Sara Hendren:

Welcome to episode one of Sketch Model, an audio series about the engineering classroom and how the humanistic disciplines of the arts, the humanities, the social sciences, shape, the why and should questions about the technologies we build.

Erin Cech:

Engineering students when we give them these technical assignments that are mathematics based without challenging them to think about the broader context and implications of this, I think that does engineers a disservice because it extracts the profound messiness of doing any kind of engineering design, and they have to...

Sara Hendren:

We're starting today with Professor Erin Cech, who's been looking under the hood at engineering education for a long time. Cech found some counterintuitive and troubling things happening in the engineering classroom, so I asked her to tell me about it, how engineering students grow less interested in social and civic matters over the course of a four year education and what it might mean to redress those trends. Erin Cech is an associate professor of sociology at the University of Michigan where she also has an appointment in the Department of Mechanical Engineering. She has a particularly interesting combination of training and interests that bring her here today. I hope you'll stay with us. Erin, you're a sociologist, but also trained in engineering, can you just tell us a little bit about your own wish to be an engineer in the early days and what your training was like, and then how your interests shifted?

Erin Cech:

I went into undergrad wanting to be an engineer in the traditional sense, but really with a focus on more non-traditional technical concerns. My grandmother was blind and I was always really interested and concerned about issues of assistive technologies. And I've looked at the technologies that were available to her and I thought, we can do better. We need to do better. And I was really inspired to go into electrical engineering for that reason. And as I went into my courses, I was sitting alongside my classmates and I was learning these theories and equations and transforms and thinking, Okay, these are things I need to know as an electrical engineer to be able to make these technologies happen, but I was just so struck by the absence of any kind of conversation about the implications of the work that we were doing for inequality, for social justice, for environmental concerns.

And as I got more comfortable in my classrooms, I would raise these questions either to classmates or to faculty members. And it wasn't just that faculty and my fellow students didn't know how to answer these questions, which I certainly would have been understanding of, but didn't see those as relevant questions to be asking in the first place. I really sought out other places to think about these kinds of concerns. I took some sociology classes and they introduced me to concerns of power and infrastructure and institutions and culture. And it was really by uniting the kinds of lenses I was able to get in those sociology classes with what I was experiencing and learning about in my engineering courses, it really drew me to want to be able to understand the field of engineering and the cultural assumptions behind what engineers do and want to do and how those might even perpetuate processes of inequality.

Sara Hendren:

Erin, your research is expansive in its breadth, but it's united, I've heard you say, by an interest in the mechanisms in education that reproduce inequality and especially the mechanisms that are often

hidden from view or even behind a veneer of neutrality. Is that right? And can you say a bit more about that?

Erin Cech:

Yeah, that's a really good summary of it. My quest as a scholar is to try and better understand the ways that the things that we take for granted as neutral or bias free or even joyful and exciting can have all these biases built into them. And it's analogous to the idea of the missing masses problem in physics. Where is all this mass? And the analogous point is where is all these biases being reproduced? How do we see the overdetermined nature of things like racism and sexism and heteronormativity being continually perpetuated and reproduced? And one of the ways I think that we need to understand those things is to look at those cultural beliefs that are really hidden in plain sight.

Sara Hendren:

Yeah. Just to dig into it a little bit, the area of your research that's been on our minds a bunch at Olin is what you've called a culture of disengagement. And that's based on some research that you did between 2003 and 2008, I think. You found among undergraduates in four different engineering programs, so including research universities, small colleges, but in a series of longitudinal surveys you did on those campuses, I think with 300 students, what came out after the four years of the engineering degree was pretty surprising in those engineering programs. And just to set the stage, remember, lots of people are drawn to engineering because of its deeply practical nature, its applied science, so it lives in the world, in people's lives, and their everyday settings.

You'd think from the outside that engineering would actually draw young people with that very pragmatic tinkerer spirit, problem solving, very grounded in the world and so on. And all of that, of course, is necessarily social as well as technical. But you found something different happening over the course of four years for young people who self-selected into the engineering major. Can you talk about what you mean by a culture of disengagement?

