

Finding the “I” in Interdisciplinarity

When I was assigned to a federally funded project to revolutionize engineering education at Virginia Tech, I thought being an effective scholar meant shunning my unconventional background. Instead, I had to embrace it.

In 2015, the National Science Foundation launched an effort to spur what the federal agency called an “engineering education revolution.” The field had been teaching engineers the same way and drawing from the same populations for more than half a century, even as the world shifted. Virginia Tech’s electrical and computer engineering department was one of over two dozen entities to receive \$2 million for a five-year project to produce more culturally aware, diversely trained engineers. Named RED (for “revolutionizing engineering departments”), these grants required an interdisciplinary approach, stipulating that one of the co-principal investigators (PIs) have a social science background.

As a PhD candidate in science, technology, and society (STS), I became a research assistant on the project. Engineering professor Tom Martin, one of the forces behind the grant, had tapped my PhD advisor, historian of innovation Matthew Wisnioski, to be a co-PI. As social scientists, our expected role was to observe and advise. But the grant’s mandate for radical change, combined with my own diverse background, ultimately led me to conclude that observation was not enough. After two years of traditional research, I took the unusual (for a social scientist) step of designing interventions to help the engineering community at Virginia Tech expand by recognizing diverse career paths, nontraditional students, and people who may not fit the description of a typical engineer.

Science has long aspired to crack the code of interdisciplinary research. When I joined the RED grant in 2016, it had been a little over a decade since

the National Academies of Sciences, Engineering, and Medicine released their consensus report on facilitating interdisciplinary research, which had commenced with a call for urgency from a member of the White House Office of Science and Technology Policy: “There is this long-standing call for this type of research. The question we have to ask ourselves is, what is the problem? Why isn’t this proceeding at a more rapid rate?”

It’s now clear that interdisciplinarity is relatively easy to fund but hard to actualize. I was surprised to discover that becoming an effective interdisciplinary researcher also required that I embrace the value of what I call inner interdisciplinarity—my own unconventional background—and what it could bring to the team. My experience exposes conventions and infrastructure that so often keep interdisciplinary research from reaching its potential. It also suggests how to surmount such barriers.

“Eat this cracker and walk a few steps”

I didn’t take a traditional path to a PhD; in fact, graduate school was never on my radar growing up in Mississippi in the 1990s. As a first-generation college student, I chose to study nursing because it offered a guaranteed job. After I began working at a hospital as a registered nurse, I learned about library and information science and started a master’s degree program. Years later, chats with one of my patients, who happened to be the chair of the information technology department at the local university, inspired me to switch programs and earn a master’s degree in network technology. A master’s thesis about baby boomers

and health care apps introduced me to qualitative research and landed me consulting work with a biostatistician who encouraged me to pursue a PhD. This led to my applying to graduate STS programs. I didn't know much about academic careers or the workings of higher education, but I knew I wanted to think more about how technologies shaped society and vice versa.

On the day that I learned I'd been awarded an assistantship that would enable me to join the STS program at Virginia



Keith Holmes, *Nurse in Red*, 1991–1993, oil on board, 25.2 x 18.9 in.
© Keith Holmes. Photo credit: Science Museum / Science & Society Picture Library.

Tech, I was working as a nurse on the ambulatory surgery unit of a large teaching hospital in eastern North Carolina. I was partway through a typical day, clearing patients to go home after minor surgeries such as hernia repair or gall bladder removal. I had my charts open on the computer screen next to my email. When I read the message from the program's director announcing the position, I felt so overwhelmed that I went into the restroom and leaned against a stall to breathe through my eagerness and disbelief.

Minutes later, I had a new patient to assess. I explained the requirements he'd need to meet before he could leave: I'd

make sure he could urinate, eat a cracker, sip ginger ale, and walk a few steps. Unable to keep my excitement to myself, I told him that I had just received funding to start my PhD. He looked at me blankly, waiting to be cleared.

Four months later, I gave away my scrubs, sold my stethoscope, and moved to Blacksburg, Virginia. I was eager to present myself as a scholar, which to me meant distancing myself from nursing. Although I couldn't see it then, it is now clear to me that there's something powerful about being a nurse. I've seen the worst in people and the best; I've cared for millionaires and homeless people alike; and I've seen how paying attention to people can improve health and save lives. I couldn't have realized then how important that experience would be in my new role—or how academia is biased toward individuals having only narrow expertise.

