caise | center for advancement of informal science education

What is STEM Engagement?

An Interview with Josh Gutwill

On July 6, 2018, Amy Grack Nelson, Evaluation and Research Manager at the Science Museum of Minnesota, interviewed Josh Gutwill, to understand his thinking on the topic of engagement. Dr. Gutwill is the Director of Visitor Research and Evaluation at the Exploratorium. His work includes research on learning in informal environments as well as evaluation of exhibits and programs to improve visitors' experiences. A video of Dr. Gutwill's interview, as well as interviews of other researchers, is available at InformalScience.org/engagement.

What led you to study engagement in your work?

At the Exploratorium, we have a lot of phenomenon-based interactive exhibits that offer rich learning opportunities, but we noticed that people weren't spending a lot of time or going very deeply into the phenomena, at least from our perspective. So way back around 2002 or so, we started a project to develop or redesign exhibits that would really encourage people to go much more deeply into the phenomena. In particular, the exhibits would foster self-directed inquiry where they could take the inquiry where they wanted to take it. That project was called Active Prolonged Engagement (APE). We were really interested in what self-directed inquiry looked like. We started to videotape people on the floor at some of these more open-ended exhibits, and as we designed exhibits we came to this notion that we want visitors to be engaged in the activities of inquiry, including scientific inquiry and even arts-based inquiry. That kind of engagement involves asking questions, doing experiments, drawing conclusions, and showing their creativity, trying things other people haven't tried. In thinking about all that, we were asking what is engagement? What does that mean? For us, it was really about the amount of time people were spending on a given learning activity. So for us the definition of engagement became spending time in an exhibit with attention focused on the learning materials provided.

How did you use engagement or the APE idea in various projects?

APE was the beginning of us really thinking about engagement. I'm sure that people at the Exploratorium before my time were thinking about engagement, although they might not have used that term, so I don't mean to claim this as my idea or something that happened only starting in 2002. Obviously even in 2002 it wasn't my idea, it was a team effort. But after the APE project, we did some work in the Tinkering Studio and we noticed, "Okay, so we've successfully made these exhibits that promote greater engagement, and the engagement lasts an average of three minutes, with

some people spending up to an hour at an exhibit." But in the Tinkering Studio, people spend a lot more time, an hour or an hour and a half, during which they're engaged in some learning activity. We wanted to think about what learning really looked like in the Tinkering Studio, and we created a learning dimensions framework. One of the dimensions in that framework was engagement. We retained the time aspect of it, so it was a behavioral assessment, essentially the amount of time an activity would hold attention. We also noted how people were participating in the activity. Doing all kinds of things—playing around, making things, exploring materials, trying something over and over—all that would be considered engagement. But also in this project we added the emotional dimension of engagement, the sense of being emotionally invested, and the way we looked for that was whether people were displaying emotions that looked like to us pride, joy, disappointment, or frustration. Those also could be indicators of engagement for us. Another big one was that a lot of times people in an exhibit or in the Tinkering Studio will finish whatever they had been doing, and they'll look up and come out of whatever state they were in, maybe a flow state, and look around. For us, it showed major engagement if they then went back into the activity and did something else. That would be a wonderful indicator of a high level of engagement.

A more recent project was the Exhibit Designs for Girls' Engagement (EDGE) project, which was led by Toni Dancstep and Veronica Garcia-Luis. They developed an observational scale for engagement that has three different levels, adapted from Tessa van Schijndel's Exploratory Behavior Scale and Chantal Barriault's tool for looking at engagement at exhibits in museums. The first level is initiation, the second level is focus, and the third level is breakthrough. What we found was that, at least at science museum exhibits where there's a lot of interactivity and there's typically a pretty high level of engagement, lots of people were at the breakthrough level. In future, we would probably want to disambiguate that third level a bit more to increase the variance in the data. Those are the projects that come to mind that have really focused on engagement, but all of our exhibit development projects think about engagement and at least use holding time as a proxy for engagement.

How does your concept of engagement potentially differ from that of other people?

