

What Drives Visitor Engagement in Exhibits? The Interaction Between Visitor Activation Profiles and Exhibit Features

RENA DORPH , MATTHEW A. CANNADY , AND CHRISTIAN D. SCHUNN 

Abstract This paper explores the use of science learning activation to understand how various types of visitors engage with different exhibits. In particular, we examined how learners engaged in two very different resource-rich exhibits using two distinct analytic techniques. Regression analyses revealed that learners' prior science learning activation can be used to predict learners' engagement at each of the exhibits. A latent class analysis grouped learners into four emergent activation profiles (Low Motivation, High Motivation, Low Ability and High Ability), and found that learners within each profile engaged differently with the two exhibits. Analyses across the two approaches suggest that engagement in a science center exhibit experience can vary widely by learners' activation. The study provides an analytic lens for understanding which learners are being engaged by an exhibit. Finally, the paper discusses the implications of this study for design, selection, and evaluation of exhibits in science centers.

INTRODUCTION

What exhibits should be selected for inclusion in a science center? Obviously well-designed exhibits are desired, but even then, not every participant will engage with an exhibit in the same way. How can we ensure that there is something for everyone who visits? How do we know if our goals for engagement are being met by our choices of exhibits? Can there be a science to creating a portfolio of exhibits that maximally support the engagement across the diverse visitors who we hope walk through our doors? As a science center director and learning researchers, we have been searching for ways to answer these questions that are both grounded in the research literature and in the wisdom of practice.

The challenge described above is often met by considering the options for exhibits within a set of goals and constraints. What are our goals

for the visitor experience in our science center? How much space, money, or time do we have to devote? What exhibits are available to be designed to meet our goals? Is there evaluation data that provides evidence that these exhibits will yield the kinds of goals we have for our visitors?

In choosing exhibits in the absence of outcome evidence from a particular exhibit, one can also consider if the exhibit is designed in a way that includes the features of experiences that are usually associated with the desired outcome goals for visitors. Synthesizing across a wide range of researchers and practitioners, we have identified features of science learning experiences, writ large, that have been shown to lead to desired outcomes of science learning experiences: varied, abundant (Lombardi 2007), and flexible resources; sensitive and high quality *facilitation* (Reeve 2006); presence of *role models* (Nauta and Kokaly 2001); *appropriately*

Rena Dorph (rdorph@berkeley.edu) is the Director of the Lawrence Hall of Science at the University of California, Berkeley. Matthew A. Cannady is the Research Group Director at the Lawrence Hall of Science at the University of California, Berkeley. Christian D. Schunn is a Professor in Psychology, in Learning Sciences & Policy, and in Intelligent Systems as well as a Senior Scientist at the Learning Research and Development Center at the University of Pittsburgh.

challenging (Salonen et al. 2005); *relevant and authentic* activities (Assor et al. 2002; Krajcik et al. 2008); includes opportunities for reflection (Lombardi 2007) and feedback (Hattie and Timperley 2007); engagement in the *practices of science* (National Research Council 2011); *choice/control* (Stefanou et al. 2004); presence of *scientific language* (Gee 2004); promotes *stimulation and/or enjoyment*; offers *increasing complexity*. However, this approach is often not sufficient as a decision-making strategy. Researchers and practitioners have highlighted a key, and possibly obvious, point that demands consideration as well: the same activity may not yield the same experience for each individual who participates in it (e.g., Fisher and Frasier 1983; Dorph et al. 2016). One person's relevant may be another person's irrelevant, depending on who they are and their prior experiences, etc.

At the same time, it is difficult to find examples of studies that make causal links between individual or combinations of these features and specific science learning outcomes within informal learning settings. So, while the field has been able to identify lists of features that exist within "successful" science education programs, we do not have compelling evidence that helps us sort through for whom and under what conditions and for whom do which of these features support which outcomes (Chi et al. 2015).

Given the lack of evidence to date, we explored these questions from a different vantage point asking, which visitors are most engaged, in what ways, by which types exhibits? The implications of the analyses presented in this paper offer an opportunity to add another consideration. In this paper, we explore the idea that the construct of science learning activation can help organize variation in learners in a way that productively complements the extensive considerations of diversity of learners by gender (e.g., Baker 2016; Crowley et al. 2001; Machin 2008), socio-

economic status and ethnicity (e.g., Dawson 2014, 981–1008; Dawson 2018; Falk et al. 2016), or other demographic based distinctions. We also demonstrate that we can use this construct to analyze how different visitors will engage with different types of exhibits. The implications of these analyses offer a research-based approach the design of a portfolio of exhibits.

