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Image courtesy of The Tech Museum of Innovation

The Role of Engagement in STEM Learning and Science Communication

Reflections on Interviews from the Field

Background

Since producing the Inquiry Group report *Many Experts, Many Audiences: Public Engagement with Science* in 2009, the Center for Advancement of Informal Science Education (CAISE) has been following how the concept of engagement is being defined, used, and measured in science communication and informal STEM learning settings and experiences.

In informal STEM education, thinking about engagement has evolved from a focus on innovative ways of attracting the initial attention of science center/museum visitors or media consumers to

strategies for designing environments and activities that foster deeper experiences such as experimentation, skill development, and contemplation in a variety of settings.

In the science communication field, engagement increasingly refers to "two-way" approaches to designing and facilitating interactions between STEM professionals and diverse "publics" that take into account the knowledge and prior experiences of those audiences. The American Association for the Advancement of Science (AAAS) and others have championed the gradual shift from Public Understanding of Science to Public Engagement *with* Science that has been an important symbolic development among researchers and practitioners working in this area.

Because engagement with STEM topics and activities is linked to the development of STEM interest, identity, self-efficacy, and other important dimensions of learning and communication, the CAISE Evaluation and Measurement Task Force chose it as a topic to further explore as part of its interview series.

In 2018, we interviewed 12 informal STEM education, science communication, and citizen science professionals who study or develop activities and environments where engagement is an observable, identifiable phenomenon and/or an intended goal of a designed experience. We asked these experts how they conceptualized engagement, how they measured it, and how engagement intersects with other related concepts., such as identity and interest.

Who we interviewed

Benjamin Heddy
Assistant Professor, Educational Psychology, University of Oklahoma

Bruce Lewenstein
Professor of Science Communication, Cornell University

Christian Schunn
Professor of Psychology, Learning Sciences and Policy, and Intelligent Systems, University of Pittsburgh

Douglas Clark
Research Professor of Design Based Learning, University of Calgary

Eric Klopfer
Professor and Director, Scheller Teacher Education Program and The Education Arcade, Massachusetts Institute of Technology

John Besley
Ellis N. Brandt Professor of Public Relations, Michigan State University

Josh Gutwill
Director of Visitor Research and Evaluation, Exploratorium

Karen Peterman
President, Karen Peterman Consulting, Co.

Karen Purcell
Project Director, Celebrate Urban Birds, Cornell Lab of Ornithology

Paulette Vincent-Ruz
Doctoral Candidate, Learning Sciences and Policy, University of Pittsburgh

Sara Yeo
Assistant Professor, Communication, University of Utah

Victor Lee
Associate Professor of Instructional Technology and Learning Sciences, Utah State University

What is engagement?

An Interview Series on STEM Identity, Interest, and Engagement | bit.ly/eval-measure

Explore videos, interview Q&A, and resources from our interview series sharing diverse perspectives from scholars whose work focus on different aspects of STEM identity, interest, and engagement.

As with other constructs that CAISE has explored, we heard a range of definitions of engagement, which varied with the disciplinary perspective and professional roles of those interviewed. One science communication scholar began by distinguishing between different categories of engagement (e.g., educational, democratic, institutional),which describe the myriad ways that people engage in different contexts (Lewenstein). While most of the experts were focused on educational engagement, the work of one citizen science designer equally embraces the democratic and institutional aspects of engagement, and she pointed out that scientists, educators, and communicators need to "adapt the evaluation and our understanding of engagement to the community we are working with" (Purcell).

There was a general consensus among those we interviewed that educational engagement has cognitive, affective, and behavioral dimensions, that can take the form of wrestling with ideas; feeling emotional responses to activities, such as interest or frustration; and using physical movements or gestures that demonstrate, for example, active attention and listening (Clark, Gutwill, Heddy, Lee, Schunn, Vincent-Ruz). One communication scholar characterized public engagement activities as ones that are designed to get people to process information and phenomena at a deeper cognitive level, which is important for forming and changing beliefs (Besley). Another science communication researcher mentioned online activities such as liking, sharing, and commenting on content as behavioral examples of engagement that may have consequences for both the individual person engaging and the way in which others perceive and respond to content (Yeo). Some experts who study or design digital learning environments explained that engagement sometimes looks like "hard fun," a term coined by late researcher Seymour Papert to describe learners grappling with problems, puzzles, or challenges just out of their reach in what psychologists call the Zone of Proximal Development (Klopfer, Clark).