Dismantling rigidity

I quickly assumed my place in the weekly meetings about the RED grant. Our specific project was aimed at dismantling a rigid curriculum that had funneled students into either electrical or computer engineering, often leaving them stuck without the ability to explore all their options or the means to obtain the sort of interdisciplinary skills that today's employers need. The team worked with other faculty to cross-coordinate new curricula for undergraduate education that fostered both depth and professional breadth so that students were no longer tracked to a single narrow major. We hoped the revised curriculum would open possibilities for engineering majors and attract students from places beyond the wealthier, whiter regions of northern Virginia, where most enrollees hailed from.

Those first few weeks were a whirlwind of new language and concepts. Every time someone said a term like *circuits*, *photonics*, or *culture change*, I had to check in with myself that I was following the conversation. It wasn't just the words that were foreign: so were the customs, aspirations, and expectations of my new colleagues. I sat at a table with directors, department heads, and people from globally known institutions whose idea of the mundane felt exotic; people would talk about travelling internationally or attending elite universities as if it were as common as walking on two legs.

Although I couldn't see it at the time, feeling out of place was to my advantage. My role would be conducting qualitative interviews as part of a climate-and-culture study of the department, and I needed an outsider's perspective. When someone asked whether I would be intimidated by interviewing engineering faculty, I thought, "Why?" I had already learned to communicate with physicians, who were notorious for hanging up on nurses, not to mention family members who frequently gave me the third degree as soon as I entered their loved one's hospital room.

I soon saw similarities between the engineering program and my experiences as a nursing student. Engineering's concept of rigor mirrored nursing's expectations of perfection—for example, when instructors would interrogate me about the possible adverse effects of medication. Scholarly discussions about the toxicity of weed-out culture reminded me of *my* incoming class of 60 nursing students, which shrank to a graduating class of 30. And the engineering school's version of critical thinking, which was geared toward seeking out risks or weak points of system failure, felt more familiar than what STS considered critical thinking, which involved comparing different schools of thought through lenses such as cultural capital, power structures, and artifacts of technology.

Other skills from nursing quickly came into play when I started conducting interviews. I knew how to establish trust within minutes of entering a patient's room, and I had years of practice listening to patients tell meandering stories and redirecting them toward relevant details.

Over the next two years, I interviewed more than 50 faculty, alumni, undergraduates, and academic career advisors about the department's focus on research rigor, silos of research specialties, the way faculty staked out their own

Engaged scholarship meets nursing interventions

In my second year in the doctoral program, I took a class called Engaged STS and found what I hadn't realized I was seeking: scholars actually making change. I recognized that my urge to intervene stemmed from my experiences as a nurse, where the question of "So now what?" is vitally important. Central to the profession is responding to patients' situations with carefully crafted "nursing interventions." A patient presenting with increased temperature after surgery? Assess other symptoms, administer Tylenol, reteach the patient to use a lung exercise device, wait an hour, and recheck vitals. When I saw something going wrong, my every professional instinct was to intervene. And having been trusted by my interviewees with their thoughts and experiences, I now felt compelled to respond; they were not simply informants or categories of data, but actual humans.

So I learned about critical participation and about making and doing, part of the low church of STS because it emphasizes social impact over theory and embraces action and participatory research. I passed my qualifying exam to continue the PhD program and—after some months of conversations—I embraced the role of intervening scholar.

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turf, and the lack of diversity in terms of race, gender, and socioeconomic status. I learned that faculty saw their role as preparing students for jobs in defense and technology or for advanced engineering degrees. Students seeking alternate careers lacked support; one double major told me he got better career advice from his creative writing instructor than from the program. I also heard students' accounts of how hard it was to be the only woman or person of color in an advanced seminar, to stick out among the "nerdy boys."

I reported these findings to the project team, and then I stepped away. The team's attention shifted toward meeting accelerated university deadlines, including analyses and updates for the curriculum committee, which was planning changes across an engineering department that included over 95 faculty and 1,100 students. Meanwhile, I took on other roles within the project team and became absorbed in the STS canon, exploring the works of scholars including Donna Haraway, Thomas Kuhn, and Bruno Latour. I was forced to challenge my own beliefs as I explored their theories and how they laid out frameworks of history, philosophy, and sociology to make inequities visible. But I didn't forget the data I had collected. I sometimes would review my files, fighting the urge to ask, "So now what?"

