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Assessing Exhibits for Learning in Science Centers: A Practical Tool

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ABSTRACT

This paper presents an exhibit assessment tool for science centers that is based on the premise, supported by learning theories and research, that the level to which a visitor is engaged by an exhibit is a direct indicator of the learning taking place. Observable behaviors are used to distinguish three stages or levels of visitor engagement described as initiation, transition, and breakthrough. A distinctive visitor engagement profile can be constructed for an exhibit that can then be used in assessing the effectiveness of subsequent changes made to the exhibit experience. It is suggested that the visitor engagement and exhibit assessment model describes and predicts relationships between exhibits, visitors, and observable learning behaviors in science centers.

Learning is without a doubt the most complex of human activities. From babies mastering language, to the development of attitudes and beliefs about the world, investigating and understanding our environment, making music or managing the political affairs of nations, we are all, in various individual ways, constantly involved in learning. Scholastic instructional settings where learning is formally organized, guided by curricula and led by teachers, dominate in the learning of science. However, science concepts, data, and theories, often embedded in science news stories, are all around us, quite apart from what is presented in the formal education system.

The media and the Internet provide access to a very wide variety of science news and opinion. Museums, zoos, aquaria, botanical gardens, and science centers make science available to the public through programs and exhibits. They are often referred to as "informal learning settings" where "free-choice learning" occurs (Falk, 2001). There is a very large, if not total, degree of self-direction and self-selection involved when people choose to visit one of these settings. Then, once that choice has been made, there is the freedom to decide on the content of the experience. Falk and Dierking (2000), leading researchers in the field of informal learning, posited that "free-choice learning tends to be non-linear, is personally motivated and involves considerable choice on the part of the learner as to what to learn, as well as where and when to participate in learning" (p.13).

Of the windows on science that are not available at home through the media or the Internet, science centers are distinctive because of the participatory experiences they offer their visitors. Bell, Lewenstein, Shouse, and Feder (2000) described "designed spaces"—including museums, science centers, zoos, aquariums and environmental centers—as science learning environments, rich with real-world phenomena, where people can pursue and develop science interests, engage in science inquiry, and reflect on their experiences through sense-making conversations. Designing those experiences can be driven by many objectives, but visitor learning of some kind is usually a priority. However, assessing the learning that results from a visitor spending time at an exhibit is very challenging. Furthermore, it cannot be accomplished with the same methods that are used in formal instructional settings where participation is mandatory and the learning objectives are explicit and strongly focused on cognitive gains. In science centers, the learning is much more multi-dimensional and any assessment of the learning experience needs to take into consideration the affective and emotional impacts, the very personal nature of each experience and the contextualized nature of that experience. We believe the framework and model we describe is appropriate for the learning that takes place in science centers and can provide useful information in the design of visitor experiences.

Evaluating the learning experience of visitors to science centers is increasingly focused on questions from stakeholders who want to see that their investments are contributing to effective programs (Stone, 2008), that the science center is having an impact in the community (Persson, 2000; Rennie & Johnson, 2007) and, at the very least, shows evidence that visitors are taking away positive experiences (Paris & Ash, 2000). Some criticisms have been raised in relation to what learning visitors can accomplish in a science center, as illustrated by a quote from a retired chemistry professor in a recent study by Rennie and Johnson (2007, p. 168) "and at (the local science center) all they learn is how to push buttons!". However, most of the literature and research in this field clearly shows that the informal setting of the science center is a rich learning environment that nurtures curiosity, improves motivation and attitudes toward science, engages the visitors through participation and social interaction and generates excitement and enthusiasm, all of which are conducive to science learning and understanding (Bell et al., 2009; Braund & Reiss, 2004; Griffin, 2004; Ramey-Gassert, Walberg, & Walberg, 1994; Rennie & McClafferty, 1996; Stocklmayer & Gilbert, 2002).

The benefits of understanding the impact of exhibits on science center visitors obviously extend beyond the need to provide proof to stakeholders. Science center program and exhibit staff want visitor feedback in order to improve the visitor experience and increase the impact of the interaction. Many large science centers and museums have research and evaluation staff who respond to this need and integrate their results into the design and development of the visitor experience.

The benefits to the visitor of this research and application loop are increased opportunities to engage with and learn from the science center's exhibits and programs. The Exploratorium's APE Project (Active Prolonged Engagement) is an example of the important role research and evaluation of the visitor experience plays in the design and development of high-quality, engaging science exhibits (Humphrey & Gutwill, 2005).

It can be argued, however, that most methodologies used by researchers and external evaluators require substantial financial and human resources as well as expertise in investigation methods. Despite having the best intentions, we believe that for most science centers, the resource demands of research remain a difficult hurdle in conducting research on the visitor learning experience and exhibit evaluation. What is needed, on a practical level, is a research methodology or a tool, based on learning theory, that is feasible for science center practitioners to undertake with relative ease, producing practical, usable results. Science centers are searching for convenient and effective ways to assess visitor outcomes. Rennie and Johnson (2007, p.169) noted that "Although most science centers routinely collect demographic data about their visitors and often information on their enjoyment, it is not always easy to shape information about enjoyment into a compelling case for their impact". Persson (2000) has commented that such efforts are often limited by the lack of an influential database of studies that demonstrate impact.