Erin Cech:

Sure. As engineering educators, we want to not only teach students what it means to have technical skills within the context of engineering, but also how to be engineers. And being engineers in the world in part is understanding and practicing the professional responsibilities of engineers. And so because engineering is one of those maybe last majors where you can get a four year degree and go out in the labor force and practice in that profession, it puts a lot of pressure on four year institutions, four year degrees to teach students what their professional responsibilities are. And so we would hope that as students are going through this engineering education as freshmen and our first years through the context of their engineering education until they're seniors and they leave and graduate, that their concerns about the professional responsibilities would grow and deepen. And what I found is the opposite, that as students went through their undergraduate engineering education, they became less interested in professional and ethical concerns.

The importance to them of understanding the consequences of technology actually declined over the course of their engineering education. And for those who went on to be engineers in the workforce, there wasn't any uptick in that. It wasn't that they left an abstracted space of engineering education and encountered these concerns in the labor force and suddenly reignited this sense of concern for their professional and ethical responsibilities, but rather it just stayed about the same. And so what's so interesting and really troubling about this is students come in quite interested and focused on these sorts of professional responsibility concerns, engagement with them in the role of an engineer, but the

engineering education process, at least the way that it manifests within these institutions, actually pulled that out of them to some extent.

Sara Hendren:

Talk a little bit about both the disengagement and then what you've also called the depoliticization of engineering. What are the mechanisms by which that happens? Some of it seems like is at the level of the identity formation process of the engineer, but then there are also these incentives and disincentives you said, for the way that faculty structures get shaped and the process of accreditation and so on.

Erin Cech:

It's the content of what students are learning and also the way that they get subtle and maybe not so subtle messages about what is relevant or irrelevant in the context of engineering. And so we can see this manifest within what gets included in the curriculum of engineering program. What are seen as the kind of core technical courses that everybody must take, and everybody must hit a certain grade to be able to continue on in the program? And what are seen as more tangential, less relevant, less core knowledge sets and skills? And those things might be electives, they might be farmed out to other departments, other colleges on campus. And students get a message really quickly about what they need to excel at to be able to continue on in the program. That's how it can manifest and play out in a curricular space. But even more so the kind of interactions that students have with their faculty members about what is included in their homework assignments, what they get graded on, what is included in the exam's materials or lab materials they have to do.

Even instructors will say, Oh, well I have to teach technical writing as part of this class. Okay, class, we're going to do this one module in technical writing. And everyone knows that this is not something that is valued within the context. And then students police themselves about they will joke or critique or prod one another. And on the content of this critiquing has to do with the bounds of what is considered legitimate and relevant topics of knowledge and conversation within the context of engineering and what is not. Depoliticization is the idea that STEM in general, engineering in particular, not only can be stripped of political, social, cultural concerns, but that it should be. That the only way we can do objective, neutral, good engineering is to as much as we possibly can bracket out all of those considerations. And so bringing in questions about inequality, about access, like I did as an undergrad, like many undergrads do is seen to break that wall of destabilization.

And so often it's skirted away as something that's outside the context of this course or outside the context of this particular assignment. And so students learn really early what counts as "real engineering" and what does not. That is part of what is called the professional socialization of students as they're learning not only to do engineering, but to be engineers in the process of their undergraduate engineering education. Depoliticization is one part of that. Another component of that is this perceived strict binary differentiation between the technical and the social as those things can somehow be extracted. But anyone who takes a minute to reflect on any design experience with a team knows that the technical is developed, completely intertwined with social processes, and you never can separate technical and social content and fields like engineering are never purely objective and neutral because there are humans that are doing them. Even the most seemingly technical work is technical all the way down as we say. It is always already social.

Sara Hendren:

People hearing this might think, Oh, well. Okay, yes, I understand, but that's not my story at my institution or among the young people that I mentor because people say we have an ethics course in our program. Or they say, we talk a lot about real world problems and it's in our brochure. It's really front and center. But you've identified plenty of these, what you call, formal commitments, you say, among these institutions. But you've also said it seems like, if I'm getting this right, that the mere presence of ethics courses can actually have the opposite effect of doing this interwoven leavening work of the so-called real technical content that ethics courses can actually backfire. I'm wondering if you can say a little bit more about that.