First of all, there's a really big distinction between trying to assess engagement in a formal environment and doing it in an informal environment. Maybe the Exploratorium is unusual in this respect, but I don't think so. From everything I know about informal environments, people there really vote with their feet, so just looking at whether people are spending time and focusing their attention on something in informals is a pretty strong indicator of engagement. In contrast, in schools you're required to work on certain things at certain times. I read this great paper by Roger Azevedo published in 2015, in which he summarized a bunch of different people's work. He described Ann Renninger's work on interest, which states that you can sort of fake engagement, but you can't fake interest. In other words, you can look like you're engaged but not really be interested, but you can't be interested and not be engaged. There's a practice in many schools of coercing attention. The teacher says, "You need to look at this now," and the kids do it and they work on it. It's hard in that situation to really use time spent or even focused gaze as indicators of engagement, because kids are being mandated to do this kind of work. They can game the system in a way that I think you can't really do in informal environments. Azevedo lamented how poorly defined the term engagement is, but I think he was really focusing on formal environments, and at least in that paper he was describing a number of other papers that were all speaking about formals. Meanwhile, in informals I think there is a pretty well-accepted definition of what engagement is—it has to do with time and attention. There are a lot of folks who use tracking and timing, for example, as a method to assess engagement. They also use repeat visitation: Somebody tries an activity and then leaves and then comes back. Scott Randol and I

have had conversations about this, and he doesn't feel that time on task should be a good indicator of engagement, but at least at the Exploratorium we've done so many studies and looked at so many people and there just isn't much time off task. When people are at an exhibit and looking at the exhibit, mostly they're interacting with it, they're doing something. They're touching it in some way, and when you talk to them afterward they report that they were engaged. It's a very rare person who sits in an exhibit and is actually spacing out and looking over at their kids or other people in their group instead of focusing on the exhibit. We would not consider that engagement anyway, because their gaze wouldn't be on the exhibit, and they wouldn't be interacting with the exhibit. So, I haven't seen a lot of disagreement about the definition, but I'm sure there are people who want to assess it in other ways and don't feel that our approach is quite right.

I should just add that for us, with the APE project and a lot of other projects, we add the word "active," so we say "active engagement." We're saying that we want people to author the experience for themselves in some way, to self-direct the experience. That means doing things according to their own interests and desires, not just following a set of instructions that has been laid out by the museum. When they do that, we do add other assessments. I think Azevedo's point about having multiple methods for trying to get at engagement is really strong, and we do that ourselves. We'll do both audio and video recordings of people and examine what kinds of questions they are asking at the exhibit and how they answer those questions. Do they turn to the authority of the label and just say, "Okay, the label's gonna tell me my answers"? Or do they use the exhibit to try to answer their questions? Do they turn to the other people in their group and talk about the question in order to try to answer it? That would be looking to themselves rather than looking to the authority of the museum. All of those represent active engagement for us, and those reactions would be in addition to just spending time and having a focused gaze or even just manipulating the exhibit.

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

I think engagement is a foundational aspect of learning. Can you even have learning without engagement? I'm not sure. It's hard to really imagine that, especially in our designed learning spaces. I suppose there's subconscious or unconscious learning. But from our perspective, with the kinds of learning that we're looking for, you really need engagement as a prerequisite. It's like a first step. But in informals, it can actually be a marker for learning itself because of the free-choice nature of the environment that I talked about earlier, where people can vote with their feet. When people are engaged they're doing a lot of the activities, and they're practicing the skills of science that we're hoping they'll practice. They're often displaying the joy and excitement of learning science, technology, engineering, math, and art that we have in our environments. So when they're doing the exhibits, people tend to be very much on task, and I think that can be a stand-in for learning itself. Engagement doesn't have to be just a prerequisite here, it can even be a stand-in. This is written up in the *Learning Science in Informal Environments* book, as well as in Ann Renninger's work on interest, and Chantal Barriault's work. People often theorize that engagement leads to situational interest development. It can even lead to individual interest, which is that interest that drives you to do your own thing and pursue your own desires, and then that individual interest can beget greater engagement. So, you can have a cycle, and if that theory of engagement and interest and the interaction between them is right, then obviously engagement is key to developing lifelong, life-wide, life-deep learners.