Learning in Science Centers: A Comprehensive Definition

Assessing the learning outcomes in science centers needs to not only focus on cognitive gains, but must take into account the conditions, the processes, and the engagement that lead to learning. In a recent review on the nature of learning and its implications for science center research, Rennie and Johnson (2004) proposed that measuring a visitor's actual cognitive gains from an interaction with an exhibit does not capture the multiple outcomes experienced by the visitor.

Models and frameworks have been proposed to better understand the nature of the informal science learning experience. Among others, Dierking and Falk (1994) recommendeded that any definition of learning applied to a science center and museum environment must take into account the affective experience these institutions provide for their visitors. Their landmark interactive experience model, which integrated the personal, social and physical contexts of learning (Falk & Dierking, 1992) was updated and further developed into the contextual model of learning (Falk & Dierking, 2000). The model stresses the importance of a visitor's personal agenda, interest, and motivation, as well as the socio-cultural nature and the physical setting of these environments.

It is now understood that people are not passive recipients of knowledge or empty vessels to be filled. Learning is an active process, an interaction between ideas that learners currently hold and newly presented experiences. This description is the constructivist approach to learning, which is primarily interested in how individuals engage in the making of meaning from experience. In other words, learning involves the active construction of new knowledge (Hein, 1998). Inevitably, motivation plays a key role in the constructivist perspective on the learning processes.

Researchers in the field of informal science learning are now often basing their investigations on constructivist and socio-cultural theoretical frameworks when studying the impact of a science center visit (Rennie, Feher, Dierking, & Falk, 2003; Rennie & Johnson, 2004). It is well documented that exhibits that encourage social interaction, build on visitors' prior knowledge and experience, and respond to visitors' interest and motivation have been shown to present visitors with the most opportunities for making meaning and conceptual re-shaping (Csikzentmihalyi & Hermanson, 1995;

Falk & Adelman, 2003; Falk & Storksdieck, 2005; Hein, 1998; Stocklmayer & Gilbert, 2002)

Engagement is Key to Learning in Science Centers

Csikszentmihalyi and Hermanson (1995) described the "flow" experience and the significance of engagement in the learning process. Understanding that engagement leads to the making of meaning and the construction of knowledge has played a significant role in the development of theoretical frameworks about the nature of learning in the science center. For example, in a study examining the effects of a science center visit on people's awareness of science and technology, Stocklmayer and Gilbert (2002) concluded that "the engagement and subsequent interactions with exhibits. . . . are determined by the prior experience and understanding of the visitor" (p. 842) and that "the engagement of the individual is the key (p. 856)". Rennie et al. (2003) agreed that understanding learning "requires that the precursors to engagement, as well as engagement itself be investigated" (p.113).

Observable Behaviors and Their Link to Learning

Early research in this field often characterized visitor learning behavior with such variables as approaching an exhibit, reading signage, asking questions, discussing the exhibit, and duration of time spent at the exhibit (see Rennie & McClafferty, 1995, for a review). Researchers in these cases measured the frequency of such learning-associated behaviors as an indicator of learning. Studies often sought to determine the relationship between learning-associated behaviors and exhibit styles or exhibit characteristics. Boisvert and Slez (1995), for example, concluded that the greatest learning, as determined by time spent at an exhibit, occurred with staffed exhibits and small, highly interactive but easily understood exhibits. A series of studies by Borun and her colleagues investigated measures of family learning with respect to exhibit interactions (Borun, Chambers, & Cleghorn, 1996; Borun, Chambers, Dritsas, & Johnson, 1997; Borun & Dritsas, 1997). Of particular interest to this article is the investigation in which Borun et al. (1996) developed measures of learning based on the learning goals of exhibits used in the study. These learning outcomes were then correlated to visitor learning behaviors. The findings showed a strong relationship between learning levels and observed behaviors.

Observing visitors and analyzing their interactions and conversations has become an accepted methodology in assessing visitors' learning experiences. At the Exploratorium in San Francisco, for example, researchers study observable behavior as a way of measuring the degree of visitor interaction with different types of exhibits and how different exhibit elements affect visitor learning behaviors (Gutwill & Allen, 2002; Humphrey & Gutwill, 2005). Atkins, Velez, Goudy, and Dunbar (2009) recently investigated the impact of different labels on visitors' learning experiences by analyzing observational data and recorded conversations. Analyzing visitor conversations provides a window into understanding how visitors are making meaning from their experiences and is widely used in family learning research (Ellenbogen, 2002; Ellenbogen, Luke, & Dierking, 2004).

"We can't necessarily see that learning has occurred, that new knowledge is gained, a different opinion is held, or there is a disposition to modify behavior, for example.

Rather, learning is observable in an individual's actions, that is, what that person does or says" (Rennie & Johnson, 2004, p. S6).

Observable Behaviors, Visitor Engagement and Exhibit Assessment

In this article, we present a visitor engagement and exhibit assessment model that we have developed on the foundation of a framework of observable behaviors and activities related to engagement that are indicative of learning (Barriault, 1998, 1999). We believe this model will provide science center practitioners with an assessment tool that is methodologically rigorous yet feasible to implement and that can generate real insights into the impact of exhibits on the visitor learning experience. We suggest that the model will provide science center staff with a comprehensive, far-reaching learning assessment tool with applications for science center exhibit evaluation, floor staff training, and exhibit development and improvement.

The visitor engagement and exhibit assessment model consists of

1. a visitor engagement framework (VEF) of observable behaviors;
2. the arrangement of those behaviors into learning related categories;
3. a visual representation of the level of engagement elicited by an exhibit; and
4. a model that indicates where intervention might increase visitor engagement with an exhibit.