Erin Cech:

And this seems really counterintuitive because we should be able to have ethics courses in engineering education curricula and have them serve their purpose, be taught by people who are ethics experts, and be able to think about and trust that students can bring the knowledge that they have in ethics classes into their more technical classes. But the problem is the differentiation itself because if entering ethics can be extracted from the "technical classes," then that just perpetuates depoliticization. It reinforces depoliticization rather than undermining it. And so what I've argued before is that we need to incorporate ethics into classes that are usually reserved for the most technical material because we have to get students to understand that every time they do engineering work, they will always be engaging with ethical concerns. And if it's not immediately apparent to them, it's their responsibility to think about where the ethical and moral and public welfare concerns are in the work that they are doing.

Sara Hendren:

So can I just tell you a casual anecdote, and I'm wondering if it indicates anything that you found in your research? I was overhearing my fifth grader in remote school, so he was interacting with a math teacher on video. And she introduced herself to him by saying, I really love math because she said math is concrete. And she said, when I was at school, we would learn about a story or a poem and I would write my response about what I thought it was about and then I would show it to my teacher who would tell me that no, the teacher, they had a different interpretation of what the story was actually about. And this math teacher was saying that that was frustrating to her as a student and so she was drawn therefore to math for being concrete.

And I just thought in the wake of overhearing that I thought, for one thing, I think that misrepresents both math and literature. I understand what she means on the surface, but does that story sell an idea that, okay, if you're someone who's invested in the concrete, in the reliably correct, the pristine purity of what can be calculated and quantified, does that actually do this sorting work where then students get that message in subtle ways over and over and over time they become a little bit allergic to some of the messy what does it mean to interpret the story differently than you? Meaning what does it mean to have different ideas in the world and different values and competing needs and so on? Or is this just an anecdote? Do you have any response to that?

Erin Cech:

Yeah, that is a really clear articulation of, I think, what is so common in discussions about which side of campus you hail from. And there's a couple of things that I think are important to note. One is I think this issue of the perceived concreteness of STEM and math based work generally and the selection of particular individuals into or out of those fields is really iterative. In some of my work, I've found that students who are first years and have strong commitments to public welfare and social responsibilities are actually more likely to leave their engineering programs than students who have less attachment to

that when they're first and second years. And so that shows a filtering process certainly of, I'm not finding myself in the context of this major, or I'm not finding the concerns that I have, the values that I have represented in the field in which I'm in. And then I think there also is this way in which students who are going through their engineering education come to understand the performance of being a student in a particular way that they are given a homework assignment.

They're only required to solve a technical mathematical proportion of it and articulate back the response in a mathematical form that can be put in a square on green engineering paper. That extracts for students the profound messiness of doing any kind of engineering design that many students don't see until they're seniors, until they're doing some kind of senior design project. And then all of a sudden they're introduced to the messiness of what doing engineering design is really all about. And one way that I think about it is we allow engineering students when we give them these technical assignments that are mathematics based without challenging them to think about the broader context and implications of this are perpetuating the privilege of objectivity, the privilege of not having to question these things. And I think that does engineers a disservice because it makes engineering work actually easier than it is in the real world. It's hard in the real world because of these kinds of issues, and we're not preparing students the way that we need to be when we extract those concerns.

Sara Hendren:

And let's just make this even more vivid and colorful for folks who haven't maybe spent much time in engineering classroom. Can you describe how a typical engineering exam question might get framed, and then how it might be framed otherwise to include a sociotechnical lens, so one that's not siphoned off and then exported to an ethics course, but right there in the exam question itself or the problem set or a design challenge or something.

Erin Cech:

I would certainly point folks to Donna Riley's work. She's written a textbook where she actually takes, I think it's thermodynamics ideas and incorporate them into these broader sociotechnical considerations. But an example like that might be an exam question that's looking at water pressure through pipes and a student is given the parameters of that problem and the parameters of the pipes, and they are to output a mathematical outcome again that they can put in a square on their homework assignment or in an exam. An alternative to that would be why is there a water pressure problem in the first place? Maybe it is the historical example of the Central Valley in California where water was being siphoned off to be used by more wealthy areas in California and was causing this tremendous drought for indigenous populations.

