

What is STEM Engagement?

An Interview with Victor Lee

On July 12, 2018, [Mac Cannady](#), Director of Quantitative Studies at the Lawrence Hall of Science, interviewed [Victor Lee](#), to understand his thinking on the topic of engagement. Dr. Lee is Associate Professor of Instructional Technology and Learning Sciences at Utah State University. He is a learning scientist and technologist who is interested in supporting teaching and learning of STEM content and practices with new technologies in both formal and informal settings and across age groups. A video of Dr. Lee's interview, as well as interviews of other researchers, is available at InformalScience.org/engagement.



What led you to study engagement in your work?

Well, a lot of times you hear people saying, “This lesson is so engaging,” or “This technology is so engaging,” or “This is a good way to boost learner engagement.” There are now so many new technologies, like maker education, which people boast will be more engaging than what we already have in classrooms or in other settings. I was starting to wonder, “What do you mean by engaging? What’s going to happen that’s going to be so different in there?” And as I started to look more carefully, it wasn’t quite clear what *engaging* meant. Was it more time on task, was it that people would report more positive feelings about the activity, or did they just say they learned more? I got a bit curious and thought that we needed to figure that out, because one of our jobs in the research community is to push for a little bit more precision and use data to show what things seem to be.

What specific projects have you done that included aspects of engagement?

There are [two projects](#) that are related in various ways, and they both involve wearable technologies. I think it’s a really interesting ecosystem that we’re walking into, because we’re able to get more data from individuals without being in their faces per se. In the first project, we were trying to revamp data as statistics education with youth by having them inspect their own data, and the hope was that it would be a much more engaging form of statistics learning than what’s currently provided in school settings.

Outside of school settings, we’re using different wearable technologies that may be able to collect electrodermal activities. Your reaction to what you’re experiencing produces a signal on your skin that, at least in the lab, in psychology studies, is correlated with sitting up and paying more attention. In that particular project, we’ve been

looking at maker education in afterschool settings and clubs to ask the questions, “What parts of making are engaging for the youth who actually participate in this? What populations find it engaging, and how widely engaging is it (if we accept that sitting up and taking notice demonstrates engagement)?” For the past two years we’ve been partnering with museum and community programs in two different locations, obtaining data from youth who are participating in maker projects to see what aspects of those experiences are engaging. We hope that will produce some information that we can use to cultivate more engaging experiences in a whole range of learning settings.

What is your working definition of “engagement”?

There are a lot of fairly precise ways that people talk about engagement, but there isn’t really a consensus about what it means. In the work that I’m doing I’m making an appeal to sit up and pay attention and take notice of your feelings. When you have that heightened attention (which we talk about in scientific terms as more like heightened arousal), you’re noticing more, and you’re ready to respond more to what’s going on. We can get signals about heightened arousal using some of the new wearable technologies that are available. That’s generally how I’ve been looking at it, but I also think there are some everyday notions of engagement where we see people nodding because they agree with something that’s being said, or raising their hand and waving it in the air because they really want to speak. I think those also have validity, but those are different senses of engagement that I’m not focusing on particularly in my current work.

How and why do you think engagement matters for science learning?

Engagement is one of those things that is a linchpin. We have a lot of great ways of designing information so it’s easier to process. We have ways of setting up exhibits and experiences and resources, and we have a pretty good research base

that shows these ways will produce a greater effect than other ways. But all of those approaches assume that the audience wants to look at this and is willing to spend the time to do that. That’s a pretty big assumption. What we’re doing right now in this day and age is competing for attention. So with my research, we look at social media, and what they’ve been able to do is get our attention. Then they insert information that can be used for various purposes: to sell something, to promote their ideas, whether or not it has direct oversight. I think we’re looking at an attention economy and we’re trying to compete in it. Studying engagement for information learning is largely asking, “Well, what things are getting your attention? What are you willing to invest time in, that finite resource, and look at and process?” If we can harness that, then I think we can best utilize a lot of these other findings about how to best design that information and how to best organize that experience so that the audience gets the most out of it. But I think that linchpin is to first get people to care enough to feel like what we’re showing them is worthy of their attention investment.

How are you measuring and assessing engagement in your work, and what are some of the tradeoffs of that approach?

We’re using wearable devices, which are wristbands similar to a smart watch or a Fitbit device. They measure how much electricity your skin can conduct at any given moment. It turns out that there is a pretty strong correlation between more skin conductivity (and spikes in skin conductivity) when you have heightened arousal. That relates to our primitive survival instinct that evolved in our brains and our bodies. Using those, we are getting data about four times every second about skin conductivity, and we’re coupling that with wearable cameras so that we can see what these youths who are in these informal learning environments are seeing and encountering. Our goal is to figure out what sorts of things lead to these natural spikes and make them willing to spend more time looking at or investing in and attending to the information. In addition to those data, we have accelerometer data