THE VISITOR ENGAGEMENT FRAMEWORK

Barriault (1998) developed a visitor-based framework for assessing visitor learning experiences with exhibits in a science center setting. Ten years of use at Science North (Sudbury, Canada) have shown that this framework works with a wide variety of exhibits and is a practical tool for science center staff to easily understand the impact the exhibits have on visitors' learning behaviors. As a result of this use, small changes and additions in the descriptions of behavior and in the types of activities mean that the framework can accommodate a wider variety of visitor experiences.

The framework consists of seven discrete learning behaviors that occur as part of a visitor's interaction with an exhibit. The learning behaviors can be grouped into three categories that reflect increasing levels of engagement and depth of the learning experience (initiation behaviors, transition behaviors, and breakthrough behaviors). These levels of engagement capture the progression in a visitor's learning experience (Barriault, 1998).

Initiation Behaviors (Doing the Activity; Spending Time Watching Others Engaging in the Activity). When visitors demonstrate these learning behaviors, they are taking the first steps toward a meaningful learning experience. Even though they are not yet completely involved in the experience, they are gaining some level of information through the interaction which, in turn, could lead to more learning. Above all else, visitors need to feel comfortable about committing themselves to engagement with an exhibit. Initiation behaviors enable them to test the waters with minimum personal risk and provide an entry point into further learning opportunities offered by the exhibit.

Transition Behaviors (Repeating the Activity; Expressing Positive Emotional Responses in Reaction to Engaging in the Activity). Smiles and outbursts of enjoyment along with repetition indicate that a level of comfort has been achieved and that visitors are willing, and even eager, to engage more thoroughly in the activity. Regardless of whether the activity is repeated in order to better understand it, to master the functions, or to observe different outcomes, the net outcome is a more committed and motivated learning behavior.

Breakthrough Behaviors (Referring to Past Experiences while Engaging in the Activity; Seeking and Sharing Information with Others; Engaged and Involved). Each of these behaviors acknowledges the relevance of the activity, and the learning gained from the activity, to the individual's everyday life. The learning behaviors in this category reflect a commitment on the part of the visitor to gaining information and knowledge and to further exploring the ideas being presented. By referring to past experiences, seeking and sharing information, and becoming engaged and involved, a visitor's interaction with an exhibit becomes a meaningful learning experience that takes full advantage of the exhibit's learning opportunities. It becomes evident that the visitor is making meaning, building his or her own understanding of the concepts through prior knowledge, prior experience, and further inquiry. Labeling these behaviors as part of the learning process is consistent with the constructivist literature on learning (Hein, 1998), as well as with Falk and Dierking's (2000) contextual model of learning. Breakthrough involves engagement that clearly moves beyond short-lived, purely physical interaction.

Examples of types of activities that characterize each of the learning behaviors are outlined in Table 1. Through our experience in applying this framework, we have found these examples to be useful reference points for practitioners when applying the exhibit assessment and modification tool in the science center. It is important to note that although the seven learning behaviors tend to occur sequentially, that is not always the case. In fact, the behaviors can occur in a variety of sequences. A rich learning experience means that many or most of these behaviors occur during an interaction with an exhibit.

APPLYING THE VISITOR ENGAGEMENT FRAMEWORK

Observing Visitors in the Science Center

Science center staff at Science North, Sudbury, Canada are using this framework as a tool to better understand the impact their exhibits are having on visitor learning experiences. After initial training and guided practice using the VEF, science center staff observe visitors as they interact with an exhibit and record the learning behaviors they see using an observation sheet (see Figure 1). Visitors are either observed live on the floor or recorded with a video camera and observed later. Information about initiation and transition behaviors can be acquired by simple visual observation of visitor-exhibit interactions. However, to collect information about breakthrough behaviors, we often need to hear and analyze the conversations between the observed visitor and others, be they friends, family, or staff. In both live and video recorded observations, consideration must be given to the influence the person or the camera

Table 1. *Types of activities that characterize learning behaviours*

Learning behaviour	Type of activity and exhibit examples
Initiation behaviors	
1. Doing the activity	In passing, not done completely Doing the activity somewhat completely Doing the activity without further exploration or testing of variables
2. Spending time watching others engaging in activity or observing the exhibit	Looking at the exhibit working, or someone doing the activity Watching the exhibit or person using exhibit with expressed interest in the activity (facial expression or verbal) Interested in learning outcome or in learning the activity; visitor does the activity after observing.
Transition behaviors	
3. Repeating the activity	Doing the activity two to three times to attain desired outcome, to master the exhibit's function. Enjoyment of outcome Changing the variables once looking for a difference in outcome; becoming involved/engaged
4. Expressing positive emotional response in reaction to engaging in activity	Smiling, pleased with exhibit Stronger signs of enjoyment such as laughter; verbal references to enjoyment Obvious signs of eagerness to participate; excited disposition;
Breakthrough behaviors	
5. Referring to past experiences while engaging in the activity	Reference to past experience with exhibit or science centre Simple reference to comparable experience in visitor's life Reference to comparable experience in their life as well as making comparisons and deductions based on observations of similarities and differences
6. Seeking and sharing information	Calling someone over to look at exhibit, or to ask them to explain an exhibit; asking a question to staff or family member without lengthy discussion or exploration of topic. Reading signage; having conversations about exhibit and related science with staff or family member Sharing experience and information with others by explaining the exhibit to them, giving them details about gained information and observations; discussions and questions about exhibit with staff or family member/friend
7. Engaged and Involved: testing variables, making comparisons, using information gained from activity	Engaging in inquisitive behaviour, exploratory actions such as repeating the activity several times, reading signage, asking questions; remaining on task for 2–3 minutes Concentration and motivation are obvious; doing the activity as a means to an end, or meeting a challenge; length of interaction significant, 3 to 5 minutes; outcome or result of activity important Experimenting, testing different variables, looking for different outcomes; engages in discussion with others (visitors or staff) about the various outcomes; experience— 'flow'; involved in activity for long period of time i.e. more than 5 minutes