How are you measuring or assessing engagement in your work, and what are the tradeoffs, if any, in your approach?

We assess engagement of the learner, and we also assess aspects of the design itself. I'll talk about the learner first. As I mentioned, we measure holding time with fixed gaze or touching the exhibit,

manipulating the exhibit in some way. That's observational. Then we do audio and video as a method and we code the audio and video in lots of different ways, depending on the project. In some projects, we've coded the video looking for questions and answers, as I mentioned before. In some projects, we look for expressions of excitement, joy, or frustration. Sometimes we do self-reports, so we can just ask people. We've done think-aloud protocols with people, retrospective or video, and exit interviews. We've done surveys asking them how engaging something was or how interesting it was. Sometimes we use those terms kind of synonymously with visitors, just because it might be more familiar to them to talk about interest.

Regarding tradeoffs, it's hard to validate self-reports. It's hard to make sure that people are being accurate. One thing we try to do is to have a self-report happen right after the experience so it's fresh in people's minds. We also try to assure people that we are not the ones who created this activity, exhibit, program, or whatever it is so they can be fully honest with us about it, but it's hard to really check validity. With gaze and holding time, first of all gaze is hard to determine. We don't use eye trackers here, although I know some people do. It's sometimes hard for coders to be sure of gaze. With holding time, you don't always know what's happening in learners' minds, and we think it's a good proxy for engagement, but for some people that might not be accurate. We do do inter rater reliability on both holding time and on gaze, to try to determine whether what we're seeing is engagement or not. Our multiple coders check for validity or at least for reliability on that. Finally, the video analysis work is just very, very time-intensive. It takes a really long time to code. We try to use special video coding software. We used to use Studiocode, but now we use DataView, for which you don't have to transcribe the video—you can just code it directly on the video. It's been great that those kind of tools exist and can speed things along. But even with that, you're talking about at least seven to one, possibly eight to one, time, while transcribing can be twelve to one, so it's pretty brutal to do those. You can really only do those when you have a fair amount of funding and can really dig into the data that way.

What advice would you give practitioners who want to integrate your findings about engagement into their work?

It's a little hard for me really to think about advice to practitioners, because here at the Exploratorium, in my department of Visitor Research and Evaluation, we work at the intersection of research and practice. We do what we call jointly-negotiated research, where the researchers and the practitioners are really partnering in the work and have equal power to set the research questions, think about the methodologies, and even interpret some of the analyses. When we're doing the research, almost by definition the audience for the research is practitioners as much as researchers. We're always thinking about what the products of this research will be, like what questions we're we going to answer, how we're going to answer them, and how that work can be utilized. We're almost always thinking about both practitioners and researchers, so we design it to be integrated into practice. So, I don't know that they need much from our findings. Obviously dissemination is really important, getting the word out, but one of the beautiful things about jointly-negotiated research is that the practitioners on the team themselves often work to spread the word.

But here are some thoughts. There are tools available for practitioners, such as the Relating Research to Practice website, which is an excellent resource that contains hundreds of research briefs. Those are essentially easy-to-read, one-page abstracts, designed for practitioners, journal articles that have been translated into the language of practice. Also InformalScience.org is an excellent resource for practitioners looking for research to better understand the concepts and phenomena of any new practices that they're trying to design for in their environments. Once they've learned about the subject and maybe they've talked to us about it, I would just encourage people to really think about

their own context and their own audiences and adapt. My advice is, don't look at it as a prescription; look at it as a description that you can then utilize. Have faith in yourselves to know what's really right and best for your own audiences. You have a tremendous amount of experience, and you know your space, and it's going to be different from the spaces that we study, whether we study them at the Exploratorium or at other places. It's always going to be different and it's going to need to be adapted. So, I wouldn't take anything as a cookie-cutter prescription that you can just utilize. I have faith in my colleagues, whether they're researchers, evaluators, or practitioners, to take what we've done and make it their own. They should self-direct, just like we want learners to do: Direct their own inquiries.

