CERAMIC TECH CHAT
Episode 50
Title – "STEM outreach in rural communities: Katrina Donovan"

INTRO

McDonald: "I'm Lisa McDonald, and this is Ceramic Tech Chat.

> Working on problems in the lab can sometimes feel far removed from the struggles of everyday life. But most research is conducted with the aim to provide solutions to real-world challenges. It's important for scientists to keep that in mind because their research could be the basis for outreach activities that inspire others to pursue a career in STEM."

Donovan: "There's a quote by Rosalind Franklin. She said, 'Science and everyday life cannot and should not be separated.' And I love the quote so much because we're always looking for solutions, how can we improve something. You know, I think sometimes we get so involved in the beauty of solving the problem we forget who we're solving the problem to. And it's just important to inspire that next generation of STEM individuals."

McDonald: "That's Katrina Donovan, faculty member in the Department of Materials and Metallurgical Engineering at South Dakota School of Mines and Technology. When Katrina moved back to her home state of South Dakota after studying and working on the West Coast, she had the goal of using her knowledge and experiences to help expand access to STEM opportunities in the state's rural communities.

In today's episode, Katrina will describe her expansive background in materials, from polymers to ceramics, and how her current research harnesses South Dakota's rich geological resources to help inspire and teach students and educators across the state."

(music)

SECTION 1

Donovan: "So, my journey to science actually is kind of an interesting one. I grew up on a ranch in a very rural part of the United States. I grew up on the Pine Ridge Indian Reservation. And there isn't a ton of opportunities there, but I was fortunate to be a part of an NIH study, and it was super cool because there was a group of us from high schools there that got to go to Washington, D.C., and do a biomedical health study at Georgetown University. Going into high school, I knew I liked science and math. But the opportunity to travel to D.C., and this would have been the early 2000s, was just an amazing opportunity that didn't really come around that often. So, it really opened my eyes to just all the opportunities that STEM and science bring to you.

Even though that was more on the bio side, I really thought I wanted to go somewhere medical. And that wasn't how it ended up. I found out I pass out at the sight of blood, I pass out at the side of cadavers. And so, there was a lot of you know failing along that way to really find my passion material.

So, as I was in my undergrad studies, I was kind of working toward that medical degree. I started doing research, and I was looking at, really, it was like solar applications, but we're looking at zinc oxide nanoparticles, nanocomposites. And I was still pretty early on, but I started realizing I was enjoying my materials research more than I was enjoying this medical path I was pursuing. And so it was really in undergrad where I made this flip from my high school experiences at Georgetown, realizing I can still help people, still work with people, but on a materials side.

But that's kind of my start of my journey into materials, was being a 15-year-old in South Dakota, getting that opportunity to go to Georgetown University, and then that putting me on a STEM pathway."

McDonald: "And it really is so critical to be able to have these opportunities for younger students so that they even know these opportunities exist so they can pursue them once they get to those more decision-making years coming out of high school."

Donovan: "Absolutely. I completely agree. One of the things I tell my students, I like the phrase, 'Successfully stumbling forward.' You know, passing out multiple times thinking I want this medical degree, you know, maybe it's not so much STEM isn't for me, it's maybe this isn't for me. And that's part of life, I think. Accepting that maybe something isn't your specialty but shifting that a little bit. Always persevering, one step in front of the other."

McDonald: "Let's learn a little more about all the different materials that you have experience with. Because I know you mentioned briefly, you started with some oxide nanoparticles in undergrad, but since then I saw on your LinkedIn that you've worked with things like biofilms, you've worked with microfluidics. So, can you take us on that journey of all the different materials you've had experience researching with?"