Visitor Learning Behaviors Observation Plan										
Exhibit:										
Date:						YC = young child (0-5)		T = teen (14-19)		
Time:						C = child (6-10)		A = adult (20-64)		
Observer:						PT = preteen (11-13)		S = senior (65+)		
Visitor				**Initiation Behaviours**		**Transition Behaviours**		**Breakthrough Behaviours**		
Number	**Subject w/ Description**	**Age Group**	**Gender**	**Doing Activity**	**Observing Others or Exhibit**	**Repeating the Activity**	**Positive Emotional Response**	**Refering to Past Experiences**	**Seek / Share Information**	**Involved / Engaged**
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
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16										
17										
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19										
20										

Figure 1. *Visitors Learning Behavior Observation Plan.*

may have on the visitor's behaviors. Proper protocols are also necessary with respect to ethical practices as they apply to studying human subjects. These protocols are consistent with Gutwill's (2003) pioneering work on implicit consent.

The observational data are quantified and plotted to produce what we refer to as the exhibit's Visitor Engagement Profile (VEP).

Plotting Behaviors: Visitor Engagement Profiles

The levels of engagement shown by visitors at a particular exhibit can be depicted in VEPs (Figure 2). Each of the three Engagement Level categories, Initiation, Transition and Breakthrough, is represented by a bar showing the percentage of visitors who show one or more of the behaviors characteristic of a category. The baseline for a VEP is the number of visitors who approach an exhibit and pay attention to it. Visitors who do not stop to interact with an exhibit are not included in a VEP. In other words, the attracting power of an exhibit is not assessed when using this tool. Instead, the VEP focuses our attention on the learning behaviors demonstrated by visitors once they have made the commitment to engage with the exhibit. The argument can be made that it is very challenging to know the reasons why a particular visitor does not stop to interact with the exhibit being assessed. The popularity of the exhibit, for example, may make it difficult for visitors to find an opening to interact with it. Alternatively, visitors may be members of the science center and have interacted with the exhibit many times in the past. Therefore, for the purposes of assessing the impact of the exhibit on the visitor learning experience, we have chosen to include only those who interact with it.

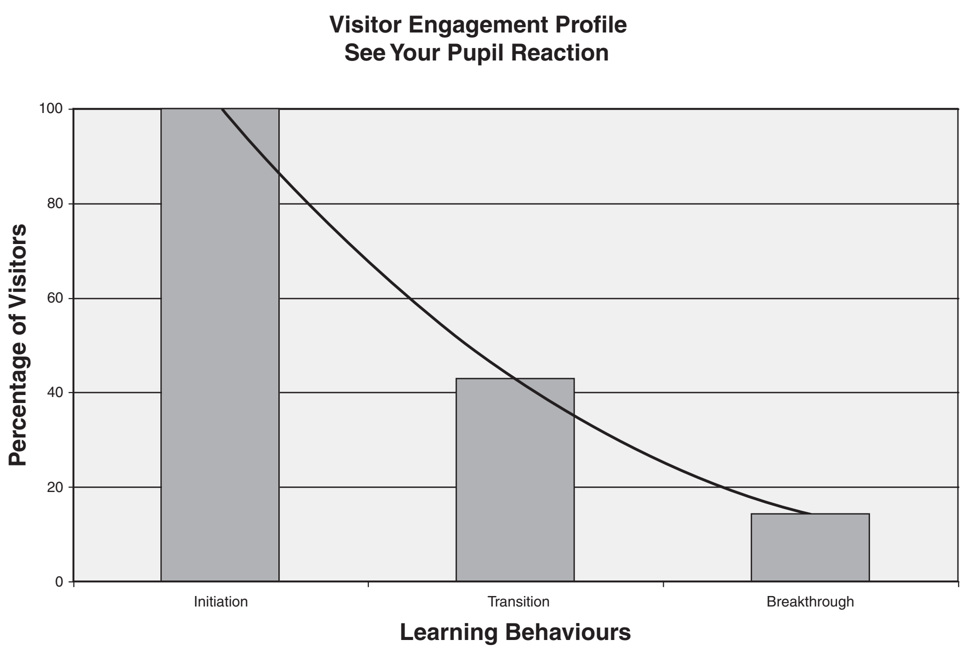

Figure 2. *An example of a Visitor Engagement Profile with an engagement curve for the Pupil Reaction exhibit at Science North.*

