Tanya Domi: Hi, this is Tanya Domi. Welcome to the thought project recorded at the graduate center of The City University of New York, fostering groundbreaking research and scholarship in the arts, social sciences, and sciences. In this space, we talk with faculty and doctoral students about the big thinking and big ideas generating cutting edge research, informing New Yorkers and the world. Joining us today are Ricardo Toledo-Crow, director of the Next Generation Environmental Sensor Lab at the GC's Advanced Science Research Center, where he oversees design and fabricate of environmental sensor and a variety of projects to monitor and collect New York City environmental data. And Kendra Krueger, who is the Advanced Science Research Center's, science education coordinator, and also the outreach and education director at the ASRC Sensor CAT, The Center for Advanced Technology.

Every year across the globe the calendar hosts more than 50 environmental awareness days designed to highlight the now crisis level impact of human activities on the planet and our environment. The threat of this impact has become particularly clear in the face of the Coronavirus pandemic and a recent study in nature climate change that suggests we may have already missed the opportunity to cap climate warming at a safe two degrees Celsius. Over the next several broadcasts leading up to and beyond Earth Day, the Thought Project Podcast, we'll talk with graduate center faculty, students, and administrators who are using their scholarship and expertise to address a variety of environmental and climate change issues that arm New Yorkers, with the information they need to take action. Joining us today is my colleague, Sean Ray, the graduate center, science media manager, and I'd like to extend a warm welcome to our guests today, Ricardo and Kendra. Welcome to the Thought Project. So I think maybe a first place for us to start is to ask Ricardo. Could you tell us a bit about the community sensor lab, its connection to the ASRC?

Ricardo Toledo-...: I started at the ASRC about two and a half years ago to set up and run the Next Generation Environmental Sensor lab as part of the environmental science initiative on the fifth floor of ASRC. It soon became clear to me that there was a great interest in low cost and no power sensors are somewhat of a novelty. And it's a departure from the classic scientific instrumentation that is normally associated with research, but then Kendra have been running the illumination space visits with some students and she asked me if she could bring some students around to the lab to which I said, "Yes, of course."

And we had, I think a couple of visits and at some point I think one of the teachers that came with the high school students lingered in the lab and asked me if we could do something with her or she could do something with us. And so I said, "Sure." We initially started with just talks with teachers from the school. And then that led to a couple of sessions where we had some students in the lab and we did some preliminary work. And then from there it took off and became a very, very popular and a lot of fun project, I think for me. And I think for Kendra too.

Speaker 2: So what kind of projects? What do you have the students building in the lab?

Ricardo Toledo-...: So initially what we did is we set up a very simple system that had just a CO2 sensor, a small inexpensive CO2 sensor, and the students put it together here in the lab, sort of under our guidance. And then they took these sensors back to the high school and they use them to do different sorts of experiments. These sensors are great teaching tools because they allow the students to come into some kind of a tactile contact with what the CO2 might mean. Everybody has an idea of what CO2 is and it's in the news. And we all know that the CO2 in the atmosphere is the main part of global warming. CO2 is also something that we have in sodas. And it's what we excel when we breathe.

There's a notion that the CO2 might be poisonous, which it is to a certain degree, but it's not a hazardous gas per se. So these initial sensors allow the students to sort of come into a first contact what this gas might be. They learn the levels at which [inaudible 00:05:20] atmospheric CO2 is currently. We also introduced them to some of the historic data from the CO2, as it has been rising throughout the world. That was the first sensor system that we put together. And after that, we've been expanding to other kinds of environmental variables, such as temperature, pressure, humidity. And now we're moving on towards the particulate matter, which is really the particles, the solid particles in the air, which is very important in New York City.

Tanya Domi: So Kendra, how do you see this program addressing issues of environmental justice and advocacy?

