Castro, Division Director, Division of Engineering Education and Centers, National Science Foundation). University of Michigan's Dean of Engineering, Alec Gallimore, moderated the panel, and we had an excellent interdisciplinary turnout and an engaged audience (the event was held in person and live streamed). The panel not only gave

Johanna an opportunity to discuss her findings to a diverse, multi-disciplinary, and engaged audience, but it also fostered links across University of Michigan (specifically, between the technical fields and social science and public policy). And, the panel—which was widely publicized—helped to establish the importance of public interest technology at the University of Michigan, and the importance of public interest technology education at universities more generally.

Dr. Okerlund has presented the findings of the research she did at University of Michigan across the country as well, including New York University's "A Better Tech" conference and the ACM Technical Symposium on Computer Science Education. She also presented her findings to faculty at UNC-Charlotte (her graduate institution).

Dr. Okerlund's Perspective

Finally, Johanna reports that the fellowship fundamentally changed her perspective on how to create technology in the public interest:

> "In the classes and the TAP, I began to learn how to write for a public policy context. This involved identifying the values of the audience and being explicit about how I wanted to frame the technology or policy. I would need to propose a path forward for that technology that would likely not be a particular technological solution. For example, I needed to argue what area of research needs increased funding or suggest a particular mechanism for deliberative decision making. I was not suggesting the answer to a technological issue; I was suggesting the mechanism that should be put in place in order for people with the right expertise to find the answer. This was a really different way of thinking about technology for me, since I had previously mostly only thought about technology from the perspective of someone developing the technology.
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> I also have a much deeper understanding of the ways technology and society influence each other. I had previously been aware that algorithms could be biased and that large tech companies designed apps and websites in the interest of their bottom line rather than in the interest of the people using them. I now better understand the complex relationship between technology and social factors. It is often not the case that technology causes social phenomena to occur; rather technology and social factors are inextricably entangled. Certain technologies may have a particular impact on society, but only because society is arranged in a certain way to begin with. I now have a set of examples I can draw on and a sense of what to look for.
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> Part of my education as a technology designer has been developing sensitivities and learning new things to take into consideration when designing technology. I now have a much broader set of sensitivities and set of phenomena to draw on as a designer, particularly in terms of how to design with communities or societies in mind, not just an individual. Specifically, I know how to think more explicitly about how technology or issues are framed and what causes these collective frames to emerge. For example, technologies such as Al were initially framed as optimistic, but with continual failures that reach the headlines, this frame is shifting and trust is eroded. The way people use a

technology might be influenced by how it is framed in the public consciousness, which is not something that I as a designer have direct control over, but it is something I can take into account.

I am also much closer to seeing a path forward for how to design and develop Al technologies in a way that benefits everyone. I had previously been aware of some of the issues with Al technology such as racial bias in algorithms and how echo chambers form. However, I had mostly been thinking about technological solutions that would mitigate these issues and I was not hopeful that there would ever be progress. I now look at the issues around Al more broadly and can see different types of paths forward. One of the reasons there are so many issues with Al technology is that the development is very centralized and homogeneous; it is typically exclusively big tech companies that create large Al systems and deploy them at scale. A way of combatting this that I would like to explore in the future is ensuring that there is Al development being driven by small local communities or that is driven by people who are marginalized by typical Al development.

Similarly, I am now aware of a broader range of activities and forms of expertise that can (and should) influence the future of technology. Moving forward, the technology world does not always have to look like creating a new piece of technology. Rather it can (and should) look like lots of different things including maintaining existing technologies, exploring non-technological solutions, training people, building infrastructure, and creating contexts for voices to be heard. I'm excited to figure out how to make sure other researchers and developers in my research field of HCI as well as students learning CS see the value in these other technological activities as well.