Theoretical Underpinnings

What do we mean by science learning activation? We define science learning activation as a set of dispositions, skills, and knowledge that commonly enable success in proximal science learning experiences and that are in turn influenced by these successes. In other words, we think of science learning activation as a developing set of resources that an individual consistently carries from one learning experience to the next, such from home to school to museum or from exhibit to exhibit within a museum. Young people who are more activated towards science are more likely to have a successful learning experience (i.e., will choose to participate, will experience positive engagement, and will meet science content learning goals).

Through extensive literature reviews and empirical research, we have developed a theory of science learning activation that involved four dimensions: fascination, values, competency beliefs, and scientific sensemaking. **Fascination** with natural and physical phenomenon refers to the emotional and cognitive attachment that the learner can have with science topics and tasks that serve as an intrinsic motivator towards various forms of participation. This dimension includes aspects of what many researchers have referred to as curiosity (e.g., Loewenstein 1994; Litman and Spielberg 2003), interest or intrinsic value in science (e.g., Hidi and Renninger 2006; Hulleman and Harackiewicz

2009), and mastery goals for science content (Elliot and McGregor 2001). It also includes positive approach emotions related to science, scientific inquiry, and knowledge. **Competency beliefs** about self in science refers to the extent to which a person believes that s/he is good at science functions and tasks in science settings. In general, educational and psychological research has revealed that competency beliefs (or self-efficacy beliefs) are an important predictor of many types of achievement behavior (i.e., choice of task, engagement, effort, and persistence; Pintrich 2002; Schunk et al. 2008). **Value** refers to the degree to which learners value various aspects of science, including the knowledge learned in science, the ways of reasoning used in science, and the role that science plays in families and communities (Brickhouse et al. 2000; Dogan and Abd-El-Khalick 2008; Hill and Tyson 2009). This dimension draws upon expectancy value theory (Eccles and Wigfield 2002; Wigfield and Eccles 1992) and identity development theory (Tan and Calabrese Barton 2008) to consider the ways in which learners value science. **Scientific sensemaking** refers to the degree to which the individual engages with science learning as a sensemaking activity using methods generally aligned with the practices of science: asking investigable questions; seeking mechanistic explanations for natural and physical phenomenon; engaging in evidence-based argumentation about scientific ideas; interpreting common data representations; designing relevant investigations; and understanding the changing nature of science (Apedoe and Ford 2010; Lehrer et al. 2001). The literature suggests that using scientific sensemaking better positions a child to learn science (Lorch et al. 2010; Songer et al. 2009; Zimmerman 2007).

What do we mean by engagement? Engagement is used in many different ways in the literature, ranging from dispositional to

situational. Studies of museum learning that employ engagement as a process or outcome variable mostly understand engagement as participation and use observable behaviors to measure this variable. Typical measures of engagement in these studies are derived by collecting data about things you can directly observe or count. For example, dwell (or holding) time is an established measure that is easy to capture by timing the number of minutes that a visitor spends in a specific exhibition or task. Many museum researchers suggest that this established measure is easy to capture and serves as a reasonable proxy for the depth of visitor engagement with exhibits (Horn et al. 2012; Humphrey and Gutwill 2005). Other measures for engagement often utilized by museum learning researchers may include patterns of behavior in exhibits such as: which exhibits learners visited, whether they repeated the experience at an exhibit, whether they varied the experience at an exhibit, whether they returned to an exhibit once they left it, and whether they talked about their experience while using an exhibit (Block, et al. 2015; Dancstep and Sindorf 2016; Fleck et al. 2009; Kim and Crowley 2010; Leinhardt and Crowley 1998). In addition, there are those who may utilize post-exhibition behaviors such as picking up materials designed to support follow-up activities or visiting an exhibit-related website after leaving the museum as measures of engagement (Gentry 2016).

For the purposes of our work, we build on more foundational work on the nature of engagement during learning. We conceptualize engagement also as situational but more internal in nature, specifically one's focus, participation, and persistence on a task, and understand it as related to adaptive learning (Carini, et al. 2006; Finn et al. 1995; Fredricks et al. 2004; Fredricks et al. 2011). We define *engagement as the intensity of productive involvement with an activity*

(Ben-Eliyahu et al. 2018). We pay attention to three dimensions of engagement: (1) affective engagement is conceptualized as those emotions that occur as part of engagement during a learning activity; (2) behavioral engagement focuses on what students who were involved in the learning activity would look like or be doing; and (3) cognitive engagement focuses on thought processes or attention as indicative of cognitive engagement; we differentiate the type of thinking from thinking itself or attending to the activity. Research suggests that a combination of these three facets of engagement supports students to succeed in science learning experiences (Ben-Eliyahu et al. 2018; Fredricks et al. 2004).