Kendra Krueger: So as some people may know, environmental injustice is this concept that climate change and other environmental factors are not experienced equally across communities and specifically communities in New York City. And there tends to be a trend where communities that have less resources and have been historically or systemically marginalized. They're the brunt of a lot of these environmental injustices, which include air pollution, water pollution, soil toxicity, and other factors due to proximity, to traffic, different distribution plants, or parking facilities, transportation facilities. And considering this, there then is not the same level of advocacy happening because you can't have the same policies that are happening across the board.

Some communities are going to need more resources to heal and to face the challenges. Yet there might not be the same level of monitoring happening of the environmental conditions in these areas or the same number of resources supporting that kind of environmental monitoring. So the idea behind the community sensor program and community sensor lab is that we're developing these low cost environmental sensors that can be developed and maintained and installed and supported by community folks in their local neighborhoods so that they can be collecting data in their local neighborhoods on these environmental conditions, which can help them in advocating for better conditions.

Tanya Domi: Sure. Like with their assembly man or their member of city council, bringing that information to them and trying to pass some laws that would help protect their communities, right?

Kendra Krueger: Exactly. And there's even smaller local issues, even within apartments monitoring the internal air conditions due to out gassing from different neighbors. I know Ricardo's got a great sort of anecdotal story about monitoring the air coming in from his neighbors [crosstalk 00:08:21] coming in. So just thinking about that, not only is there this gap in advocacy, but also in knowledge about, what can you use? And what's the technology that can be utilized and applied in order to advocate? So we want to bring this knowledge and help to investigate the knowledge with the people in the community and figure out what they also would like to be monitoring and knowing, and pair that with this technology that's available, this do it yourself, low cost technology that's made out of Arduinos, which are these microcomputers basically that have the ability to interface with these different types of sensors. And this is a whole new field of technology that's emerging that you can have these tiny sensors, things that as Ricardo mentioned, can measure CO2, particulate matter, PPM 2.5, all of these things fit on one board that can be small enough to put in your pocket.

Tanya Domi: That's really cool. Definitely empowering people, right? I mean, you can carry it around with you.

Kendra Krueger: Exactly. And it has wifi capability. It can run off of the battery and not only then are they going to have this technology, but they're learning the skills in how to build it. The basics of circuitry, the basics of electronics, the basics of coding. And so, there's an underlying philosophy that we're teaching folks how to not only be advocates, but also teachers themselves about STEM, education and STEM skills.

Tanya Domi: That's very, very impressive, actually. It's cool. Very cool.

Speaker 2: Yeah. Yeah. No, it certainly is. And actually, what you touched upon towards the end there Kendra is something that I think will be great for us to explore a bit more and talk a bit more about the model that you're using to train the students. One of the things that I understand is that the data that they're collecting is actually feeding into a larger data set that you guys are developing. Is that correct? And how do you share that with them?

Kendra Krueger: Well, I can talk first about the educational model and then maybe Ricardo can talk more about the data and our plans for the data. The educational model is this idea. It's a train the trainer like program because we want to not just go into communities and place this technology and be like, "This is going to be good for you and you should do it." But we want to connect with community members and give them a suite of skills and figure out what's most important for the community and then train different stewards to be the maintainers and the local basically expert that can be the advocate for the community. And that is

also going to be teaching other folks in the community. So right now we're working with undergraduate students as our main facilitators. And they're learning not only how to put the sensors together, but also how to create educational material. So learning how to make many presentations, learning how to talk about key concepts of environmental justice, of data acquisition, of climate change around hardware and coding so that they can have practice and speaking about these things and teaching other folks.

And then the next iteration they'll teach the next cohort of students, which we're already now partnering with community gardens and farms across the city who have their own workforce development squads of youth and community members that will take part in our training. And then they will become the stewards for their garden sensors. And so we'll install these second-generation sensor in the gardens of this summer, and the students will be the maintainers and the stewards of those sensors, and then help us to develop the next generation of sensors, which right now we're focused on air quality sensors. And we then are planning to do water quality and soil quality as well. And also flood based sensors. That's a project that's happening in Jamaica Bay.

Speaker 2: Wow.