And so having that as the context for this problem then promotes requirements that students think through not only what one mathematical solution might be, but a whole host of possible solutions that actually incorporate considerations of what is needed in populations where the power structures lie in the administration of the state and things like that. And maybe the focus that week is on power dynamics within local politics or something. And students had readings or they had to learn about how local political factors influence infrastructure and how that can impact civil engineering design. And they have to demonstrate that knowledge and understanding in their exam alongside their articulation of the mathematical outcome. I'm not a data civil engineer by any means, but something like that I think would work.

Sara Hendren:

Which implicates all kinds of just disciplinary competency for both students and for faculty. And let's explore this a little bit because we're thinking a lot about disciplinary competency that we want students to understand on our team at Sketch Model. In other words, we want them to understand that these sociotechnical questions, they're framing, they're rationalization, they're histories and they're contours and so on, that all those belong in the humanistic domains and social sciences. That's where they live, so we know by definition. Everybody at Olin, for example, is going to be an engineering major, all of them. They're not going to become very fluent even at the level of say, an undergraduate minor, which we don't even have. But they're not going to become fluent even to that level in, for example, philosophy or history or rhetoric or something. But those are the domains among others that articulate those big why's and whethers and should questions for technology.

I myself as a professor, I want students to know at a certain moment, I want them to have a stopping moment to say, Aha, I've actually reached an ethical question and I want them to have in their mind's eye, Oh, not exactly the answer ready to hand. But what this means is that there exists out there a whole subfield of philosophy called ethics that's devoted to this very matter. I want them to know the unknown, just to recognize it at least. And okay, I'm at this moment as a technical person, that's the resource that I need now, that ethical subfield. And I wonder if there's a tension in trying to both expand the borders of engineering to include the sociotechnical, but shouldn't they also be able to recognize precisely where the technical stops and the integrity and the depth of those other kinds of domains. I think there is a tension there in trying to both expand the borders of engineering, but also understand the full compliment of the humanistic domains that already lack the prestige of STEM.

Erin Cech:

I think there is a tension, and I think the tension actually is rooted in the resistance. It's a change that would be required to integrate these kinds of considerations into engineering education. Often students or faculty who are resistant to the idea of making any change in engineering curriculum would say, Well, I'm not a sociologist. You can't expect me to be an expert in sociology. You can't expect me to be a philosopher as well as an engineer. And I think that's a deflection mechanism more so than a real concern because like you, what I advocate for is teaching students that they're experts in the things that they don't know or understand about the problems that they're trying to solve, and that they should be going to the experts in that realm, seeking out their expertise, and equally importantly, valuing it in the considerations that they're making around problem solving.

And so it is knowing what you don't know, that is a really optimal outcome to what we're looking for here. And it's difficult. One solution I will often say is there are a lot of engineering courses that could be co-taught with faculty in other disciplines to get students exposed to these ideas from the very people who are experts in them. Although, there are some difficulties with that. First and foremost, often the faculty from different disciplines are not respected to the same extent. They often are more likely to be women and/or people of color, which can add to the difficulty and the potential lack of respect they receive by engineering students. But in addition to that is a sense of that built up within these issues of depoliticization that I was talking about in that even the content itself is not seen as important or as relevant to learn and to be held accountable to. I think we have to break down the stronghold that deep politicization has on engineering education as we try and integrate more of these considerations into the classroom.

Sara Hendren:

You've said, and this is pretty damning, that it's not just at the site of the classroom, but that accreditation even with ABET, that's A-B-E-T, the Accreditation Board for Engineering and Technology.

These are evaluators who assess engineering education programs for folks who don't know, but you've said yourself that while ABET has expanded its purview to include the sociotechnical, to include competency and understanding context and ethics and so on. But still, the folks who evaluate, those folks are trained in the core disciplines of engineering or in industry. They tend not to be the folks who themselves might have the training, the competency to evaluate and recognize where these kinds of practices are taking place and where they're meaningful and authentic and all that. It seems like this is a devaluation of the humanistic and social science expertise we need all the way through.