Researchers and practitioners also conceptualize engagement on the basis of the duration of a learner's interaction. For example, in science centers and museums, "initial engagement" with an exhibit can sometimes lead to "active, prolonged engagement" that takes a variety of forms (Gutwill). Some researchers look at engagement in the space of a brief moment, attending to variation in unconscious physical behavior, such as pupil dilation and heart rate (Lee), while others consider intentionality and sustained commitment to be critical hallmarks of engagement (Klopfer). One evaluation practitioner parsed these distinctions by pointing out that engagement is "not always a construct that could be considered an outcome of an activity. Sometimes it's about the activity and how much you've done the activity itself" (Peterman).

Some researchers apply an equity lens to their work and note that typically engagement has been thought about as a "top-down" phenomenon in which institutions identify strategies to encourage communities' participation in science. Using a more equity-oriented approach, engagement can be conceptualized as creating conditions in which communities can identify the activities or research

that they find beneficial or meaningful (Purcell).

How can we measure engagement?

As with other constructs, some researchers measure engagement through psychometrically developed surveys (Schunn, Vincent-Ruz). These surveys, which are often administered to learners following an activity, ask them to characterize the amount, dimensions, or forms of engagement during the experience, on a scale. Surveys can provide a summary of engagement for an individual during an experience, but they require the researcher to define the construct in advance, setting a potentially narrow definition of what counts as engagement (Lewenstein). Another disadvantage of surveys is that they must either interrupt or follow the activity, so they are not able to capture ephemeral or contextualized engagement.

Other researchers attempt to capture in-the-moment engagement by measuring psychophysiological phenomena, assessing behavioral choices, or making direct observations of learners during an experience (Lee, Heddy). These approaches may include tracking of eye movements and gaze; examination of likes, shares, and comments in social media; or specific observational protocols (Yeo). The advantage of these approaches is that they are able to measure the engagement itself, while it is happening. Researchers using these methods acknowledge the complexity of interpreting the data. For example, an increase in heart rate might be read as engagement, when it was really due to an unrelated loud noise (Lee), or what appears to be careful thought might actually be reverie (or vice versa). It is also challenging to discern whether people like and share something on social media because it had an impact on them or because it conforms to their preexisting views and perspectives.

To measure the behavioral aspect of engagement in science centers, some researchers record holding time (amount of time spent at a given exhibit) and level of interaction with materials (e.g., in a makerspace), captured via direct observation, video recording, or both. These kinds of experiences also have affective aspects, which may include emotions such as joy, frustration, disappointment, and pride, based on the success of an interaction. One researcher noted that in these settings, it might indicate a high level of engagement for someone to engage in an activity, pause, and then decide to continue engaging with it in a different way (Gutwill).

Researchers who study digital learning environments used similar approaches, such as surveys, video observations, and back-end analytics that can provide information related to engagement, such as the length of a session and whether repeat engagement occurred. Often these analytics are used to complement other sources of data. One caveat we heard about measuring engagement overall is that a methodology or instrument which works in one context with one audience does not necessarily work in/with others. It is important to look at the metrics, such as the statistics related to the survey's reliability and validity, each time a tool is used with a particular audience. For all scales, it is important to think critically about what methodology to choose and whether it will provide the needed data in order to make claims about the value of a particular learning experience (Peterman).

Another consideration mentioned across the interviews was *when* to measure engagement. Several researchers noted the importance of measuring engagement in real time through strategies (e.g., video observation, psychophysiological data, timing and tracking), while others emphasized data collection at different time scales to understand factors such as sustained and repeat engagement

(e.g., data mining of analytics), or changes in engagement patterns. All the experts noted that measuring engagement often interrupts it, which is a challenge.

How is engagement related to other constructs, and learning?

The researchers and practitioners that we interviewed generally agreed that what draws and holds people's attention and what they choose to focus on play a key role in learning. One person mentioned being "interested in understanding engagement that leads to transformative experiences that may change the way that learners see and interact with the world" (Heddy).

Some of the interviewees thought that engagement overlaps with motivation and with interest at a minimum, with the distinction that engagement tends to describe an intrinsic desire and commitment to being actively involved in the moment, whereas learners may also have other interests and motivations (e.g. extrinsic) for participating in a particular task. One science communication researcher pointed out that getting people interested or motivated to learn more about a topic might be a way to encourage them to engage further with scientists (Metag).

The interviewees agreed that there is a need to further study the interaction of engagement with other variables, such as how prior experiences and previous level of science interest can affect a person's engagement in a learning activity. Researchers at the Learning Activation Lab, for example, aim to understand the overlap between interest and engagement. In their work, they explore whether students with high science interest have different levels of engagement during certain activities than students with low science interest. Overall, throughout these interviews CAISE learned that while engagement has distinctions from other constructs it is integral to them, and that it provides an increasingly rich area of learning and communication design and research.

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