A driving motivation for the design of this study is the need to understand if particular types of science center exhibits are more likely to result in affective, behavioral, and/or cognitive engagement depending upon the science activation of the learner. Given the conceptualization of engagement we employ, we have designed self-report measures to extend beyond observable transactions and behaviors and include internal states such as affect and cognition.

Study Context: Two Contrasting Exhibits

In this study, we examine how learners with different activation levels engaged in two very different resource-rich exhibits, an exhibit focused on active participation in engineering design challenges and an exhibit focused on learning facts about dinosaurs. From the perspective of a science center Director, these two exhibits were selected to complement each other as elements of our floor program. As a medium sized science-center, we seek a wide range of exhibit options to ensure that individuals across our diverse audiences that fits into our modest

exhibit footprint. Operationally, this means that our two larger exhibits must be different from one another so that visitors who are not engaged in one of them are likely to be engaged in the other.

We used the opportunity afforded by having these two different exhibits that serve as contrasting examples in the same science center to conduct this study. Accordingly (and intentionally both for visitor experience and for the study) the specific features of these exhibits (e.g. type of text labels, forms of interactivity) necessarily varied in many ways. For the ease of reference in this paper, we refer to one of the exhibits as the “Engineering Exhibit” and the other as the “Dinosaur Exhibit” to distinguish them from one another, but not to suggest that the content is the only difference.

The **Engineering** Exhibit (see Figure 1) featured a variety of independent hands-on engineering activities and design challenges that visitors could choose between freely: design and testing stations related to different kinds of artifacts such as cars, bridges, and parachutes. Because of the variety of activities available and the flexibility within each one, visitors may have left with a variety of outcomes, ranging from a new insight about physical phenomena to a new understanding of tension in bridges, to an interesting tower made from Kapla blocks. In terms of visual cues, the Engineering exhibit hall had minimal textual instructions/guidance, but sometimes small signs instruct people to follow the engineering design process. The resources available to visitors mimic or model actual materials used in engineering. As part of the design process, the making models component was an authentic engineering activity that resulted in a model of an authentic solution to a problem or challenge. Every activity available in this exhibit hall accommodated multiple users and social collaboration.



Figure 1. Photograph of engineering exhibit.

The **Dinosaurs** Exhibit (see Figure 2) featured a traveling exhibit with animatronic dinosaurs, a variety of fossils and other artifacts, and extensive labels. The exhibit's content was delivered via text, visuals, a limited number of interactive components (e.g., press a button to see one of the dinosaurs move or make a sound), and sometimes facilitation. Resources in the exhibit mimicked or modeled the actual tools, materials, or objects a paleontologist would use, and some resources, such as fossils, were authentic to paleontology. Aside from a digging activity, the procedures visitors engaged in as they read about and view dinosaur models were not authentic to the work of paleontologists or scientists. Each exhibit component could accommodate 2–3 people at a time, but they were not set up to enable extensive collaboration.

Research Questions

We examined engagement across two relatively-typical science museum exhibits, representing either greater emphasis on participation in science and engineering practices vs. learning science facts. We explored two research questions, of interest from both research and practice perspectives, related to how the environment and the learner's prior science activation interacted to shape learner engagement:

1. As a general pattern, across all participants, what was the relationship between activation and engagement across the two different exhibits?
2. Focusing on clusters of learners' different activation "profiles", how does engagement vary by exhibit?



Figure 2. Photograph of dinosaurs exhibit.

From the research perspective, we were interested in understanding if and how activation would predict engagement across both exhibitions. From a practice perspective, we were wondering (1) if knowing the patterns of activation of visitors would be helpful to selecting future exhibits and (2) if there were a way to align selection criteria with an understanding of the features of the particular exhibits that are most engaging for particular activation profiles.

METHODS

Overview

We analyze a dataset related to engagement during a science center visit collected as part of the ALES11 study (Dorph et al. 2016). The dataset includes: (1) survey data of science activation levels from a large number of learners; and (2) self-report survey measures of engagement from a subset of learners later attended the science center at the two different exhibits during the visit to the science center. The larger initial dataset is needed to discover robust learner profiles at this age level using latent class analysis, a quantitative technique that is dependent upon large sample sizes to discover meaningful subgroups that may represent less than a third of the learners.