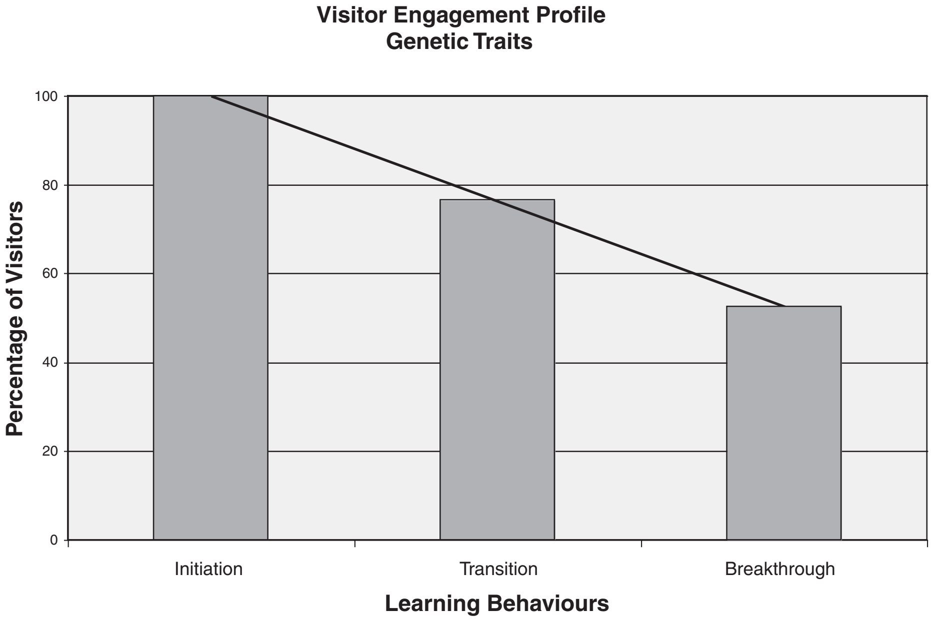

Figure 3. *An example of a Visitor Engagement Profile for the Genetic Traits exhibit at Science North showing an engagement curve with a low slope.*

The line connecting the mid-point of the summit of the bars is the engagement curve (see Figure 2). Exhibits that bring out transition and breakthrough behaviors in a high proportion of visitors have engagement curves with a low slope (Figure 3). Those at which many visitors become quickly disengaged and only a few show transition and breakthrough behaviors, have a steep, rapidly declining engagement curve (Figure 4).

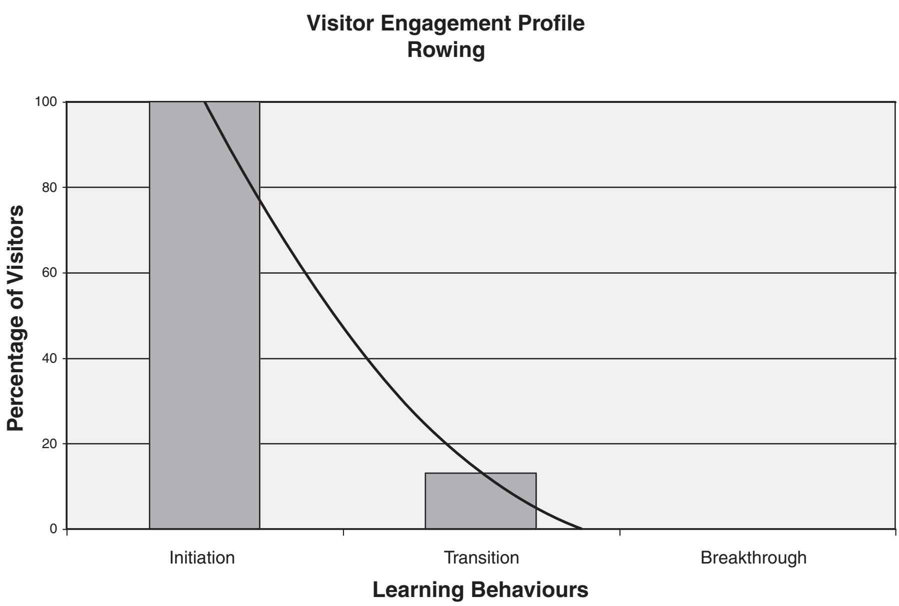

Figure 4. *An example of a Visitor Engagement Profile for the Test your Rowing Skills exhibit at Science North showing an engagement curve with a rapidly declining slope.*

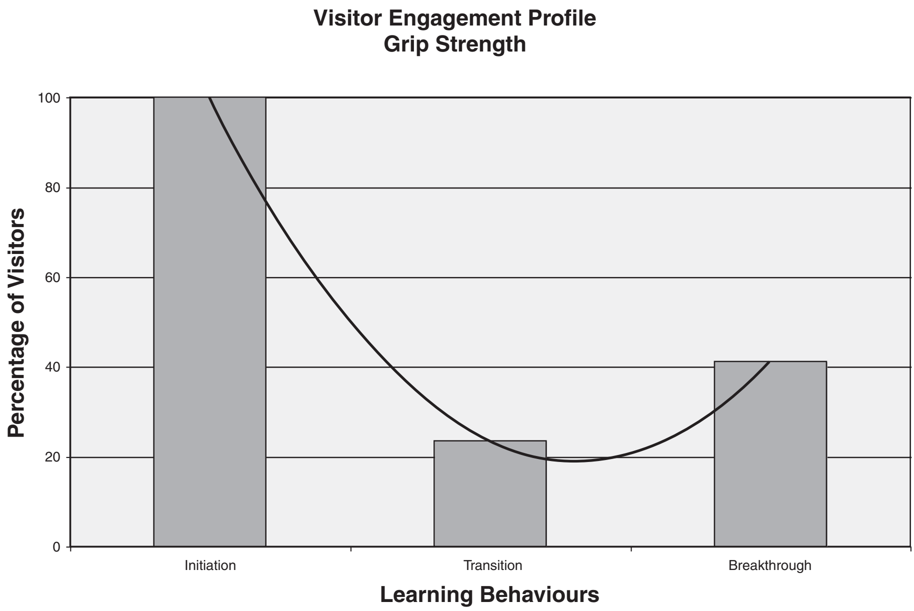

Figure 5. *An example of a Visitor Engagement Profile for the Measure Your Grip Strength exhibit at Science North showing a "U" shaped engagement curve.*