Ricardo Toledo-...: Yeah. So you were asking about the data. So that's a very good point because I love to say that one thing is to have a sensor that generates data, but then you have to do something with the data for it to be meaningful. So initially what we're doing, we have little memory chips on the sensors themselves that will store the data. The users can take these chips out and download the data to their computers. That doesn't really bring in sort of the full flexibility of these sensors. So what we're doing is we're doing something called telemetry, where we have the sensors themselves, broadcasting the data, either through wifi or other types of telecommunication. And then we are storing it currently onto the cloud, a free commercial product in the cloud, otherwise known as Google, which has the benefit that it's very popular and everybody knows everybody is comfortable with Google.

So were storing the data on Google sheets, which are spreadsheets that are known by everybody. And everybody knows some degree of how to use the spreadsheet. The downside obviously is that we're not in full control of the data in parallel my lab together with other groups in the city, including the city administration, we are building something a little bit more neutral, shall we say, this is also going to be a repository for this data. Now where that's going to be hosted is up for debate, but it will be something that is open and accessible to anybody who needs the data that would like to get the data along the lines of the New York City open data model.

Of course, there'll be super important to have proper curation of the data to make sure that it's available and searchable and the people can use it. As you can see, we sort of have the hyper-local use of data where people can get their

own data of the status of their own air quality in their kitchen, all the way to maybe having some aggregate data of a neighborhood or even the whole city. So that's a aspirational goal, we are actually putting something together within the next month with some funding from the city.

Tanya Domi: Would a community be able to afford this monitoring technology, if they were to purchase it themselves? Is that why you're getting help from the city as well?

Ricardo Toledo-...: Yeah. I mean this is the [inaudible 00:14:53] who's going to be funding us, not the city. It's the state, correct? Empire state development. Yeah.

Tanya Domi: Yeah.

Ricardo Toledo-...: So these sensors are relatively new phenomenon. They're mainly driven by consumer products like cell phones and many other cars are being built with many, many sensors in them. And this has meant that the cost per device has come down tremendously. So I have here in front of me, a little sensor is probably two millimeters by two millimeters and it costs all of $3.

Tanya Domi: Wow.

Ricardo Toledo-...: And the reason the cost is so low is because they are produced in large amounts and they're deployed in many places, we estimate around a hundred dollars between a hundred and $200. It's not nothing, but it's something that I think is accessible to many communities, many people, we could put together a pretty sophisticated unit with pressure temperature, humidity, particulate matter, and CO2 sensing capability. Now, as I just say, one thing is a hardware. The hardware has a fixed cost. The part that can be expensive is really the management and the deployment and the putting together these things. And that's where I think the community aspect of this project can really take up a lot of the expense. If we have a community who is not just learning, but it's actually producing them and setting them up and keeping them running and managing the data, the monetary costs of these things really comes down to a level where I think is definitely accessible.

Speaker 2: So the creation really becomes affordable. You talked earlier about creating these shared data sets are the participants, students and the community members who are participating in gaining these skills, is an understanding of how to read the data a part of your plan. Will it be open source?

Ricardo Toledo-...: Yeah, absolutely. I mean, as I say, the end product is really what we're all after. Being able to interpret and manage the data, which can be done on many levels. It can be done in very simple graphic terms, but a lot of statistics can be brought to bear. So there are many different layers of processing and producing and consuming this data. We start off with the simplest kind, which is typically just doing time series graphs, where you see the levels that you have in time. But then if you go online, you can find other data sets that might be brought to bear

on what we're seeing such as weather, such as wind patterns. In the case of the flood sensors we have, the tide levels, these are all data sets that are out there and publicly available.

And I think it's interesting to actually show, teach and encourage people to merge these data sets, to get a greater insight as to what might be going on. And this can be done both at the city level, as I say, but more interestingly at what we call hyper-local level of an apartment or a corner. We have corners that are regularly flooded only the three or four neighbors who live around there, know about that. The city doesn't know about this. And so just keeping a track of that or as Kendra said, my battle with my neighbors boiler, I kept track of it. I used it, I called the [inaudible 00:18:35] and they helped me out. And so it turned out to be a very important tool for solving problems.