Participants

For the activation profiles construction step, we used data from 659 fifth and sixth grade students coming from public schools in the Bay Area of California and within the city of Pittsburgh Pennsylvania. These learners were 54% female and had the following ethnicities: 45% African-American, 3% Asian, 45% Caucasian, 17% Latinx, and 11% other/don't know. They

came from a range of K-5, K-8, and 6–8 school configurations with widely varying demographics, ranging from relatively few under-represented minorities and low rates of children eligible for Free/Reduced Lunch to schools consisting almost entirely of students from underrepresented minorities and eligible for Free/Reduced Lunch.

250 of the fifth graders drawn from four Bay Area elementary schools, visited the Lawrence Hall of Science for a field trip. 220 of these had fully completed the activation survey and form the focal dataset used to answer the first two research questions.

Measures

This study relied on self-report measures of learner's levels of science activation prior to the science center visit and of their engagement during interactions with each of the two selected exhibits. Self-report measures were used given the scale of the study (ruling out video-observation) and the inclusion of affective and cognitive engagement (ruling out purely behavioral measures).

Each of the instruments went through an extensive and iterative development and validation process: (1) cognitive interviews with diverse learners to make sure the items were interpreted by learners at these ages as intended; (2) psychometric analyses to make sure the separate constructs were discriminable from one another; (3) psychometric analyses to make sure the scales produced reliable estimates for individuals across a wide range of activation levels and that the scales were not biased as a function of gender, race/ethnicity, or age; (4) validation studies to make sure the activation scales successfully predicted preferences to select optional science learning experiences and engagement during classroom science instruction; and (5)

validation studies to make sure the engagement scales predict changes in activation and science content learning from instruction (Bathgate et al. 2015; Ben-Eliyahu et al. 2018; Dorph et al. 2016; Sha et al. 2016).

Science Learning Activation. This measure includes four scales, each measuring one of the dimensions of activation. The Fascination scale had eight Likert rating items involving general and context-specific cognitive and affective reactions to science content (Cronbach’s $\alpha = .89$). The Values science scale had four Likert rating items reflecting a range of reasons students could value science content in their current and future lives ($\alpha = .70$). The Competency Beliefs scale had nice Likert rating items reflecting estimated skills in applying each of the component skills measured in the Sensemaking measure ($\alpha = .90$). The Scientific Sensemaking scale had nine items, with seven multiple choice items and two constructed response items ($\alpha = .75$). Constructed responses (related to the quality of possible research questions to investigate, and the quality of arguments provided) were scored and interrater reliabilities (Cohen’s $\kappa = .87$) for each of these coding tasks indicate substantial rater agreement (Bathgate et al. 2015). Sample items for each scale are presented in Table 1. The full survey instruments can be found in the cited papers referenced for each scale as well as at <http://activationlab.org/tools>. Two-parameter Item Response Theory models were used to calculate ability estimates (i.e., theta estimates, which have a mean of zero and generally range between -1.5 and 1.5) for each of these constructs; note that simple means across response items tend to correlate well with these theta estimates.

As a novel analysis step in the current study’s use of science activation data, a Latent Class Analysis (Hagenaars and McCutcheon

Table 1.

Example activation instrument items for each activation dimension

Activation dimension	Example item (with response options)
Fascination	In general, I find science (very interesting, interesting, boring, very boring)
Values	How important is it for you to learn about science? (very important, important, a little important, not at all Important)
Competency beliefs	I think I am pretty good at: doing experiments (YES! yes no NO!)
Scientific sensemaking	Now write a letter to President Obama explaining why you think that moving the dolphins to a protected cove is the best way to help them. As you write your letter you can use the provided evidence and any other information that you know to support your argument. [Open response coded for justification of ideas utilizing reasoning and evidence]

2002), was applied to the activation scores to reveal four common activation profiles of students, which are presented in Figure 3. Two of the profiles had higher activation levels (z-score above 0.5), but in complementary ways: either high Sensemaking ability (and middling Fascination/Values/Competency Belief levels) or high Fascination/Values/Competency Belief levels (and middling Sensemaking levels). The other two profiles generally had lower activation levels (z-score below $-.5$) but again in similarly complementary ways: either low Fascination/Values/Competency Belief levels (and middling Sensemaking levels) or low Sensemaking ability (and middling Fascination/Values/Competency Belief levels). We called these Low Motivation and Low Ability profiles. The High Ability profile was the most common profile in this group and the High Motivation was the least common profile. We used the terms

