

# What is STEM Engagement?

## An Interview with Benjamin Heddy

On June 21, 2018, [Tina Philips](#), Research and Evaluation Manager at the Cornell Lab of Ornithology, interviewed [Benjamin Heddy](#), to understand his thinking on the topic of engagement. Dr. Heddy is an Assistant Professor in the Jeannine Rainbolt College of Education at the University of Oklahoma. He teaches undergraduate and graduate courses on the topics of motivation, cognition, learning theory, human development and research methods. His research program focuses on cognitive and motivational aspects of learning; including engagement, academic emotions, interest development, and further specializing in the investigation of learning activities that occur in everyday experience. A video of Dr. Heddy's interview, as well as interviews of other researchers, is available at [InformalScience.org/engagement](http://InformalScience.org/engagement).



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### *What led you to study engagement in your work?*

I began studying engagement due to my teaching experience. I was a K–12 teacher at a residential treatment center where there were kids with severe behavioral issues, and I noticed that it was difficult to get them engaged in my course. So I tried to facilitate personal relevance or connect content that they were learning in class to their everyday life. When I did that and they noticed that the content could not only impact their learning in the classroom but impact their experiences out of the classroom, they showed more engagement, through indicators like attention, interest, and affect.

### *What are some of the specific projects you've done that focused on or included aspects of engagement?*

My research focuses on getting students to apply what they learn in class to their everyday life and then exploring what that does to motivation and learning. So these everyday life connections are engagement out of school in informal learning environments. In my current project, I'm using parental involvement as a motivational resource to facilitate out-of-school engagement, especially with science content. What I've found is that when students have experiences with content outside of school, with their parents' involvement, it increases engagement, and that increases motivation, which

in turn increases achievement in their middle school science courses. Their grades noticeably improved.

### *What is your working definition of engagement?*

I think engagement has three dimensions: cognitive, affective, and behavioral. Cognitive engagement is when you're mentally wrestling with ideas. Affective engagement is when you're interested in ideas or you're enjoying what you're learning. Even if you're frustrated about something, if you're looking into it and studying it further, that could be affective engagement. Finally, behavioral engagement in the classroom is when you're leaning forward, being attentive, and listening. Outside of school, it's when you're looking for these ideas in your everyday experience, intentionally balancing behavioral engagements. So these three components of engagement combined—cognitive, affective, and behavioral—are what make up this overall construct of engagement.

### *How does your conceptualization of it differ from others?*

I think the definition of engagement definitely differs according to field. I know that some people see engagement as school involvement or participation. I come from an educational psychology perspective, and we generally view engagement from a cognitive affective standpoint. I like to think of those differences as grain size differences, so this big idea of attendance or involvement in school is at a much larger level, a bigger grain size, than looking at individual cognitive experiences, which is at a much smaller grain size. Some people will take that even further and they'll do eye trackers to figure out what people are following on a screen when they're looking at content. That would be an even smaller grain size. I fall somewhere in the middle of the continuum of engagement grain size.

### *Why do you think engagement matters for science learning?*

That's a great question. I think engagement is particularly important in science learning for a lot of reasons. Science learning has many unique aspects to it and unique challenges that aren't present in other domains. For instance, there seems to be a gender bias in a lot of science learning. There seem to be polarized attitudes and emotions toward a lot of science concepts, such as evolution, climate change, and genetically modified organisms. There also seem to be a lot of misconceptions about science ideas, and while there are misconceptions in other content areas, such as social studies and English, they seem to be more prevalent in science, due to our everyday experiences with what we perceive to be science ideas. Between the gender bias, the polarized attitudes, and the misconceptions, engagement in STEM is a very unique process and more challenging to elicit.

### *How do you measure or assess engagement in your work, and what are the tradeoffs in your approaches, if any?*

In most of my work, I use self-report instruments. I recently created a [STEM conceptual change cognitive engagement instrument](#) that looks at what types of engagement occur when you're moving from an inaccurate science idea to a more scientifically accepted science idea: how you are mentally wrestling with those ideas. That has some limitations, because you're getting self-reports which aren't always accurate. They have a [social desirability bias](#), by which I mean people respond in the way that they think the survey administrator would like them to respond. That's a big problem with self-report instruments. So to handle those challenges, I've recently moved to experience sampling methodology, in which I try to survey participants while they're in the moment of learning. That seems to provide more reliable data, because rather than reflecting on an engagement experience they had months ago, they can instead reflect on an experience that they're having right at that moment. Finally, I have begun using

videorecording learning sessions to try to observe engagement as it's happening. The problem with that is that the person who is watching the video and coding it for engagement are looking for engagement, so they are biased to see it. We don't know if the student is actually experiencing it. In my research I try to use multiple methods: collecting surveys, doing some observations, maybe even doing some interviews, and seeing if all of those types of assessment methodologies line up. If they do, then you can be more sure that the person did in fact experience engagement.