Speaker 2: That's fantastic. So, Kendra, I'm curious to know, how does a program like the community sensor lab relate to this or [inaudible 00:18:53]'s mission in terms of both public science and building economic value for CUNY in terms of partnerships between science industry and academia and things of that nature.

Kendra Krueger: Yeah. So I think that the ASRC is committed to doing science for the public good. So creating science and technology that is somehow aiding in the improvement of lives or the inspiration of minds. And I think that this program kind of does both of those things, both in terms of the environmental justice factor, that this could lead to improving environmental conditions, which leads to improve health conditions as we've seen connections between respiratory diseases and environmental conditions, which also connects to co-morbidities. And in the case of the pandemic increased rates of COVID-19 in the same neighborhoods that have experienced different environmental disparities.

And I think in terms of building economic value for CUNY is we're tapped into a community of folks that are going to be learning about CUNY. So we're educating students outside of the community system about CUNY, and it's a great tool for recruitment to come into the lab. We're going to have students from these urban farms coming into the lab and having experience in the lab, but also in terms of partnerships with different industries, we've already started a number of different partnerships that are underway. For example, the MET is helping to fund some of our students right now because they have an interest in developing air quality monitoring inside some of their preservation casing for the artwork. And so they would love to have some students working in the museum with them. So we have this ability to connect both these grassroots projects with also different industry projects.

So students get to learn about the implementation of these devices in places like gardens and communities, but also in museums and see the connections between art and science and see these different career pathways. Because we also have other industry folks coming to give talks as well. We're also partnering with the ASRC censor CAT that's the center for advanced technology that is

working with industry and small startups who are working on different types of sensor technologies. And so we have a direct connection with other entrepreneurs that can come talk about cutting edge sensor technology as well because the current sensor has this ability to work off of wifi. But again, wifi is not available in all locations, and it's another barrier to access and to entry into this kind of technology that there's an organization called NYC Mesh that helps to set up a community wifi nodes across the city.

So we're working with them and experimenting with some of their technology to interface with our sensors. And then just in general with other city organizations that Ricardo mentioned some state funding, partnering with city council, folk and assembly members that it's building these collaborations. And I think that a big part of that economic value is having these partnerships that are lifting up these kinds of projects, where people are meaning each other, they're sharing resources, we're building collective power. And I think that's one of the greatest aspects of this kind of intersectional project.

Speaker 2: That's really great. We actually had Ryan Olin on recently and he mentioned about the partnership between the CAT, Center for Advanced Technology and the community sensor lab. And I think he even mentioned something around workforce development. Is that something you guys could expand on a bit? Ricardo?

Ricardo Toledo-...: So this has been on our radar since we've been interfacing with them, they have a mission of workforce development who are still trying to figure a way how we can incorporate that. I mean, what we do obviously is workforce development that we'd like to do it in a bit more formal way. So again, aspirational at this point, but definitely on our radar.

Kendra Krueger: I think to speak more to that because this kind of project with these sensors, there's so many different levels of learning that are involved in it from just putting together the pieces, to coding it, to placing it in a location. So monitoring the data, but also the physics of the device itself is a whole area of learning. And because the sensor CAT, they focus on nanotechnology and the fabrication of these kinds of devices. And that's a whole field of work that's really blossoming right now. And as a possibility for workforce development and training lab technicians. So this could be a really good entry level project that introduces the idea of this kind of technology and how it's created and coming then, the next step, is into the nanofabrication lab to see how these actual devices are created in the clean room facility. And to see that in itself is a whole career pathway that could be traveled.

Tanya Domi: Ryan did mention the CAT project really can serve as a pipeline for CUNY and also a pipeline for workers with dual application into new startups. And so if you were a lay person and you didn't know science, and even within the Academy, there are people that don't really, it's siloed. So you have people in humanities doing one thing and people in social science doing other things. Do you think

that people don't necessarily recognize these potential relationships or existing partnerships and that they perhaps even undervalue them or could even be dismissive of them if they didn't know what both of you have just told us? I'd like to hear your thoughts on that Kendra, and then please weigh in Ricardo.