What are the big questions in informal science education, science communication, or even formal science education for the next five or 10 years regarding engagement?

I guess one big question is "What do we mean by engagement?", which is exactly the purpose of this project. But I've been out of the formal education research game for a long time now, so I don't read a lot of the research on learning in classrooms. As I said, I think there might be more agreement on the term engagement in the informal world than there is in the formal world. Even if that's true, can the formal world come together and try to define engagement as Roger Azevedo proposed? And can we distinguish our meaning of engagement in formal and informal settings? Maybe they need to be different, or at least the way that we assess them needs to be different. Or maybe we can align them. So, I think defining engagement is going to be a really big piece of the work.

In informals, I am passionately interested in how we deepen engagement. We did the big project APE that I mentioned earlier to deepen engagement at exhibits and to get people to spend more time at exhibits. It was great and we had a lot of success. The time people spent increased by a factor of three, which was fantastic. But the average amount of time only went from one minute to three minutes. The range increased phenomenally; we went from having nobody at exhibits for more than four minutes to having people stay up to an hour, and 20% of the visitors that we studied were spending more than four minutes. So we saw these great changes, but still, people were only spending three minutes. I'm really interested in using environmental design like they've done at Explora in Albuquerque, using walls to give people a sense of ownership of the space, to reduce the noise level, and to help people go deeper at exhibits. Our Tinkering Studio does a wonderful job of this and it is kind of a more enclosed space, where people feel like they can sit down and spend an hour or an hour and a half in the space. So how do we do that with exhibits? How do we change people's expectations? I think if we communicate through our designs a lot of expectations to learners that there is so much to see, there's so much to do, don't spend too much time here because you've got to get to it all, or at least a lot of it, it's no wonder they don't stay longer at each exhibit. So we need to shift people's constraints around time. At the Exploratorium, people spend on average three hours at the museum, and of course there's variance around that. But are there ways to make the whole experience more pleasurable and enjoyable, more relaxing, so that people would spend more time. I don't know what the average time spent at Disneyland or Disney World is, but I bet it's more than three hours. People will spend more time in leisure activities. Can we get folks to spend more time here and not just have a broader experience but actually have a deeper experience? And, related to deeper engagement, how do we capitalize on the engagement and the situational interest that I think informals are so good at sparking to really foster individual interest? How do we get people so interested in something and engaged with it that they start to seek out other experiences and go outside of designed spaces, like museums or zoos or aquariums, to start pursuing their interests on their own, maybe at home or wherever? How do we get them to start thinking about the phenomena and the concepts that they've been exposed to in a museum, or—something near and dear to my heart—to start practicing those science skills more when

they're out in the world? So, I'd love to see some of that, and see people pursuing their own interests and doing more STEM inquiry. I think those would be some really interesting areas to pursue in research, an exciting area for people to explore engagement.

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

Just that I'm really happy that you're looking at it. I think it's a really rich and important concept for us to define and refine and explore and study, so I'm really happy and grateful to CAISE for choosing this concept, asking people about it, and trying to understand it in a deeper way.

One other thing I wanted to mention regarding the APE project was that it really came out of other work that was being done in the field in the late 1990s and early 2000s at three places. The Science Museum of Minnesota was working on experiment benches at that time, which were exhibits that had lots of things people could try, in order to get people more deeply engaged at exhibits. The Museum of Science in Boston had its Investigate! exhibition, which was all about asking your own questions, so we were very inspired by it. And also, the Philadelphia/Camden Informal Science Education Collaborative (PISEC) Project that was led by Minda Borun at the Franklin was a research project looking at open-endedness at exhibits and what design features of exhibits seem to promote open-endedness. Those features were things like having multiple options, allowing for multiple hands to use the exhibit simultaneously, and so on. Those three inspired us in the APE project, and I just wanted to mention that. I feel like there's been this lovely continuity and thread of work in the science museum field, looking at engagement and how to foster deeper engagement.

This material is based upon work supported by the National Science Foundation (NSF) under award nos. DRL-0638981, DRL-1212803, and DRL-1612739. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of NSF.