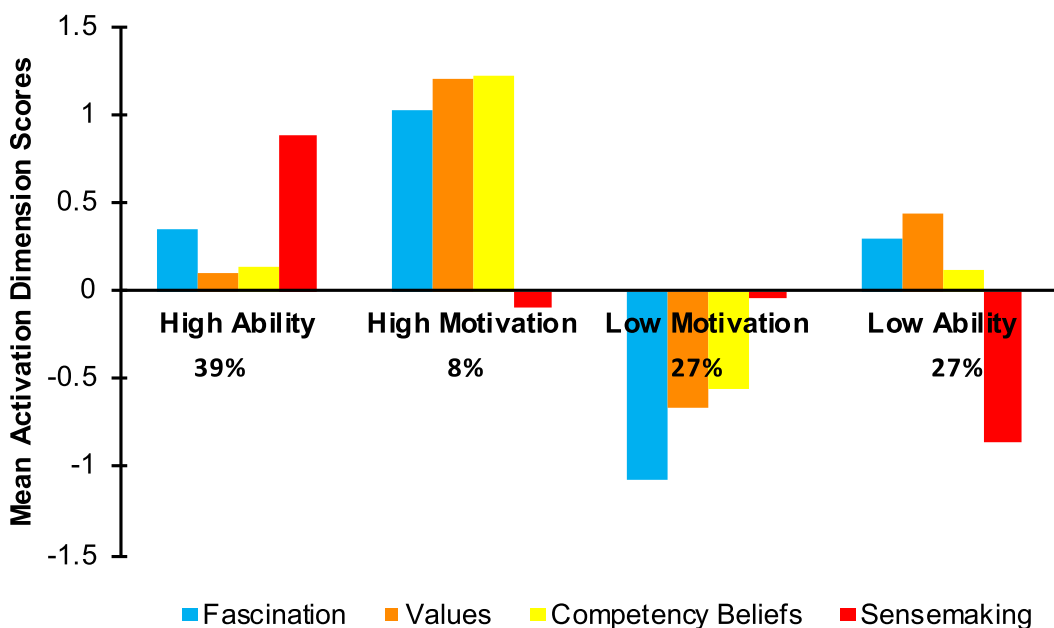


Figure 3. Activation profiles.

motivation and ability to label these profiles because we wanted the language we use to characterize these to match colloquial (rather than technical) understanding of the words used to describe them. In this case we use “ability” to represent its dictionary definition of “talent, skill or proficiency in a particular area.” Similarly, we use the word “motivation” to describe the reasons one has for behaving in a certain way.

Engagement in Science Learning Activity.

The *Engagement Survey* used in this study asks subjects to self-report their affective, behavioral, and cognitive engagement in a particular science learning experience or lesson (Ben-Eliyahu et al. 2018), rather than reflecting on more general motivational attitudes about science in general. This survey consisted of 17 Likert items measuring students’ affective, behavioral, and cognitive engagement in a recently performed task ($\alpha = .87$). A four-

point Likert scale (YES!–yes–no–NO!) was used and all reversed coded items were re-coded prior to analyses. Sample items include: During today’s activity: “I felt happy or excited” (Affective Engagement), “I worked hard during the activity” (Behavioral Engagement), “I tried out my ideas to see what would happen” (Cognitive Engagement). Factor analyses were used to investigate the instrument structure and consistently found a best fit across data collections from a bi-factor model which produces an overall Engagement score and separate Affective Engagement and Behavioral/Cognitive Engagement sub-scores. Here we use the two separate sub-scores. Prior research using such self-reports of engagement have shown that affective engagement successfully predicts growth in attitudes towards science and that behavioral/cognitive engagement successfully predicts learning science content (Dorph et al. 2016).

Procedures

The full set of participants completed the activation instrument in class. For those visiting the science center, it was completed a few weeks prior to the science center visit. The instrument was distributed in paper form by the research team in the order of Fascination, Values, Competency Beliefs, Sensemaking, and then demographic information. Sensemaking came last among the activation measures to avoid its difficulty negatively impacting attitudes, and demographics came at the very end to avoid effects of stereotype threat changing attitudes and sensemaking performance.

Those participants who came to the science center did so via buses as a school field trip. Following typical practice at this science center for school field trips, the overall visit structure was generally controlled by their teachers, providing some guidance and scaffolds for learners during the visit. In addition, for the purpose of the study, teachers ensured that their class visited both Engineering and Dinosaurs exhibits for roughly 30 minutes each. After visiting each of these exhibits, students completed the brief self-report survey about their level of Engagement in the exhibit.

RESULTS

We explore responses to the two questions (which dimensions of activation predict engagement?; does engagement vary across activation profile group?) by analyzing our data in two different ways. First, we present a cross-sectional analysis that suggests that activation is related to the learners’ engagement during their science learning experience. Second, we offer a profile analysis which used the activation profiles to shows patterns of engagement consistent with these profiles.