and temperature data. It's an all-in-one sweep to capture what is more or less arousing across a number of different accepted psychophysiological measures. I think what's different about this is that for a long time, these technologies were only used in very strict lab settings, where you plug it in into the USB port and you use this very specific software. What's interesting about wearable devices now is that we've become untethered from the desk and are able to move around in the world. Instead of getting data from a treadmill in the lab, we can go walk around in our neighborhoods and see how much distance we've covered. That's the big change: we're able to be more mobile, and now we can move freely with wearable devices. Because of that, we don't control the stimulus or the environment so much, and we're starting to see more about the wild learning experience that happens informally. The trick is to figure out how to read that signal. How do we know what it was in that environment that triggered a spike, since there are so many possible things that could happen at any given moment? That's where the wearable cameras come in, as well as a bunch of other triangulation techniques, such as youth self-reports, survey data, and our own video data. We do our best to apply thoughtful analytics and try to pinpoint what activities, experiences, or features are getting most people to stop what they're doing and want to attend more to what's happening. A lot of times, what's key is the social aspect, the opportunity to do things with their peers, to engage with them playfully as they're working on these activities and projects. That helps them turn the experience into something meaningful where they're connecting with other individuals as they're discovering things.

One tradeoff of this approach is that any given tool that you use is a very particular lens on the world, so it makes one thing stand out and it backgrounds a bunch of other things. When we think about engagement, what we're looking at in our research is, "How is your body immediately responding? How is your skin connectivity changing in response to what's happening?" What we don't necessarily see is all the different things that the person was thinking. If we had the technology to read out

thoughts, that would be incredible. But technology to read why a particular display was engaging to someone is harder to pinpoint. Often we rely on self-report, but we know that from basic memory studies self-report has its limitations. Just because it has its limitations, is it useless? No, no, it's definitely got its uses. I think the wearable technology offers something that doesn't require the work of self-report and we can compare it against the self-report. We can get also much more continuous sampling of what's going on, as opposed to asking them at the end of the day or at the end of their visit about their engagement. Or another common technique in experience sampling is interrupting them with a buzzer, and they have to stop what they're doing and say how engaged they are. When we take that approach, we're disengaging them from what they're doing so they can participate in the research. We're trying to find better ways than that but I think one of the tradeoffs with wearables is that we don't always get *why* they're responding. Also, there are false positives. If all of a sudden there's a loud clang in the room because a table fell over, and it makes everybody jump and turn their head and pay attention, that's not the engagement with learning that we were hoping to see. That's probably not the sort of thing that a lot of us are concerned about in informal spaces.

So if practitioners want to design learning experiences, how can they learn from your research to create activities that might be more engaging?

What we're seeing so far is that the social aspect of these learning settings is really key. I would encourage practitioners to design for multi-person engagement and multi-person participation where they'll talk to each other, exchange some ideas, and see how their thinking compares with somebody else's. I've talked with facilitators in these camps and afterschool programs, and they're very confident that the youth are highly engaged. The data that we collect says something a bit more nuanced about the different times that they are engaged. One issue is that if you're one person, which means you have limited bandwidth, you may notice two or three

youth being really engaged in one activity, but that's two or three out of the entire group. But your recollection of that might be skewed and you might recall it as a real successful lesson because the students you interacted with were very excited and animated. So we need to instead think about ways to get a big broad sample that's more representative. Well, we've been lucky enough to have instrumentation on every participant in the room to see the range of experiences. We know that what's engaging for any particular visitor is not one-size-fits-all. We're trying to find some regularities, but we also know that that's not capturing everybody. Even if about half of the youth are exhibiting signs of heightened arousal and paying more attention to what's going on, there's still another half where the experience didn't quite click for them, and there's something else that would click for them instead.

Have you been able to tease apart in a multi-person interaction whether the way that the exchange happens is important or whether all that matters is that there's social interaction?

It's an interesting question about how multi-participant involvement is playing a role in engagement, and we're still trying to uncover the different dynamics. There's one kind of multi-person interaction, which is having a group discussion about a phenomenon like Newton's third law and having different people share ideas. But there is another format where in an informal learning environment some of the norms that are established in a classroom are softened. In that context, people can build relationships and test out a way of talking with or interacting with other people that they don't get to communicate with on a daily basis. Is that an important aspect of informal learning experiences? I believe so. I think that it allows us to think about more of the complex tangle of what we encounter and care about at any given moment in time. If you're going to a museum you may think that a particular exhibit is interesting, that it's something you want to share with a peer or with your child who is there with you, but you also are aware that you can only spare a certain amount of time for that exhibit, if you

want to stop by the restaurant as well. So there are all of these things that are going on at any given time, but with an informal learning experience you have a lot more flexibility in what you're looking at or thinking about at a given moment. It's not strictly disciplinary content, and it's not strictly disciplinary in practice. We should leave room for some of those things that we may not be intentionally planning for, so somebody who cares a lot about science and math can enjoy a broader texture of human experience that includes conversations, joking, and laughing at some aspect of the exhibit or the ideas or can build a relationship with a docent or a mentor. That will help keep people coming back and they'll want to commit more of their attention in a conscious way.