I've also changed how I see my responsibilities as a technology educator. Not only do I have a better understanding of some of the issues at play relative to technology and society, but I also see the necessity of orienting technology education in relation to these issues whenever possible. I now think about technology skills in this broader context and I have a new set of considerations I use when I think about how to introduce any technological skill or tool to someone. I will try hard to never introduce anything without drawing attention to social or political factors in some way. When introducing a CS concept such as classes or decision making structures, I'll draw attention to the unnatural over-sanitation that these constructs impose if we try to use them to represent the real world. When discussing CS to someone who is considering it as a major, I'll discuss different types of career paths including ones that involve public policy or advocacy. I'll be mindful of the different ways that technology skills could be used and all the different types of skills and perspectives that are needed in the technology world, including care, maintenance, and people organization. I'll keep thinking about ways these skills can be fostered in educational setting to prepare students for a changing tech world. Or better yet- how I can set students up with the skills and the mindset to change the tech world themselves.”

In sum, we accomplished an extraordinary amount in just one year. In addition to providing the CS department with concrete lessons to transform their undergraduate education, we also trained a postdoctoral fellow who has begun to train other communities beyond University of Michigan. And finally, we have expanded the conversation about PIT education at the University of Michigan and beyond.

Challenges Encountered/Lessons Learned

The major challenge that we encountered is that Dr. Okerlund's work is so good that she received a permanent position and left us in Winter 2022, so she was not able to work with CS faculty colleagues to implement the lessons she developed. However, it does seem that her work left a lasting impression: during her fellowship she received an internal grant to help extend her work, and now CS students and faculty themselves have taken over.

For my part, I learned how to mentor someone with a technical background with interests in PIT. In some ways, Johanna was special because she was incredibly open (I could imagine that it could have been a challenge if the fellow assumed that they knew everything about equity, justice, and ethics and didn't think they needed additional training). But I learned both how to support (for example, encouraging her to bring her technical expertise into the TAP project) and push her (challenging her preconceived notions about the relationship between technology and society. I am eager to find funding so that I can create a more stable postdoctoral fellowship program dedicated to providing STEM-trained people with PIT training. I think that this is a crucial point in scholars' careers, that can have real impact far beyond the individual.

Finally, one challenge is simply how CS has been institutionalized. I wonder whether and how Johanna's lessons will be incorporated into a curriculum that really is focused on the technical and where the students and faculty lack formal social science or policy training. I worry that without a really fundamental thinking of the curriculum, and real respect for the research and insights of social scientists, policy scholars, and others, the changes will ultimately amount only to tweaks. And yet, it will be even more dangerous because faculty members will believe that they are providing equity/justice/ethics training and students will believe that they are receiving it.

All University of Michigan activities conducted with the Grant funds were and are consistent with charitable purposes as set forth in Section 501(c)(3) of the Internal Revenue Code, and University of Michigan complied with all provisions and restrictions contained in this Agreement, including, for example and without limitation, those provisions relating to lobbying and political activity.

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Interview with Johanna Okerlund, STPP Postdoctoral Fellow

March 4, 2021

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Johanna Okerlund is an STPP postdoctoral fellow working on the Rethinking Computer Science Education: Bringing Public Interest Technology into Undergraduate and Postdoctoral Training project. Dr. Okerlund, whose background is in computer science, will receive training in the equity, justice, and policy dimensions of data and technology, and then help rework University of Michigan's undergraduate computer science curriculum to include sustained attention to social, moral, equity, and policy dimensions of data and technology.

Johanna Okerlund
P.H.D.
Postdoctoral Fellow
Public interest technology

How has your role as a teacher and educator influenced your work?
We are facing really complex challenges such as political polarization, lack of a common understanding of truth or reality, racism, income inequality. Many of these challenges relate to or are exacerbated by technology. I may not see solutions to these challenges in my lifetime and as a technologist, I'm not sure how much progress I will be able to make towards them myself. While this may seem discouraging, I do see hope in future generations and I get a glimpse of that hope with the students I mentor and teach.

I don't consider my role to be to prepare them for the specific kinds of jobs or to contribute to a particular technological landscape, but rather that I am helping them prepare to be able to shape the types of jobs that exist in the future or shape the technological landscape itself. Working as a teacher and educator allows me to think further into the future, not in terms of specifics about what the future will look like, but rather in terms of what kinds of skills and mindsets are needed for radical and creative envisioning of a more equitable and just world.