Relationship Between Each Activation Dimension and Engagement

In order to understand whether the relationship between activation and engagement varied depending on the type of exhibit the person was in, we looked at the correlations between the mean scores on each activation dimension and the mean scores at each exhibit on the two engagement scales (Affective and Behavioral/Cognitive). Figure 4 depicts the results of this analysis. All reported relationships were statistically significant ($p < 0.05$).

Overall, we see that there were a few common patterns across both exhibits. Behavioral/Cognitive Engagement in both the Engineering and Dinosaur exhibits had statistically significant and similarly large correlations with Fascination (.3 in Engineering, .26 in Dinosaur), Values (.4 in Engineering, .43 in Dinosaur), and Competency Belief (.43 in Engineering, .38 in Dinosaur). These results indicate that learners actively participated at the exhibit halls when they thought science was fascinating, understood that it brought value to their lives, and/or believed they were competent in science. Also of note, in general, the relationship between Fascination and Engagement was consistent across exhibits. Fascination scores correlate with Behavioral/Cognitive Engagement but not with Affective Engagement.

However, there were also large differences in what predicted (especially Affective) Engagement across the exhibits. Most strikingly, while Sensemaking (.18) predicted positive Affective Engagement in the Engineering exhibit, it actually was negatively correlated (-.24) with behavioral/cognitive Engagement in the Dinosaurs exhibit. Another way to understand this is that those individuals who

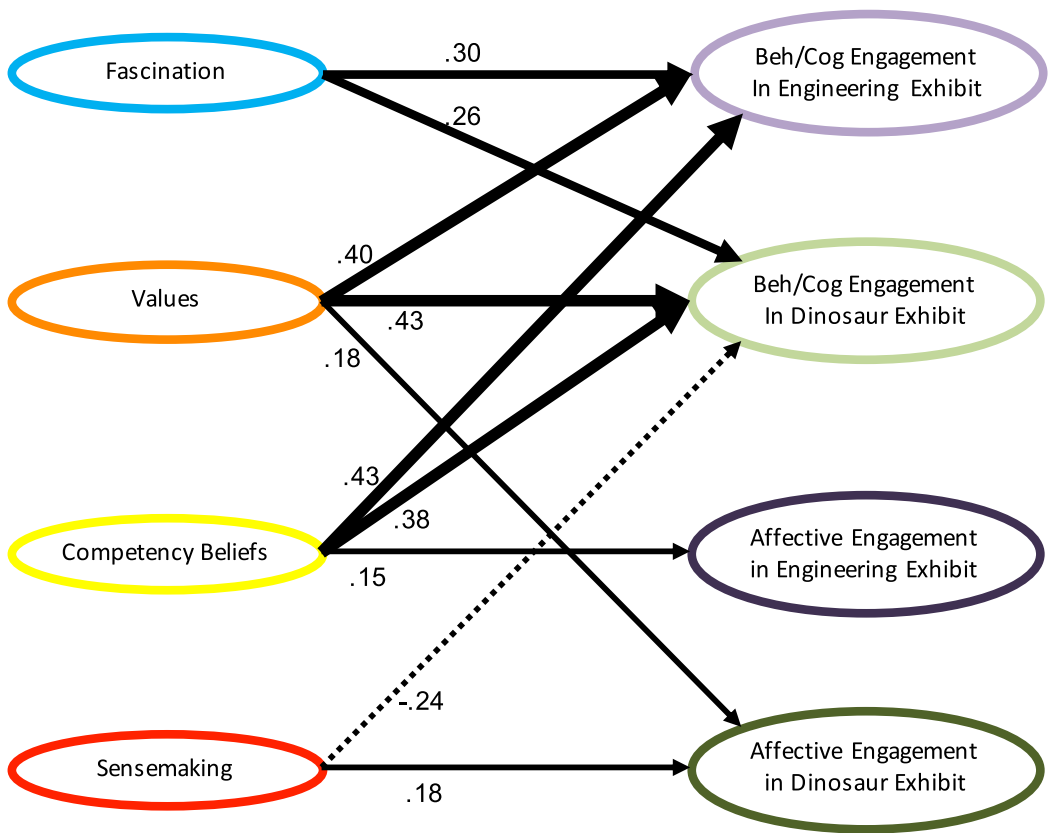


Figure 4. Relationship among activation dimensions and engagement in exhibit.

are high in Scientific Sensemaking have the lowest behavioral/cognitive Engagement in the Dinosaurs exhibit and highest Affective Engagement in the Engineering exhibit. Overall, Values, Competency Beliefs, and Sensemaking each had differential associations with Engagement across two the exhibits. For example, Values predicts positive Affective Engagement (.18) at the Dinosaurs exhibit but not at the Engineering exhibit; whereas Competency Beliefs had the opposite pattern predicting positive Affective Engagement in the Engineering exhibit (.15) not the Dinosaur exhibit.