***Can you elaborate a little bit on the self-report tool that you mentioned to measure cognitive engagement?***

It's called the [Conceptual Change Cognitive Engagement Scale \(CCCES\)](#). It's a pre/post tool, a quantitative scale. We start by assessing students' current conceptions or knowledge about a scientific construct. For example, maybe they're learning about climate change, so we assess their knowledge of it. Then we give them the CCCES and it asks them to self-report their experiences while engaging in a learning context that is specifically relevant to undergoing conceptual change. As they spend time in that context, are they thinking of the personal relevance of the content? Are they thinking of their current ideas and how they might relate to the newer ideas? Are they thinking about their affect, their emotions related to the ideas they're learning? We want to know what cognitive characteristics they were mentally wrestling with while they were engaging in this learning experience, and that can tell us a little bit about their cognitive engagement with that experience. The article about the CCCES is published in *Frontiers in Education* and that is an open-access journal, so it's free for everyone to use. This is a first run through designing and validating the scale, so we're hoping to add a few questions that might better get at the type of engagement that happens during conceptual change.

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

My work is mostly studying engagement in the out-of-school context, which is very difficult to assess. We ask students to go out and have these everyday life experiences, but then how do you assess whether they actually engaged in those experience? Unfortunately, most of the instruments ask students to reflect on their experiences when they get back to the classroom, which could be weeks later. At that point, you're not really getting an authentic assessment of engagement. So if you're going to explore engagement in an out-of-school informal context, my advice is to have some kind of mechanism to measure engagement as it occurs in students' everyday lives. That could be an [experience-sampling method](#), or it could be a tool like [Remind](#), which is an app to send reminders to participants or students. You can remind them and say, "Hey, have you thought about any classroom concepts today, and if so what are they?" You can really measure engagement as it happens. Or you could send students home with a diary to get more authentic assessments of engagement. That way, you're actually measuring them as they occur, or at least you're getting closer to the engagement experience, versus asking students to reflect on their experiences at a later time point, which won't give you such reliable data.

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

The biggest question is going to be how we define engagement. I gave you a definition that was cognitive, affective, and behavioral, and to me that's a great starting point. But these ideas are really broad. Affective could be interest, it could be positive emotions, it could be negative emotions; those types of affect are going to impact engagement in really different ways. So I don't think it's fair to define engagement as just affective; we need to note whether it's positive affective, negative affective, or social affective. Then moving to

cognitive engagement, what does it mean to be cognitive? Does it mean paying attention, or mentally wrestling with ideas? Is there a difference between shallow and deep cognitive engagement? Finally, behavioral. Is it enough to nod or shake your head as if you're listening? Is that really behavioral engagement, or do you have to be moving around, participating, and interacting with the environment? To me, all of those things are engagement, but they're different forms, so we really need to look at the mechanisms of cognitive, affective, and behavioral engagement to define these things better so that we can study them and feel confident that they are in fact engagement.

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

One idea that I think is really cool and new to the field with regard to engagement is this idea of transformative experience. That's engagement in your everyday life that changes the way you see and experience something in your everyday life. Let's imagine a student or a child is in their backyard or they're at the park playing, and they look at a tree and instead of seeing a tree made of leaves and sticks and bark, they see photosynthesis, they see chemical reactions. This would be changing the way

they see the tree. They don't just see a tree anymore; they see chemical reactions and processes, so they're viewing it as science and seeing the world through the eyes of scientists. So in what ways can we develop instruction to generate these more transformative types of engagement experiences that are going to change the way students see and interact with the world? That, I think, would be a really, really cool thing to study.

*Do you mean how do we create transformative experiences that lead to enhanced science identity?*

I think we can get there eventually. When I say a transformative experience, I'm talking about a very small grain experience in which you're noticing classroom concepts in your everyday life, and it's changing the way that you see that specific experience. However, if you have several of these transformative experiences, these small micro transformations, I think that could lead you to identify more with science and maybe to start integrating science as part of your personality. That hasn't been studied well yet, but it would be really interesting to see that if you have repeated out-of-school experiences with science content, whether it will then change your identity to align better with science.



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