How did you become interested in AI and Human-Computer Interaction?
To be honest, I was initially interested in both AI and Human-Computer Interaction because I thought they were fun. My background is in computing and I thought it was really neat how computers could be programmed to recognize objects, generate music, or recommend content for humans to consume. I was drawn to the creative potential of Human-Computer Interaction. In computing, we are often limited in our conceptualization of a computer as a screen, a mouse, and a keyboard. Human-Computer Interaction asks how interaction with digital information could be more embodied, tangible, and embedded in our environment or communities in an intuitive way.

I was initially interested in interactive systems for novel forms of creative expression through sound, visuals, or something we had not yet thought of. Both AI and Human-Computer Interaction seemed to offer the possibility of unlocking untapped human potential and I was interested to discover what that looked like. I have continued to think about ways AI or Human-Computer Interaction can offer cathartic experiences for humans or humanity. Now, however, those ideas are coupled with mindfulness of the fine line between technology that emancipates and technology that reinforces problematic norms.

How did you become interested in the social and ethical issues related to AI?
When I first learned about AI, I considered it to be separate from social or ethical issues. I had a separate interest in justice and ethics, such as through reading about feminist theory and income inequality, but my takeaways from conversations or readings on these topics was that there is not yet a clear path forward. Most of my effort related to social and ethical issues went towards articulating the problems, or discussing why possible solutions would not work. I did not feel a sense of agency for being able to make any progress towards solving the problems, so I kept these interests separate from what I thought about relative to AI or computing. In recent years, however, it has become clear to me that technology and AI systems are not neutral, and despite there not being a clear path forward, it is still crucial to take social consideration as the starting point when working with AI.

What are you excited to work on or learn during your postdoc with STPP?
I am interested to learn more about societal and political perspectives on technology. Most of my work as a technologist and as a Human-Computer Interaction researcher is centered around the technology itself, focusing on the design and evaluation of interactive systems. My understanding of the implications of a particular technology are usually grounded in the way people use it and the interactions that immediately surround it. STPP focuses on technology from many different perspectives- politics, funding, social construction, history, which are important considerations. I am excited to step outside of my discipline and understand how others are approaching these topics.

Part of my postdoc position involves figuring out how to integrate social and ethics issues into the technical practice of computing or Computer Science courses. When students are learning to code, for example, what social considerations should be part of that experience? One of the challenges is that the low level technical practice of coding is often separated from thinking about real-world applications and even more separated from thinking about the implications of those applications. I am wondering how a broad critical understanding of science and technology can inform even the lowest level technical endeavors and whether a critical mass of technologists engaging in such critical practice can help drive a shift in the culture around technology relative to social and ethical issues.

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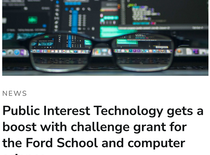

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5 challenging ideas for creating socially responsible engineers

Key takeaways and questions from a panel on the role universities and public policy can play in moving the field of engineering forward.

Written by: Brad Whitehouse

MARCH 30, 2022

EXPERTS:





What is the role of universities and public policy in cultivating socially responsible engineers?

A recent panel discussion highlighted some of the tremendous opportunities and complex challenges for making progress in this area.

Panelists at the event included, from left to right, moderator Alec Gallimore, Johanna Okerlund, José Zayas-Castro, Amy Ko and Tim McKay. Photo: Michigan Photography

"When I think about serving the common good, I think about serving people. Not just some people, but all people," said Alec D. Gallimore, the Robert J. Vlasic Dean of Engineering at the University of Michigan and moderator for the event. "So this notion of equity-centered engineering is about how we do a better job serving all people."

The event, which was hosted at U-M's Ford School of Public Policy by the Science, Technology, and Public Policy Program on March 21, was recorded and provides the full context of the discussion. But to give you an idea of the scope of the issues, here are a few key quotes from the panel to highlight some of the main themes.

Idea 1: What if every aspect of our curriculum is not as important as we think?