Relationship Between Activation Profiles and Engagement

The second analysis described herein responds to our second research question: *Focusing on clusters of learners, does the engagement of learners with different activation “profiles” vary by exhibit?* In order to understand if the relationship between activation dimensions and engagement varied depending on the type of exhibit the person was in, we looked at the relationship between each activation profile (pattern across all four activation dimensions as revealed in Figure 1) and (Affective and

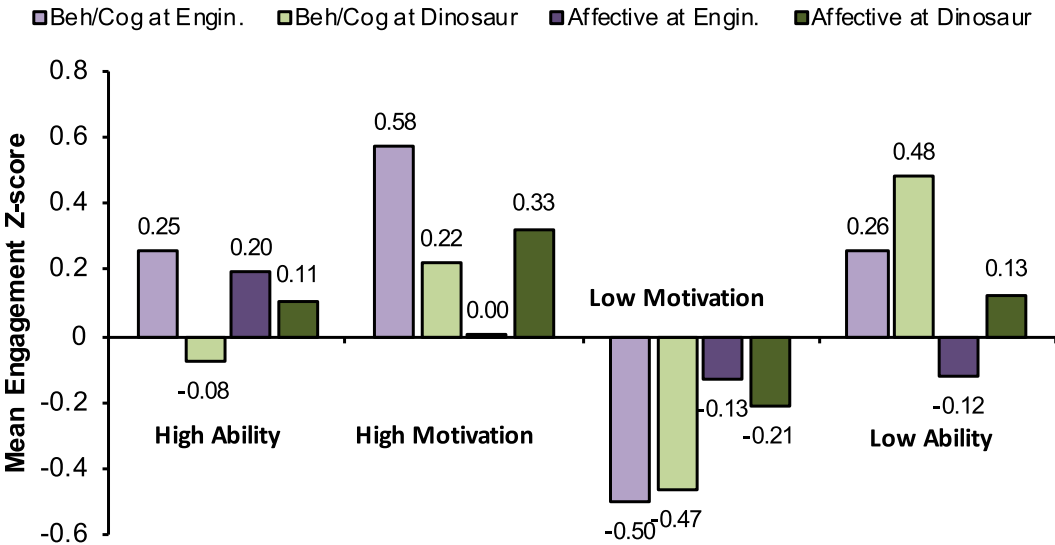


Figure 5. Engagement by activation profile.

Behavioral/Cognitive) Engagement level at each exhibit. Figure 5 depicts this analysis by displaying the mean z-score of the Engagement mean by profile.

This analysis reveals that there are distinctly different patterns of Engagement across the four activation profiles, with three of the four profiles exhibiting different responses across the two exhibits. Those in the **High Ability** group were more engaged in the Engineering exhibit than they were in the Dinosaurs exhibit. Further, their behavioral/cognitive engagement in the Dinosaur exhibit was the lowest (mean z-score of .08) among the other possibilities. In other words, the Dinosaurs exhibit was less engaging to those with higher sensemaking ability and moderate interest.

Those in the **High Motivation** group were most engaged from a behavioral/cognitive perspective (mean z-score of .58) in the Engineering exhibit. They were also more affectively engaged (mean z-score of .33) in the Dinosaurs exhibit than any other group. Accordingly, while the Engineering exhibit engaged this

group of young people from a behavioral/cognitive standpoint, it did not from an affective perspective.

The young people who clustered into the **Low Motivation** group were lower on engagement across the board. They were disengaged from both affectively (mean z-score of $-.5$ Engineering, mean z-score of $-.47$ Dinosaurs) and even less engaged from a cognitive and behavioral (mean z-score of $-.13$ Engineering, mean z-score of $-.21$ Dinosaurs) standpoint. Accordingly, the Low Motivation group is the one profile that had a similar pattern of engagement across both exhibits, albeit a pattern of disengagement.

Finally, the **Low Ability** group were more positively engaged, both cognitively and affectively in Dinosaurs (mean z-score of .48 Cognitive/Behavioral; mean z-score of .13 Affective) than they were in the Engineering exhibit (mean z-score of .26 Cognitive/Behavioral; mean z-score of $-.12$ Affective) absence of sensemaking skills may have been at work here again in that they were more engaged at a low

cognitive demand exhibit. Interestingly, this group showed higher cognitive and behavioral engagement than they did affective engagement in both exhibits, which may reflect their moderate fascination levels.