It is important to note that some exhibits, such as videos or computer interactives, can elicit high breakthrough behaviors without intermediary transition behaviors. In those cases the engagement curve has a "U" shape (Figure 5).

For science center practitioners, compiling the observation data to produce VEP graphs immediately provides a visual level of information about the impact or the outcome of visitors' interactions with a particular exhibit, based on engagement behaviors that indicate learning. If one is interested in plotting more details about individual exhibits, one could graph each learning behavior within each engagement level. In addition, if the age of visitors, or whether or not they are visiting in a group, is of interest, that information can also be plotted if recorded in the observation sheet. For example, a question we can ask is whether or not visitors in groups engage in more breakthrough behaviors than visitors who are interacting with the exhibit by themselves.

As a next step in the development of a practical and usable tool, we propose a model that shows relationships between exhibit impact, visitor engagement levels, and exhibit modifications and improvements that would provide science center professionals with a comprehensive overview of the visitor-exhibit interaction, learning experience, and exhibit design consideration. What follows is a description of that model and how we see it working as an exhibit evaluation and modification tool for science center staff.

VISITOR ENGAGEMENT AND EXHIBIT ASSESSMENT MODEL (VEEAM)

The VEF and the VEPs described in the previous sections form the first two components of a relational model we are calling the Visitor Engagement and Exhibit

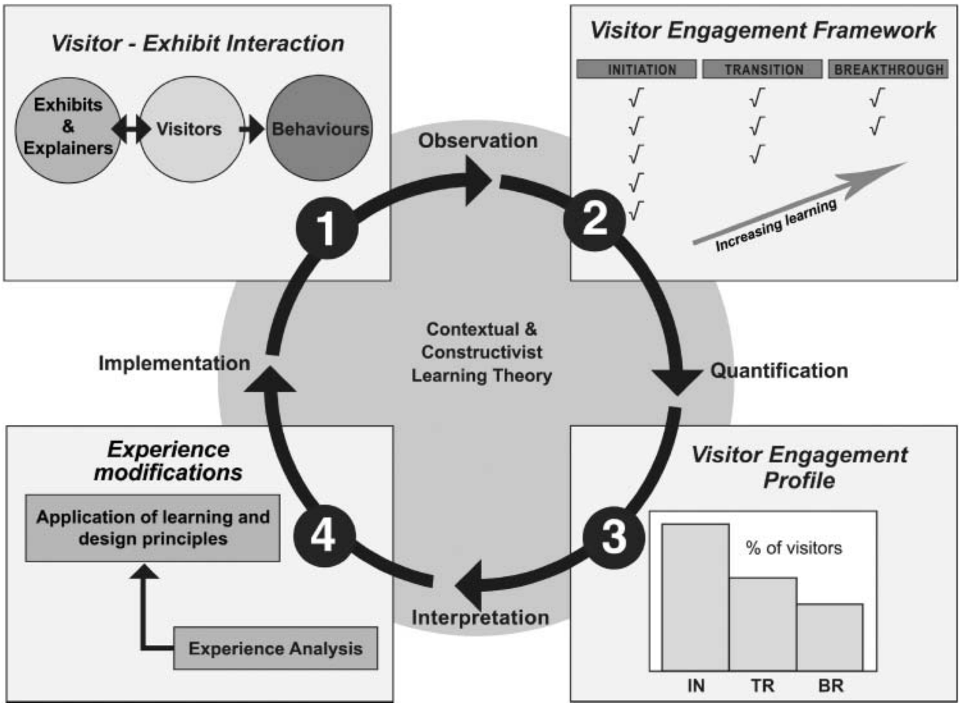

Figure 6. *The Visitor Engagement and Exhibit Assessment Model.*

Assessment Model (VEEAM; Figure 6). The model outlines the process for (a) analyzing the engagement behaviors elicited by an exhibit and then (b) using the analysis to modify the visitor experience of that exhibit. It is, in essence, a visitor behavior-based method of formative evaluation.

As previously shown, the levels of engagement observed at exhibits are quantified in VEPs (Figures 2–5) that show the relative percentages of visitors in the initiation, transition and breakthrough categories. Modification of the visitor experience through experience analysis and experience modification so as to elevate engagement is the final component of the model.