"I can tell you one challenge that stands in the way (of developing socially responsible engineers) is that in the natural sciences and in engineering we have a model of student understanding that you could compare to a brick wall. There's a kind of sense in faculty members' minds that when you take first semester physics, you put that first brick in place, and it's fully in place, right? And then you put the second brick in place, and the third brick in place.

"And so we have this sense that the only way you can learn sciences is through this complete list of absolutely everything, and if you take anything away from it, you won't know anything. This is clearly not true, and educators understand that nobody gets the same first brick even, much less the rest of them.

"So we need to be thinking about the flexibility that actually exists in our curriculum, to encourage, allow—even require—our students to engage with aspects of engineering which are unfamiliar. Like its history, and its social impact. And those need to be central parts of an engineer's education.

"Disciplines like engineering define who they are by what they do. And when our students look at our engineering faculty and don't see them think about or engage with these kinds of things, they recognize that."

-Tim McKay (Associate Dean for Undergraduate Education (LSA) and Arthur F. Thurnau Professor of Physics, Astronomy, and Education, University of Michigan)

Idea 2: Engineering education needs to take time to help students understand themselves as more than just engineers

"I think one of the most fundamental changes that needs to happen, which has already been kind of mentioned, is that students need to stop perceiving technical content as purely technical, but instead learn to perceive it as inescapably entangled with social and political factors.

"Another thing that I think needs to happen sort of from the beginning is that there needs to be room for students to form different identities relative to technology. So oftentimes the sort of identity that attracts people to computing or engineering is this problem-solving, hacking, creative. It's (a) curiosity-driven, sort of technical identity. And that's great. There needs to be room for that.

"But there also needs to be room for other sorts of identities. There needs to be room for students to form a political identity relative to technology. Or a personal identity. Or to be able to relate what they are learning in the classroom to things that are happening in their community.

-Johanna Okerlund (Postdoctoral Fellow, Ford School of Public Policy, University of Michigan)

Idea 3: Maybe more students would be capable of studying engineering if we changed our attitude and approach.

"At the core of a lot of these challenges is scaling engineering education, (and) computer science education. (There is) a belief that we can't serve everyone. And that's what creates these toxic cultures, of classrooms where people can't support each other and learn from each other and teach each other. And so I do wonder sometimes—and there is certainly some research that's exploring this—if that's actually true.

"What if we just completely just reinvented the pedagogy such that the thousand students on campus who want to study a particular engineering or CS discipline can support each other, along with faculty help and graduate student help, to do that—at an arbitrary scale? And I don't know that we've really done the research to explore how to make that work successfully and at the same scale that we do it now, but I don't know that it's impossible. I just don't know if we've had the courage yet to try those models.

-Amy Ko (Professor, Information School, University of Washington-Seattle)

Idea 4: Thinking there is always a solution might be a problem

"I wonder sometimes whether expressing an attitude that is really different from the usual attitude of engineers … that everything is a problem that you solve.

"I think that a lot of communities see that statement—you know, 'We solve problems'—and they watch problems not get solved, but get created, and it really undermines the credibility of the field. And so I think a more critical engineering could be much more effective at bringing everyone into it. Because it's only the people who actually think everything can be solved as a problem who are drawn to it now. And everyone else worries about that."

-Tim McKay

"There's a phrase we use in our undergraduate program that 'Every solution is a problem.'"

-Amy Ko

Idea 5: Keep pushing

"From the late 1960s and the early 1970s, the National Science foundation has been funding efforts to increase the diversity in engineering and the sciences.

"I'll use a quote that I have been using for the last few years from watching Cornel West. 'We need to be prisoners of hope…'

"Great discoveries in technology … they didn't come about because somebody started and made it the first time … People kept going. So yes, there is hope …. Keep in mind that probably the only place that the shortest path between two points is a straight line is in basic geometry and when you're crossing the street. But in life there are many curves, hills and valleys."

-José Zayas-Castro (Division Director, NSF Division of Engineering Education and Centers, National Science Foundation)

Watch the entire panel, courtesy of the University of Michigan Gerald R. Ford School of Public Policy.

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