Donovan: "Absolutely, yeah. So, undergrad started with those nanocomposites, and then I kind of switched gears a little bit. For my master's work, I was living in the San Francisco Bay Area, and so what I was doing was I was commuting, and so I really wanted a remote project. That was something that very much appealed to me at that time. And so I started looking into microfluidics. And I wasn't building the microfluidics so much; I was using computational fluid dynamics to model these different systems. So, I was looking at mixing flows of two different phases, sometimes like an oil and water type of system. And some of the applications we were looking for were aerospace; we had ties with NASA Ames there. So, there was a lot of different work. But it was really at that point everything was very small, microfluidic scale, looking at these small systems. But I was doing everything computationally.

I will say that was a big learning one for me. I thought there was gonna be a lot of beauty in being on a computer. And there is, but I realized I really missed the lab. So, that was my master's work, was learning it is good to have this skill, but it wasn't my passion in STEM. I needed…It was me alone on a computer a lot, to be honest, which isn't always bad, but I really like engaging with people. And I also like the lab. I like the hands-on part of this instead of just putting it into a software and, I felt, like hoping for the best.

So, that was a big shift I made going into my Ph.D. My Ph.D., I wanted to do lab work. I knew I was okay supplementing with the computer, but I didn't want that to be the core of my thesis. And so what I did there is I switched to a lot more biological work at that point.

There was research around spinal disks, and my Ph.D. advisor had a particular passion with this because he had two herniated spinal disks. And so, they're very painful, they press on the nerve, there's a lot going on there. One of the big things with it, though, is there's a mechanical part to looking at a spinal disk. It's under compression. If we twist and turn, it's experiencing sheer, you know, these torsions. There's a lot of different things going on. So, we were looking at it less from a biological side, more from like a biomechanic side. And that was awesome. It was a really good experience.

We had to find a model for that, though. Weirdly enough, people don't want to donate their healthy spinal disks. They tell me they're using them or something. So, I had no human data to work with. There was some literature that we referenced, but we actually spent, it was great because I got to work with undergrads and a couple of high schoolers on that particular project. And so there's a team of us, but we were actually looking at spinal disks, more like cow tails, I guess, but they were similar to human spinal disks. So we did a ton of mechanical testing on these cow tails. Kind of the joke in the lab, when we were going, we had all these high schoolers, when you look up cow tail or oxtail, what you're actually gonna get is a recipe if you Google it right away. So, the running joke in the lab was, 'What soup are we making today with the tails?' was kind of the joke as we were just dissecting and then squishing these samples. So, that was kind of a fun one.

We did a little bit of work with biofilms. I was really more of an assistant to another graduate student. I was helping just clean things, keep things very, very sanitary. The biofilms are very sensitive to a lot of that. I think with my cow tails we literally, you know, squish them, beat them, did all the things to them, and that other lab was a very clean lab. I learned how to be clean with biofilms.

About that same time, though, as I was working on my Ph.D., I got an offer from Hewlett Packard, and they were just kicking off their 3D-printing, like, era. It was about 2014, 2015, a lot of this was happening. And so, there was an opportunity for me to go work for them. They were looking for somebody that had a background in materials, specifically, but also fluids. Kind of the interaction between the two, the fluids and the powder. And that's really where a lot of the work I did, that computational work that I was bemoaning earlier, it came in really handy this next step where I was at HP and I was looking at a lot of fluid and powder interactions. We looked at things like how fast we can fuse our system. We also looked at depending on how much we load our droplet, can we get things

like improvements in mechanical properties, electrical properties, optical properties. There was a whole range of material properties—that's what I just described, right?—a bunch of, a whole range of material properties that we can modify if we knew the fundamental science there. So that was kind of actually the cornerstone of my Ph.D. was looking at a lot of those different parameters within the 3D printing system.

McDonald: "So, how'd you end up where you currently are now, after Hewlett Packard?"