At that point, I opened my files with the data from my interviews once more. With my advisor, I identified three problems my research had uncovered: people with marginalized identities felt unheard in the department, academic advisors had insights about students' lives that faculty members lacked, and students had difficulty finding practical information about career paths outside of defense and technology. These problems, we agreed, seemed ripe for intervention.

Eventually, I developed three interventions specific to these problems: a podcast, a seminar, and a white paper. I received enthusiastic support from the project team. After four years of Wednesday-morning grant meetings, they knew my work ethic and were willing to give me the freedom to do my projects and to lend help in ways that weren't spelled out in the grant. For example, Luke Lester, the head of the engineering department and PI of the grant, brought departmental support, prodding faculty to respond to my surveys and giving me slots to speak at faculty meetings. Lisa McNair, another co-PI and the engineering education expert on the grant, helped ensure that my work was aligned with national standards in engineering education, best practices, and goals.

For those who told me they felt invisible, I sought to provide a literal voice via a podcast called *Engineering Visibility*, where I interviewed students about their experiences. In an episode called “Seeing the Nontraditional Student,” I talked with students who had arrived at Virginia Tech after following other paths from high school. Other episodes featured women in engineering, people who’d never expected to find themselves in graduate school, faculty describing what they value about teaching, students describing how they were coping with the pandemic, plus first-generation students and staff members devoted to their support. All along the way, I recruited alumni, students, and faculty to participate with the goal of helping the community of electrical and computer engineers recognize how much diversity they already had.

My next intervention tackled a different sort of visibility—that of engineers seeking nontraditional careers. In the research phase of the project, I had interviewed 18 undergraduates, including four pursuing nontraditional careers, who said they had few resources for exploring different options. I assumed there were many other students in their position, and thought they needed a forum to explore

A conversation with a member of the engineering faculty showed me how to proceed. “We get numbers,” they told me, speaking of their colleagues. So I collected data on over 1,600 student-advisor interactions to quantify the care work that advisors do. The result was a white paper intended to help faculty start to see their students as more than the problem sets they turned in (or didn’t). Faculty were surprised, for instance, when I told them that academic advisors sometimes came up with ways to make sure students had something to eat. One of the key points of the white paper was to make the care work that the advisors do for students visible to faculty, who tended to value what they saw as academic rigor without recognizing the importance of supporting students in other ways.

Taken together, these three interventions enabled the engineering community to “see” itself as I had seen them—as distinct individuals, as seekers in search of satisfying careers, and as a community where multiple supports were required to graduate each student. One testament to the impact of these interventions is that the podcast is being continued under the director of communication and, as of

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these opportunities. I assembled a panel of engineers from outside the mainstream, including a fashion entrepreneur, patent attorneys, and a financial professional, who together represented diverse ethnic backgrounds. In a 90-minute virtual conversation, they described how they used skills from electrical and computer engineering to get onto their career path, and then students could attend breakout sessions with the panelist of their choice. More than two dozen undergraduates and administrators attended.

My biggest challenge came when I tried to help the engineering faculty better understand their students. Engineering undergraduates at Virginia Tech are assigned professional academic advisors who are distinct from the engineering faculty teaching their classes. My research found that the advisors had a very good understanding of what students encountered in their day-to-day lives: financial struggles, family responsibilities, feelings of exclusion, and lack of belonging, plus other challenges that made it difficult for them to thrive—including being uncertain where their next meal was coming from. By contrast, most engineering faculty only discussed academic performance with those same students. They routinely attributed academic struggles to a lack of academic preparation, not a potential consequence of financial, social, or other struggles.

2021, had been downloaded hundreds of times. The white paper remains easy to find on Virginia Tech’s website for others to build on. In their project report to the National Science Foundation, the Virginia Tech faculty on the grant wrote that there was now a better understanding of stakeholders across the department, including a new understanding of “concerns such as care work, sense of belonging, advising, and student success, particularly non-traditional forms of student success.” Ultimately, members of my team produced 21 publications and presentations.