Ricardo Toledo-...: Yeah. I think that there is a danger in the scientific community to becoming siloed in, in any industry or community to becoming too hyper-focused on one specific goal. And I think that in this project specifically where we're trying to break down barriers of entry in many different places, both between the scientific community and the academic community and local folks and local communities, but also between industry and also between artists and folks in the humanities, because this is this intersectional type project where it's looking at multiple issues simultaneously, it's looking at issues of injustice, which is a social issue. It's looking at issues of the environment as a science issue, it's looking at issues of technology, which is an engineering issue and also finances and funding, and how are we going to make this happen and talking to people in ways to make it happen.

And I think even particularly in the education field, it's a great project because it's not only creating a project-based learning tool that just has sort of an abstract meaning to it, but it's a project where there's a community based outcome to it. There's an actual motivation and a drive, which I've seen the students pick up on it more because it's not just they're giving me this thing to do as something to do, but that there's actually a motivation, there's actually a change that's going to happen. And in terms of also breaking down some of these boundaries between the Academy and the sciences and local communities is that often with outreach, many projects, try to get science out into the community and they go, and they run these workshops out in the community, but that's only a one-way street.

And we're trying to create more of this two way street, where we're bringing the voices of community folks into the research center also so that they can become drivers in the scientific community as well, because we need more diverse voices in these scientific spaces and in these industry spaces. And we need more people talking on an even playing field and we don't have to have these dichotomies or hierarchical authority figures that are just based on the social dynamics of education or otherwise. But everybody has something to offer and a voice to be heard in these spaces. And when there's a problem that needs to be addressed for multiple people.

Tanya Domi: Ricardo?

Ricardo Toledo-...: This is indeed a very multi-disciplinary project in the sense that the whole process involves all sorts of types of sciences. It's engineering, it's physics, it's computer science, it's a certain degree of mathematics, but it also has all the communication aspect, the outreach aspect. And not everybody has to know everything about every part, but we all have to know what is going on and what

the other part is doing. We don't want anybody to be siloed. The other thing that's very important is to keep a language that is accessible to everybody. The science and engineering can evolve into very technical jargon with a lot of delays. That's three letter acronyms that-

Tanya Domi: The different language, many times alienating.

Ricardo Toledo-...: A lot of people at some point will tune out as it be too difficult. So we want to have an atmosphere where every question is important and also to bring a certain sensorial aspect to what we're doing, how does this work? Have you had an experience where you can actually see particles floating in air? And I sort of read trends and bring people to observe the world in a different way. And on that note, there is a very, very important resource for our project, which is a great help. And that is this incredibly large and incredibly supportive online community of people throughout the world who are doing something similar or something along the lines of what we're doing. And it's just a matter of going online and joining the forums and asking questions. And it's really very, very supportive, and very gratifying to see how a project like ours can link up to websites in Germany, websites in Japan, and in Russia that have the same questions and are using similar technologies, part of a very global movement, I would say.

Tanya Domi: That's really interesting and really fascinating. And also you're actually creating a pipeline for CUNY and for the communities across the city. And maybe even beyond this global network. Yes, Kendra?

Kendra Krueger: I just wanted to add one thing because we didn't really touch on this language that this whole field of science, which has historically kind of been called citizen science, but we're sort of moving away from that terminology now and using this language of community science now, as it's a bit more inclusive and it speaks to more of this collaborative space that we hope to [inaudible 00:30:39].

Tanya Domi: Thanks for sharing that. That's good to know. Good to know the contemporary vernacular, thanks to both of you, very interesting project, and we wish you all the best as you go around and try to help us clean up the globe. Thanks for tuning into the Thought Project and thanks to our guests, Ricardo Toledo-Crow, and Kendra Krueger at the Advanced Science Research Center at the graduate center CUNY. The Thought Project is brought to you with production, engineering and technical assistance by Kevin Wolf of CUNY TV. I'm Tanya Domi, tune in next week.