Erin Cech:

Yeah, absolutely. And I think one instinct that people have in response to critiques like that from ABET is to say, Well, we just need more industry people in. And one thing that's becoming really clear in a project that I'm just starting to work on students learning to be watchdogs of public welfare is that there's no incentive in industry, and in fact, there's often a disincentive in industry to think about the social and public welfare impacts of the work that engineers are doing. If somebody is working in a corporation where they're tasked to design a particular thing, it is not in the organization's interest often for the engineer to be thinking critically about the potential implications of what they're working on for society. And so really the only place where engineers are going to learn what this professional responsibility is, is in higher education or maybe through additional training in their professional societies, but there's a huge disincentive in industry to be thinking about these things.

Sara Hendren:

It's clear that this is a lot. It's a lot to ask of engineers and of engineering. Erin Cech understands this, and she's able to name a debate about curriculum that's really a much bigger debate about the shape of higher education in general. Call it the skills versus critical thinking debate. Do you need to know more how to, more specifics deep in your field upon graduation and entry to the workforce or more flexible, adaptable mindsets that you'd bring to the workforce, which will change over the course of a lifetime?

Erin Cech:

I think a lot of times in conversations like this, the issue arises that we are expecting too much of engineers. We are expecting too much of engineering education, and maybe even we're expecting too much of the engineering profession. And I think what the kinds of things that we are talking about today, the resolution of them does require engineering education to ask more of the students. There are certainly ways to balance that. Often I say take more technical content out. We know that 80% of what students learn in any given engineering field is not actually anything they practice in their engineering job and they learn it when they're in the job. That's not a popular thing to say often, but I think in addition to that being something that's challenging, I think it also opens up opportunities for how do we support engineers in the labor force once they're there to do the hard work of thinking critically about the work that they do?

And I think professional societies and organizations are a really untapped resource here, and they are the collective space that engineers have. Engineers are not unionized or many of them are not unionized. They don't have a place to go often where they can connect with hosts of other members of their profession in a way that often doctors and lawyers are a little bit more interconnected in their workplaces and can support one another. Engineers can be isolated within the organizations in which they work. And so developing much more robust collective spaces for engineers to gather, have conversations, think about advocacy and activism, I think is a really important step forward and is

necessary for us to think about how engineers can serve in a capacity that demands them to have more consideration for the impact of what they do on the social and the public.

Sara Hendren:

Erin Cech helped me think about the current state of the engineering classroom, where some of its best intentions go wrong and what might be a remedy for the future. But I wanted to know a longer sweep of history to understand better how have engineers and engineering schools understood their work over the last century? How does that history shape where we are now? I asked two scholars to help us out, James Malazita of Rensselaer Polytechnic Institute, and Matthew Wisniewski of Virginia Tech.

Speaker 3:

Engineers are looking at this world in the 1960s and saying to themselves, on the one hand, we're putting people on the moon and this is the height of progress, and now all of a sudden we're being accused of bringing civilization to the brink of collapse. And that sounds a little apocalyptic, but of course, if we look at life today, people are saying something that's actually pretty similar.

Sara Hendren:

That's coming up next on Sketch Model. Sketch Model is a production of Olin College of Engineering, a four year undergraduate engineering college outside Boston, Massachusetts. Sketch Model is an ongoing investigation into the substantive engagement between the arts and humanistic disciplines in engineering education. And it's been supported by the Mellon Foundation. We spent the last four years running programs at our institution, bringing more robust arts and humanities to our campus in the form of residencies, summer fellowships for students, and collaborations for faculty and staff. You can read all about these programs and ideas on our website, olin.edu/sketchmodel. That's O-L-I-N.edu/sketchmodel. Sketch Model team members are Sharon Breitbart, Kristin Casasanto, Jonathan Adler, Deb Chachra, and Benjamin Linder. I'm Sara Hendren, thanks for listening.