Along the way, I also developed a methodological and conceptual framework for other applied STS scholars to use by developing a concept I call “groundwork.” Early on, I told my advisor I’d found nothing in the literature to tell me how to be an applied social scientist. He replied, “That’s your dissertation.” Groundwork is my attempt to provide language for my political, social, and emotional labor of intervening as a scholar. It gives social scientists an approach to negotiate interventions that protect vulnerable populations, to translate knowledge so different groups can respect it, and to measure success. I hope that other scholars can use the framework to structure interventions and build upon it to enhance engaged research more broadly.

Interdisciplinarity across a team and within individuals

My experience speaks to that question posed about facilitating interdisciplinarity at the National Academies' convocation almost two decades ago: Why isn't this proceeding faster? I think one reason is that interdisciplinarity must go beyond bringing together a diverse team of specialists.

Yes, it made sense that the RED grants required PIs to represent distinct academic roles: a department head in engineering (or someone in a similar position to drive change), an expert in engineering education, and a social scientist to assess culture. But effective interdisciplinarity means more than combining individuals from different disciplines onto a team. It also means drawing out diverse expertise within individuals. It wasn't my nascent understanding of STS that led our team to pursue interventions but something harder to define: an environment where I could be more than my single specialty, where I could bring to bear my inner interdisciplinarity.

It took everything I brought into my PhD program to make my interventions happen: the registered nurse, the first-generation college student, the undergraduate trained in psychology and English, the master of information technology who'd assessed health tech, the eager intervening scholar, and the kid from Mississippi. Like me, most scholars have multiple levels of expertise and experience that would, if engaged, yield more creative, more influential work. But today, academia encourages them to leave these other identities and experiences at the door.

Social norms, academic infrastructure, and hiring practices all push academics to be just one highly specialized thing. We go to college and typically choose one major. From then on, it seems, peers and mentors identify us with a single, all-important specialty. I spent so much of my graduate career convinced that I had to select one area of expertise and stick to it steadfastly. That's why I thought my nursing background was a detriment to my success as an STS scholar. This mindset holds back interdisciplinary success.

Individuals should be empowered to offer myriad forms of expertise if they are able to engage their inner interdisciplinarity. My advisors gave me the respect and resources I needed to apply instincts from my nursing background to the project—including soft encouragement and hard cash for professional podcast editing. They even told me that the diversity of my experience had convinced them that I could get things done. In sad contrast, I had met others outside of the project who suggested that my abundance of ideas meant I should reconsider my decision to pursue a PhD.

Can this encouragement of inner interdisciplinarity be formalized by, say, taking the time for conversations within interdisciplinary teams to discover individuals' diverse experiences and how they might contribute? I saw something like this happening in Virginia Tech's new curricula. The write-up of the RED grant project outcomes describes one of the “most exciting and gratifying” changes in the department as hearing how students have started to introduce themselves. “They no longer just say, ‘I'm an EE [electrical engineering] major,’ they say for example ‘I'm



Tim Okamura, *PPE*, 2021, oil, colored pencil, on wood panel, 48 x 60 in.

an EE majoring in Robotics & Autonomy with a secondary focus in Green Engineering.” The four co-PIs on the grant were affiliated with Virginia Tech's Institute for Creativity, Arts, and Technology, which is devoted to interdisciplinary work at the intersection of science, engineering, art, and design. The revolutionized engineering curriculum actively encouraged students to include nonengineering courses in educational programs, including an official route to explain how they could bring engineering concepts into nondisciplinary courses and vice versa. Something similar, albeit more complicated and less formal, happened for me as a scholar.



Virginia Powell, ca. 1995. A nurse monitoring a patient after an operation and taking notes. Wellcome Collection. Attribution 4.0 International (CC BY 4.0).

I'm convinced that there are ways to unleash inner interdisciplinarity through increased visibility and by emphasizing processes as much as (if not more than) outcomes—including how to build trust, infuse care, broaden what counts as success, and find language to communicate and meet project needs. Departments should be encouraged to take on such initiatives and incorporate them into decisionmaking even after the funding has gone away.

Ultimately, I'd like to see more formal mechanisms to break open boxes—both exterior and interior. Allowing multiple labels on job and grant applications would be a start. That could make interdisciplinarity a new norm, not only in curricula and research teams, but also in the way researchers and students identify themselves. Encouraging researchers

to embrace their whole selves, moreover, could provide crucial insights that make for more effective, relevant research. To capture those insights, academic norms and culture must first make inner interdisciplinarity visible, and then demonstrate that it is valued.

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