Quantitative data drawn from the observations of visitor behaviors and depicted in the VEPs are the starting point for analyzing visitor-exhibit interactions. Exhibits with low transition and breakthrough categories might well be judged ineffective, depending on whether learning is a major part of their purpose. In that case a detailed review of the engagement behaviors noted in the observation phase can stimulate ways of modifying the visitor experience. Such changes could be to encourage interaction with an on-the-floor explainer or to alter the exhibit itself so as to bring about more of those behaviors that were originally sparse. Providing context and everyday life examples in the exhibits for example, may increase the likelihood that visitors will make reference to past experiences or prior knowledge and engage more deeply with the exhibit's learning opportunities. To encourage visitors to share information or their experience with others, one might consider adding a social or collaborative component to the exhibits such as a cooperation exercise. Adding testable variables to an exhibit would likely increase the percentage of visitors who become engaged and involved,

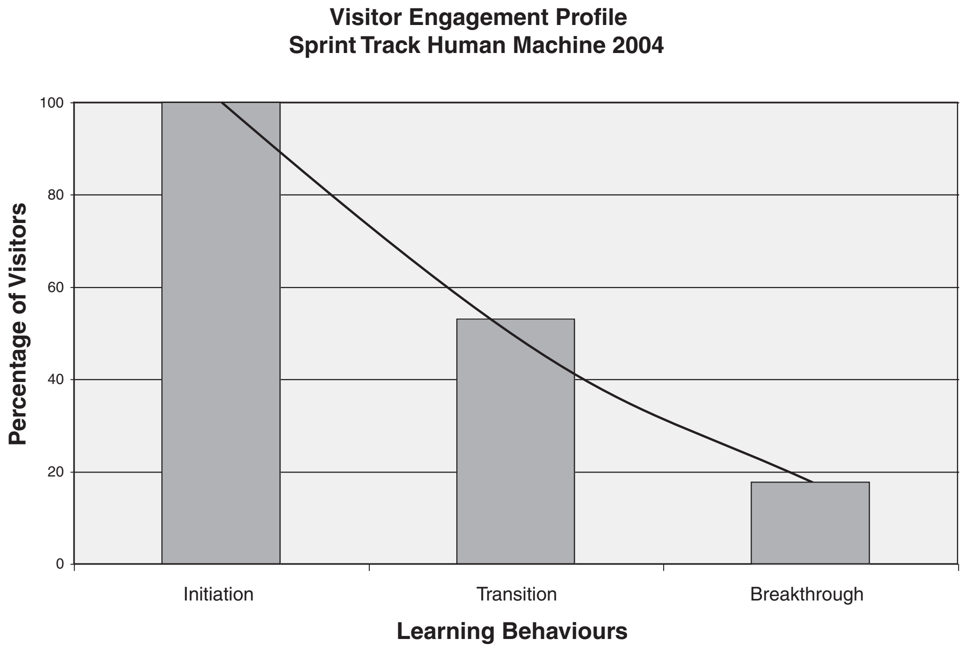

Figure 7. *The Visitor Engagement Profile for the Sprint Track exhibit in 2004, before changes were made to improve the visitor learning experience.*

like having different sized gears at a car-building exhibit, or many tools to build dams in a sand-and-water exhibit. Open-ended questions as labels might increase the occurrence of breakthrough learning behaviors.

Improvements to the level of engagement provided by individual exhibits can then be demonstrated as the VEP changes. An example from a study conducted at Science North (Barriault & Kneller, 2004; Waltenbury, 2005), will help illustrate the application of the model in improving an exhibit's impact on the visitor learning experience.

Applying the Model to Improve Exhibits and Visitor Learning Experiences

Experience Analysis

The Sprint Track at Science North is an exhibit that was first introduced in the Human Machine special exhibition in 2004. It is a 10-meter sprint track with starting blocks where visitors are timed when they reach the end of the track. A video coach and a replay video of the visitor encourage participants to improve their exit out of the starting blocks, like professional athletes would do in an actual race. The VEP (Figure 7) for the 2004 Sprint Track showed good levels of transition behaviors as visitors clearly showed high levels of enjoyment (positive emotional responses) and repeated the activity often. The breakthrough behavior levels were not as high as expected, suggesting that visitors were not taking full advantage of the learning opportunities presented by the exhibit. For example, although the video coach and the play back option were intended to encourage visitors to make changes to their positioning and test variables to improve their time out of the starting blocks, these exhibit features were not used by visitors as often as hoped.