Donovan: "So, Hewlett Packard was great, I finished up my Ph.D. About that time, I was living on the West Coast, originally from South Dakota, there was an opening back at my alma mater for my undergrad, and when my husband, who's also an alum here, when we saw these openings, we're like, 'This is that window.' And so we both applied, both got jobs, which was, you know, awesome. And so that's, we're back home, close to family. So that's how we came back to working at South Dakota Mines. I probably would have continued at HP for a little bit longer, but that's how we ended up back here is the call from home, I guess, is probably you know a strong pull for us. I will say, too, I haven't talked about it a lot, but I did a lot of STEM outreach during my Ph.D. work before I started working at HP, and I really got engaged in that. And there was always, you know, I think for my husband and I, both of us engineers, there's always this pull to go back home and give back in whatever way or capacity we could. And so that's kind of fulfilling in some ways, I think a dream for both of us."

(music)

SECTION 2

McDonald: "So, what kind of research at you currently focused on in South Dakota?"

Donovan: "So, a lot of my research right now is focused around ceramics. That's been a big shift for me. I do have a strong polymers background, but it has switched more to ceramics. Probably, about three years ago, we got this NSF grant that was focused on improving undergraduate STEM education. With that, we were going to start implementing a lot of glass work. However, we were waiting, like a two-year wait post-COVID for equipment to get here. You know, we ordered it, and they're like, 'Great, we'll ship it in two years,' and we're like, 'What?' That was just that time of life. So, we're like, 'Oh no, we have to refocus.' And so we switched from focusing on glass to ceramics, and by ceramics I really mean probably more minerals is a good way to say it. Living in the Black Hills, we have a wide range of minerals that are just exemplary. Geologists travel just to see this area between the Black Hills. And then we have the Badlands, which are kind of more clay-like bodies east of us.

So, my current research focuses on completely local materials to make clays and ceramic glazes. It's actually really cool. I have a high school teacher right now who's working with me, and she's working on a NASA grant, and her entire focus is just getting that ceramic glaze figured out, which is super cool. She's got a clear glaze and a bunch of colors. It was funny because we were talking. She's like 'We can buy this and make this. That's not

new. But we're constraining ourselves to what can we use in our local neighborhood to make this clay body, to make this glaze.' And so that's been a fun challenge. The whole time she's doing this research, she's also making it into a module that can fit into her K–12 classroom, which is huge. So, it's not like all of this will just go and be published; she's gonna integrate it into her classroom.

So, that's currently what I'm working with, a lot of glazes. We're also looking at applications, local sources for gum, cellulose, those types of things to help the application of the glaze onto a clay body. But 100% local is what we're doing for our ceramics."

McDonald: "And you're just so uniquely positioned because I've done vacations out in the Badlands, and the geology in South Dakota is just so rich and also obvious. Like in the Badlands, you can see the striations, the layers. So it's something that's you can physically see. And especially if you're working with undergraduates, high school students, it's something they can see and grasp and really not just like hear about theoretically, they're able to go out in the backyard and see it, which probably helps so much with them understanding the concepts, getting engaged, wanting to create these glazes from all the local things around them."

Donovan: "Oh, you're totally right. We have a week-long summer camp that we do with high school students, and we have, it looks like a gun, but it's like a space gun. It's a big XRF, it's a handheld one. And you can put it up to a rock, and it'll give you mineralogy. High school students love taking that thing out, and it's like we're looking at all different kinds of clay bodies. We'll actually take some of those clays, come back and make, you know, pinch pots and things with them. And we'll talk about why this clay body, even though it might have pinched well when we fired it, it failed. So there's a kind of very holistic look from, alright, we have a mineral all the way to, you know, a product being a pinch pot and looking at the science of why did or didn't it work, right? And so, the students love that. But you're right, the Badlands are so beautiful. We've got the wonderful striations.

Recently, a colleague of mine, she's a geologist. We got an NSF REU, so research experience for undergraduates. Also passionate about that level, too, not just my high schoolers; I do like the undergraduates as well. But we have a whole study where she goes and does field work out there, but we're gonna be taking undergraduates through where they get to see all those striations. We're tied in with the Park Service as well. And then there's a lot of rich Lakota history there. So, we're super excited for them to see just how different, too, the Badlands [are], you're talking about those striations, you go out into the hills then, and it's rock-hard granite. Just a lot of interesting geology there."