GENERAL DISCUSSION

The current study involved an investigation of individual drivers of (self-reported) engagement and the way those might vary across exhibits. Two exhibits were examined that were quite different along many dimensions in order to test the hypotheses. Interesting differences in patterns of self-reported engagement as a function of learner activation profiles emerged. This now creates an opportunity for future research to consider more broadly how exhibit features shape which learner activation profiles are the best match as a larger set of exhibits are examined.

As we consider the implications of this work for exhibit design and selection, we note several implications. First, while research to date has pointed to environmental features that support science learning, it is critical to understand that these features will interact with individuals differently. The activation dimensions of competency beliefs, values, and fascination significantly correlated with engagement in the exhibit galleries. This implies that it is a learner's level of activation when entering a science learning opportunity can have a large influence on the resulting level of learner engagement. Although this may suggest that environments contribute less to a learner's engagement, the environment may play a significant role in how a learner's activation levels shape the learning experience. For example, having high sense-making appeared to help individuals feel positive about the very open-ended experience offered in the Engineering exhibit. At the same

time, having higher levels of motivation to engage in science (fascination, values, competency belief) in science, may not be enough to ensure consistently positive affective engagement during a science center visit. This finding is consistent with what science center directors know all too well, while we may be able to select exhibits in ways that positively engage visitors on cognitive and behavioral dimensions, our selection of exhibits is not the only thing that influences whether or not a visitor has positive or negative affect (feel good or bad) during their experience. Affective engagement often also has to do with other aspects of visitor experience (e.g. social experience, atmosphere, amenities) rather than something to do with the exhibit content.

Second, our analysis suggested that both activation dimensions and profiles serve to explain differences in engagement, but in very different ways across two exhibits that generally were engaging visitors to similar levels on average. Perhaps most interesting and novel is our findings is the relationship between activation profile and engagement. These results indicate that perhaps the best explanation and predictor of engagement is a learner's particular combination of activation dimensions which collectively capture the learner's approach, philosophy, background and abilities related to science. Research can now take up this general approach to studying engagement by learner profiles across many exhibits to understand what key exhibit features influence which learner activation dimensions or activation profiles produce high levels and consistent patterns of engagement. From a practical perspective, these findings are of particular interest because they provide exhibit decision makers and designers the opportunity to select/design for exhibition features that engage particular and diverse types of visitors. For example, knowing that

traditional “fact-based” exhibitions may not be a good match for engaging those visitors who have high scientific sensemaking abilities may lead one to focus resources on more interactive and engaging exhibits that are more likely to engage more profiles of learners at some level. Further, consider another example that is relevant to discussions about broadening participation in science centers. Since science center experience designers want to make sure that it is engaging to those with either (or both) lower motivation and ability, it may be necessary to consider exhibit types and features that are different than the usual experiences currently offered at many science centers.

We note that only two exhibits were examined in this study and that they varied along multiple dimensions. Future research will be needed to replicate these findings at more exhibits and to learn exactly which exhibit features may be most likely to interact with learner activation profiles. For example, is it complexity of the content or degree of openness/lack of structure that makes one exhibit more engaging to a particular profile of visitors? In addition, the current study focused on self-reported engagement levels rather than observational measures for a number of theoretical and practical reasons. It remains an open question how activation profiles will interact with exhibit design to influence engagement at such observable levels. The prior validation work on these survey instruments suggests that observational measures should also show similar effects, at least and may also accurately capture important learning variation in engagement.

IMPLICATIONS

The study described in this paper offers evidence of how the construct of science learning activation can help organize variation in learners

in a way that productively complements consideration of diversity simply as a matter of demographic and background characteristics. We demonstrate that we can use the construct of science learning activation and the analytic approach of activation profiles to analyze how different visitors will engage with different types of exhibits. The findings suggest that knowing information about visitors’ activation profiles can help one assess the degree to which the features of any particular exhibit will result in visitor engagement. This reminds us how important formative exhibit evaluation is for maximizing the impact of exhibitions. Exhibition designers and evaluators may find the engagement survey instrument a helpful addition to the suite of methods they utilize for such evaluation efforts. We now also have a shorter version of the engagement survey that may be more practical in museum contexts (Bathgate and Schunn 2017).

Science centers could consider measuring the activation profiles of their typical audience (s) in order to design/select its exhibit portfolio to maximize the potential that they will find their exhibit offerings engaging. Further, the findings related to the low motivation and low ability profiles offer new ways of approaching the challenges science centers are facing related to broadening participation. The findings presented herein offer an opportunity to expand beyond the typical ways of making decisions about what exhibits to select and present in a science center. The implications of these analyses offer a research-based approach the design of a portfolio of exhibits that will support productive engagement in all of their visitors. **END**

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