What do you see as the big questions for informal science education, science communication, or formal science education for the next five or ten years regarding engagement?

It's a fascinating time right now with social media and everybody having access to information on demand. So there are two big questions that we need to consider in science communication and in informal learning. The first one is, how do we as concerned educators and advocates compete in this landscape where attention is a finite resource and there are so many different things competing for people's attention? I think one of the first steps is figuring out how to get people to pause their scrolling when they're looking at their newsfeed, put down their very fun device, and go to a particular activity where their device is not going to be the dominant interaction feature. Building on that, how do we get people to use their devices in new ways to learn more about science or participate in science discourses? It's a big challenge for us to compete in the attentional economy that this bombardment of information is creating. We have to be really up-to-date in all the different techniques that are currently being deployed, and those are changing really rapidly now.

The second question is, how can we as educators find or develop appropriate and accurate bite-size chunks of scientific knowledge or information? This is becoming a more pressing concern because in an arena where attention is a very precious commodity, we have to follow what I think in the museum world is known as the 333 rule about how long someone will stop and visit an exhibit. You have three seconds to catch their attention, and if they are willing to commit longer then you've got 30 seconds, and then if you're really lucky you have three minutes, so you have to design for all of those timeframes. When we hear news headlines or something on the radio, or when we pick up some tip from a friend, we're getting a very small nugget of information. We need to develop accurate bite-size chunks that can generate useful ideas, because right now there's a lot of very inaccurate information that can get magnified and amplified because it's so quick and catchy. We have a struggle as educators to realize how complex a lot of things are, and we're a bit resistant to moving the line on that position. But to reach more people, I believe that we need to acknowledge that not everybody recognizes nor appreciates that complexity from the get-go. What we have to do is give them a place to start that is accurate with respect to that complexity and that gives them opportunities to pursue the topic, so they can start to see more nuance later. But I think that there is so much out there competing for how we think about things that we should focus on designing messages that way, pathways to build on slogan-like phrases and catchy videos and very short, concise depictions. The messages should make it clear that this is one way to start thinking about stuff, and you can go a lot further with it, but if you remember nothing else, this is the enduring nugget. I believe a lot of instructional design emphasizes that, because you could sit in a training session or go through a whole course, then walk away remembering just a few small memorable nuggets. We need to be pretty careful about selecting and refining those nuggets, just as a good advertising agency can spend months working on a concept for a 30-second commercial which basically says at the end the brand name and a very quick slogan that's their message. We haven't

done that kind of design work historically, but I think we should acknowledge that it's how we're going to get more traction. I think there's a way for us to do that while still maintaining our position that there is fascinating complexity in the world. If we want people to be as enthusiastic about it as we are, we have to meet them where they are.

Is there anything else about engagement and science learning that you want to share?

Traditionally we've thought about engagement as having three components. One is the cognitive, which is whether you are thinking through the stuff and doing deeper cognitive processing, more attentive reasoning, and more self-regulation. Another component is the affective one, which has to do with whether you are having a good time, whether you feel good about this experience. That's an interesting one because there are things that are highly engaging but have a negative affect—you can't turn your eyes away because it's so shocking, and you don't feel that favorable about it, but you remember it. The third component is behavioral, which has to do with whether you are sitting still and paying attention, in such a way that you'll show an increase in a measure or a test later. The cognitive, affective, and behavioral components are the three ways that the research literature has discussed engagement. There was an [Educational Psychologist](#) special issue not long ago with a [lead article](#) by Gale Sinatra, Benjamin Heddy, and Doug Lombardi, who are educational psychologists and work in the realm of science education. In that article, they tease out a spectrum of ways in which we conceptualize or think about engagement, whether it's highly person-based or highly context-based, and there are different versions that are all valid. The way to move forward is to say, "Well, where within that spectrum are we operationalizing engagement, within our research and within our practice?" Engaging in disciplinary practices by participating in a scientific argument or using evidence the way that a scientist would is one form of engagement that we definitely value. Another form is whether you're responding quickly and whether your gaze is focused on something, which

is a very person-centered way and another form of engagement that we care about. Those are very different within that spectrum. What we should do is be articulate about where we're positioning ourselves in that spectrum and what tools and what methods are most amenable to different locations on that.

Wearable technology actually spans a whole bunch of different options. There are different devices. There are smartwatches, and there are wearable cameras, which have a lot of value because they give you somebody else's perspective and the person can provide some commentary on what

things they find especially engaging or not. Having that as an object to talk about or talk around can generate some really interesting discussions and feedback that goes beyond self-report after the fact. They get reminded in the moment of something they've seen or encountered, and they'll say, "Oh, I was actually really into what that person was saying," and a video might be the only way you capture that reaction. So if you don't want to spend \$3,000 on high-grade research equipment, a wearable camera for \$50 gives you a perspective on what people are seeing or doing, and I think it's given a lot of traction to research.



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