McDonald: "In addition to the rich minerology, you also have this inspiration by the Lakota and some of the other indigenous tribes in the area to teach you about, like, their ways of forming these clays into like you mentioned, like, I guess like the pinch pottery. So not only are you learning about the local geology, you probably have tons of opportunities to learn about the local culture and how they created these pots and these glazes for probably, you know, hundreds of years."

Donovan: “Yeah. And we’re in an interesting area because, especially down in like Arizona, there’s a ton of great history in terms of pots. We, the Lakota here, did not do pots in the decorative sense that they did in some of the more Southwest tribes. They did have them from what we’ve found. I work with an archaeologist at the Rosebud Sioux tribe, and she’s found remnants of those pots. And it’s interesting because they talk about how they would paddle them. It’s not a traditional like pinch or coil, like they did this paddling technique, she thinks.

The big thing here, actually, which might become a little bit of a surprise, is there’s a ceramics, but glass beads were a really big thing.”

McDonald: “Oh!”

Donovan: “I know, right? It’s super cool. They did a lot of quill work, so like porcupine quills, the Lakota would trade to get these tiny glass beads that they’d then make amazing decorative like beads, and they had jingle dresses, and it’s amazing that fusion there of the glass and the art. But these were traded, you know, these weren’t made locally. They were traded for furs and those types of things; there was the trade. But the quill work here is amazing, and the quills being part of those beaded works. So that was actually a big, probably more artistic side. The pottery, more functional, but the quill work here is phenomenal, and those glass beads are pretty impressive.

And they have a quill museum at Prairie Edge, which is a Lakota, like, trading post. And they have a huge—it’s not huge, but to me it’s huge —it’s an amazing just glass museum there that’s in this trading post that has a lot of the leather work, the quill work, all of that like in this museum from100 plus years ago. So, the beaded purses and stuff, it’s awesome.

So, you’re absolutely right that I can connect with everyone just based off, like you said, the quill work and bead work that the Lakota did.”

McDonald: “I feel like we often overlook glass because, you know, clay is pretty straightforward to make. You know, you take it out of the ground, some clays you can just harden by leaving it out underneath the sun. But glass can sometimes be a bit more elaborate. You have to get it a bit hotter, you have to cool it. And so to hear that they were trading with and using these glass beads, that is really fascinating.”

Donovan: “Yeah, it really is. And the interesting thing we were talking about, the Badlands, just south, about 50 miles south of the Badlands, is what are called the Sandhills, and they’re mostly in Nebraska. I grew up on the border between Nebraska and South Dakota, so I grew up in the Sandhills. And I was actually out there, as you said, looking for clay on my parents’ ranch. And my dad’s like, ‘Mmm, you realize these are the Sandhills. Maybe you should be looking at glass instead of clay.’ And I was like ‘Oh, touché.’

So, that’s my next project, is how local can we get with glass. Glass is obviously a little bit more challenging, too, chemically, and there’s a lot going on there. But there’s a lot of

people that can, you know, you can dig in your backyard and hopefully get somewhat close to a pottery piece. Glass is a little bit more challenging, but yes."

McDonald: "That also means it's a little bit more fun, right?"

Donovan: "Absolutely, absolutely. There's good questions to ask there, then."

(music)

BREAK

McDonald: "The Ceramic and Glass Industry Foundation's Materials Science Classroom Kits provide teachers with fun, hands-on lessons and activities to introduce K–12 students to the basics of materials science. The CGIF supports the giving of these kits to teachers through generous donations by individuals and industry sponsors. You can donate to the Foundation at foundation.ceramics.org/give."

SECTION 3

McDonald: "So, I know so far we've touched on a ton briefly of your outreach activities in STEM. You're so active, you're doing so much. So, what was your very first outreach experience? How did you start really getting into all of these different programs and events that you do?"