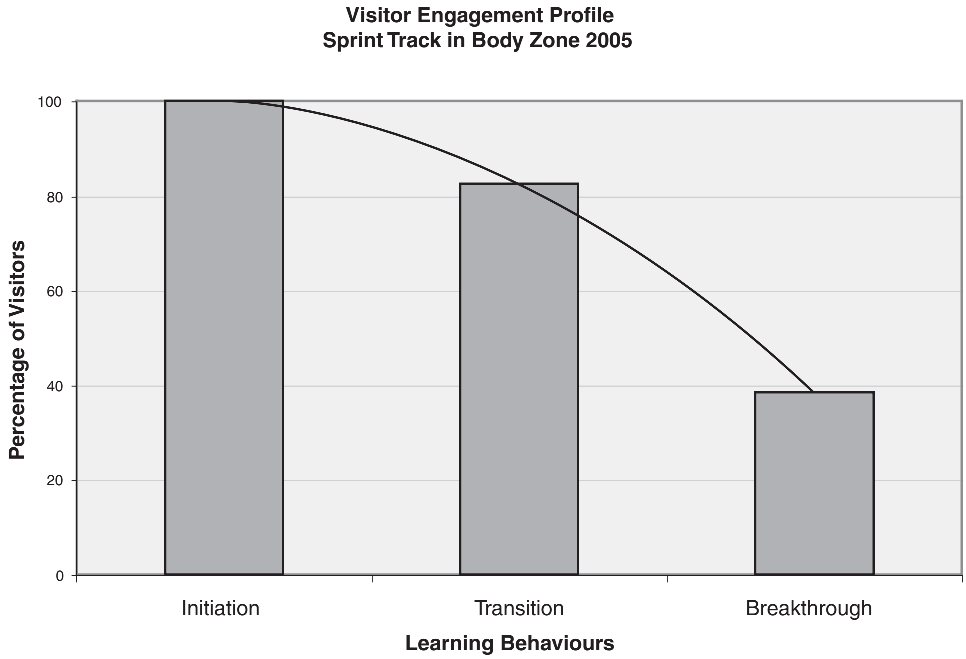

Figure 8. *The visitor engagement profile for the Sprint Track exhibit in 2005, after changes were made to improve the visitor learning experience.*

Experience Modification

In 2005, the Sprint Track exhibit was redesigned and moved to its permanent home in the Body Zone Lab at Science North. Based on observations of visitor interactions, constructivist learning approaches and physical design considerations, changes were made to the exhibit and new observational data were collected to create a new VEP. In short, the video coach and play back monitors were repositioned for easier access, and changes to the labels encouraged visitors to test different starting positions. Figure 8 shows the VEP for the Sprint Track after changes were made to improve the learning opportunities presented by the exhibit. These changes proved beneficial as both transition and breakthrough behaviors increased.

Additional Considerations

There are other questions having to do with the role of exhibits that must be born in mind when interpreting VEPs. Some exhibits may be designed and placed simply to draw people to a certain area of an exhibit gallery; some may be designed for a certain age group, or for one gender rather than another; some may be icons. The cumulative impact of a group of exhibits in an exhibit gallery is more subtle and complex than simply the sum of the engagement profiles. However, other exhibits may well have been intentionally designed to provide deeper learning opportunities. A steeper than expected engagement curve on the VEP of such an exhibit will alert staff in the science center that something is missing and modifications to the exhibit experience need to be considered.

In assessing engagement it may also be useful to distinguish between circumstances when on the floor staff (“explainers”) are available to interact with visitors and when they are not. In that case the engagement curve will reflect the role of on the floor staff in encouraging a higher level of engagement. Sponsors of an exhibit may well be convinced that the added engagement and learning is worth the cost of well-trained staff who understand how to encourage and motivate visitors.

Some of the behaviors characteristic of the transition and breakthrough levels involve conversation among individuals. If a high number of groups of visitors such as families are at an exhibit when it is assessed then "seeking and sharing information" behaviors may be very evident. For visitors, interacting alone with an exhibit "testing variables and exploratory behaviors" are the most observable evidence of breakthrough.

In applying the assessment tool we have described, it is important to avoid reductionist thinking and only paying attention to individual exhibits. Exhibits are, indeed, the smallest unit of a visitor's experience and lend themselves to analysis but it is the cumulative or whole experience that makes a visit memorable. The social context, seeing and hearing the positive emotional responses of other visitors, creates an ambience in which breakthrough is encouraged. Take an exhibit out of its context and it may not be as successful in eliciting the behaviors that occurred elsewhere. The characteristics of an exhibit that encourage connections to a visitor's everyday experience or knowledge can also be part of the context that helps an exhibit hall be more than just the sum of its parts.

A description of the overall visitor experience of an exhibition consisting of many exhibits could be usefully summarized with a median VEP derived from a significant random sample of the exhibits (rather than an average which could be skewed by a few highly engaging exhibits).

CONCLUSIONS

Much has been discovered about the nature of the learning experience in the science center setting and researchers are responding accordingly with innovative research methodologies that address the uniqueness of this experience. Examples range from the personal meaning mapping technique (Falk & Storksdeick, 2005) to recording and analyzing visitor conversations (Leinhardt, Crowley, & Knutson, 2002; Rennie & Johnson, 2004). Professional development training in the field of visitor studies is also increasing and the needs of this community of professionals are being addressed through a variety of programs and reports.

As the field of science center learning research grows, as methods become refined and as results become integrated in the design of learning experiences, it seems logical that, beyond professional evaluators and researchers, science center practitioners, from floor staff to exhibit designers, need a practical research tool that enables them to assess the effectiveness of an exhibit at engaging visitors in a learning experience.

One can also argue that the development of such a tool needs to be well grounded in science center research and informal learning theory as opposed to extrapolating formal education learning theory to the science center setting. As discussed by Rennie and Johnson (2004) "(p)erhaps now the exporting of theories in the other direction, that is, from museum research to research in education and psychology, has begun to address the 'trade imbalance' referred to by Paris & Ash (2000)" (p. 12).

The use and application of the VEF, the VEPs and the VEEAM have proven very beneficial to Science North in a variety of ways. For the visitor, the result of this research activity means exhibits that provide more learning opportunities. For the science center's staff, the use of these tools has enabled them to make improvements to the visitor learning experience. It also empowers staff to use data, not just intuition, to make changes to exhibit design while fostering a research culture that encourages reflection in developing the visitor experience.

It goes without saying that consistent application of the guidelines for recognizing and coding learning behaviors is required if the database built over several years in a science center is to reach its full value. However, the value of a culture of observation and recognizing the indicators of learning goes beyond the assessment process. It is the hallmark of a reflective center where visitors are understood and offered opportunities to engage in the processes of science.

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