Donovan: "Where it really happened for me is between my master's and my Ph.D. I had kids during my master's, and so then I was probably floundering a little bit at this loss between motherhood and science and how do I make all this work. I didn't know what to do. And it ended up being my Ph.D. advisor, but he was the director, I think was the title, of pre-college at Oregon State University. So, all the pre-college programs, everything from the day camps to STEM camps, but that was his passion. And when I was finishing writing my master's, he was like, 'You should come and do this outreach.' And I'm like, 'Well, I have kids. Like, I can't.' And he's like, 'No, no, no. It's all family science and engineering nights. Bring your kids. They can come do the activities. It'll be fun.' And it was such a beautiful thing because I don't know if I ever would have honestly gotten my Ph.D. if it wasn't him being like, 'Hey, it's okay, bring your kids. I'm not asking you to bring them into the lab and run science experiments, right? I'm just asking you to take them to this family-friendly STEAM night.' And so, that's really where I saw the beauty of what STEM can do. And that's really where I grew a passion for it."

McDonald: "And nowadays, you're running several different programs of outreach because you've been so inspired. And so would you be able to tell us a little bit about, like, the different grants that you have and how you're using each one for different groups of people?"

Donovan: "Yes, I'd be happy to. So, I guess we'll start with my first one, which is an Army outreach program. So this one is particularly for high school students. So it's an

apprenticeship where high school students get to come, they get to spend roughly 200 hours of research in the summer on campus. And we've done a lot of different flavors in terms of sometimes they're paired up directly with faculty members, sometimes they're with undergrads, but they all get, like, they have a cohort of them. That one we've had for a while. It's been running since about 2013. I took it over, to be honest, in about 2020. Last year I had just two [students] that worked directly for me, and theirs was specifically focused on ceramics as well. But really, all of them deal with materials in some fashion.

I also have an NSF improving undergraduate STEM education [grant]. That particular one, we're looking at bringing creativity into our curriculum, and that's really where my very focused journey into ceramics began was with this particular grant. It is focused at an undergraduate level, but one of the big things we emphasize is the community engagement. That's been really a large number of different areas we've worked on. We've worked with K–12 teachers. I go to the South Dakota STEM Ed conference. There's hundreds of teachers there that are focused on STEM. We also, because we're bringing art into the curriculum, we've actually coined the term Art and Engineering. That's what we call this program. We have an artist that works. We also went and talked to art teachers at an undergraduate as well as a K–12 level, and just looking for creative opportunities. And, you know, sometimes they have these big scientific visions. Sometimes it's as simple as just everyday things like one teacher was like, 'I did a clay project. I don't have a kiln,' and we're like, 'We have a kiln, we can help you out,' right? So sometimes, you know, there are these big things, but sometimes it's just being a very community-focused kind of thing.

There's a couple other grants that I have. I also was super fortunate, and I put in for a CGIF, or the Ceramic and Glass Industry Foundation, grant, and it was for the Materials Science [Classroom] Kits. And I briefly talked about the South Dakota STEM Education Conference, which is huge. That grant was focused on delivering it to a ton of outreach. There's smaller ones I did, but like the cornerstone of that one was, 'I wanna get this in the hands of teachers.' That was my big goal. And this would have been my third year I'd gone to that conference, and I advertised my session as Material STEM Kit: Come, learn, do it all.

And I had two sessions of that, and I…I was so unprepared for what I had opened the doors to. Usually, I mean, they're usually great. We usually do, like, a metal clay lab with them, talk about hands-on. This is the first time I'd done the materials kit, and I had got, I think, two of the bigger science kits and then a bunch of the small ones. So like the idea was they come, they could do the module themselves, they could take home their kit, and integrate it into their classroom. There was literally standing room only, and I don't have a picture of it because I was there like deer in the headlights like, 'Oh, my gosh, I have 60 people in a room that's supposed to fit 25.' And there's other people being like, 'Where is room?' and I'm just like, 'I do not know what to do.' So, we did get kits out to people, but the response to that was so amazing.

And there was a couple different things I learned from that as well. You'll get a little bit of a pitch about South Dakota education from me, but South Dakota is very low on STEM

teachers, and I didn't realize how low until there was a group of online STEM teachers who were attending this, and I was like, 'Why do you need a materials kit if it's all online? Like, isn't the beauty of it not having to deal with materials?' And they're like, 'Well, you know, I teach to a number of different high schools that don't have a science or a math teacher in high school.' And if you're teaching to five different classes, having five different modules can be really tricky. And that's really, like, that's what it is, because one class might have a Bunsen burner, another might not. So then we go from a Bunsen burner to needing a hot plate. Even like a single module has to have all these nuances. For them, one of the things they really liked is the beauty of this is you can ship this out, they can open it, and do it there. And so that was why that group of online teachers was really interested in it. Cause that materials kit opens doors for students who can't drive, who don't have a science teacher or a math teacher physically there. And so that was kind of one of the big things that came to me of, like, how powerful these kits really are."

McDonald: "All of your stories are just so inspirational because unless you grew up through these school systems, a lot of people may be unaware of how much need there is in their local communities, especially in maybe some of the more rural states where things are so spread out. It's not that easy to just hop over to the nearest store because you're in the middle of nowhere. So to be able to ship these kits to them with all the materials that they need. And it's just really great that, like you said, one of your goals of moving back to South Dakota was to help your local community, and everything that you're doing is doing just that."

Donovan: "You're right. I usually tell people we have more cows than we do people in South Dakota, and so hopefully that'll give you an idea of how rural it is. My cousins drove 45 minutes every day to go to a high school. So, just very different. I was talking to an undergrad the other day, and I was telling her about this, and she's like, 'Oh, you don't need to tell me. I never had a science or math teacher growing up.' For her it was a challenge then coming into an engineering school where we start them off with Calc One and some of these students have never had Pre-Calc. So that's quite a steep curve. So I think any opportunity, especially with these science kits, to give back, to create those opportunities, to inspire these students in these rural areas is super important."

McDonald: "So what types of recommendations or helpful tips can you give to other teachers who may be looking to want to start outreach in their local communities? Especially in kind of rural areas where things are so spread out. What are some avenues or types of groups they can try to connect with or meetings they can go to try to reach these different audiences?"

Donovan: "That's a very good question. One of the groups I've been involved with, every year the Girl Scouts have what's called the Big STEM Day, and that's one big thing the Girl Scouts have been doing, is they've been promoting this. I've worked with hundreds and hundreds of kids through that. So, Girl Scouts is one that'll do it. One of the big things that have started coming up is Knowledge Bowl. Even though we're pretty rural, they'll do travel competitions even in at a middle school level.

So I think it might not be directly STEM or science, but I feel like there's these little threads in a lot of different things, right? Like Girl Scouts isn't fully focused on STEM; this is one module within there. So I think that's a powerful thing, is if you have a module or something you can share or an activity you like to do that is STEM focused, you can plug in to these different things is really, really important."

McDonald: "I think that's a really good recommendation because a lot of communities have, like, newsletters, or websites with things that are taking place around town. And if you keep a tab on that, it can give you ideas of where you can go, where people already are, to meet with them."

Donovan: "Absolutely."

(music)

CONCLUSION

McDonald: "The importance of STEM outreach is gaining recognition in the scientific community, and programs such as Katrina's demonstrate how you can personalize these experiences to better connect with your audiences.

I'm Lisa McDonald, and this is Ceramic Tech Chat."

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"Visit our website at ceramics.org for this episode's show notes and to learn more about Katrina Donovan, her research, and her outreach activities. Ceramic Tech Chat is produced by Lisa McDonald and copyrighted by The American Ceramic Society.

Until next time, I'm Lisa McDonald, and thank you for joining us."