Exhibit Development: The Importance of Process and Evaluation

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Abstract:

The Space Science Institute (SSI) is a national leader in developing national traveling exhibits on space science education (e.g. *Electric Space*, *MarsQuest*, *Alien Earths*, *Giant Worlds*, *Asteroids*, and *Discover Space*). It is also known for developing effective digital media programs (e.g. www.alienearths.org), education workshops for formal and informal educators, and educational films (e.g. *Inspire Me: Weightless Flights of Discovery*). Recent exhibit projects include *Giant Worlds* and the *Asteroids* project. This paper focuses on the exhibit development process, spanning conceptual planning, design development, fabrication and launch. SSI's exhibit programs also include education and outreach programming and the development of an online version of the exhibit. Examples from *Giant Worlds* and *Asteroids* will be used to illustrate these development phases especially the importance of evaluation/research in exhibit development using a logic model approach.

1. Background

People don't stop learning once they leave the classroom. Informal education institutions—such as museums, zoos, nature parks, planetariums, and science centers—are playing an increasingly important role in America's overall education system. They provide children and adults with opportunities to learn by doing. Interactive exhibits and programs are the preferred delivery mechanism for this active learning. These institutions seek to contribute to the development of a diverse, internationally competitive and globally-engaged workforce of scientists, engineers, and technicians, in addition to informed citizens. The Association of Science-Technology Centers (ASTC) reported that in 2005 over 96 million people visited its member institutions worldwide (ASTC, 2005). Each year, science centers offer more programs designed specifically for school children and teachers. ASTC estimates that in 2005 its members served over 24 million school children (ASTC, 2005). With the popularity of these institutions, it's not surprising that the line between formal and informal education is blurring. Many education researchers are exploring how people learn in free-choice, informal institutions and publishing their findings (e.g., Hein, 1998; Falk and Dierking, 2000). As an indication of the importance of informal education research, the National Science Foundation's (NSF's) Informal Science Education (ISE) program now requires that its funded projects include research and/or evaluation components that will produce a lasting impact on the field of informal science education (NSF, 2008).

The Space Science Institute (SSI) is a national leader in developing national space-themed traveling exhibitions (e.g. *Electric Space*, *MarsQuest*, *Alien Earths*, *Giant Worlds*, *Asteroids*, and *Discover Space*). It is also known for developing effective digital media programs (e.g. www.alienearths.org), education workshops for formal and informal educators, and educational films (e.g. *Inspire Me: Weightless Flights of Discovery*). SSI's exhibit programs also include education and outreach programming and the development of an online version of the exhibit. SSI educators conducted a 90-minute workshop at the 2009 Astronomical Society of the Pacific conference on the exhibit development process. This paper explores the workshop design and what participants accomplished within a comprehensive exhibit development framework that included conceptual planning, phases of evaluation, and the role of educational research. Examples will be given from recent SSI exhibit projects: *MarsQuest*, *Giant Worlds*, and *Asteroids*. A description of *Giant Worlds* and *Asteroids* follows.

1.1 Giant Worlds

Since Galileo first glimpsed the rings of Saturn in 1610, the beauty of the outer Solar System's giant planets – Jupiter, Saturn, Uranus, and Neptune – has captivated us. Now scientists are seeing beyond their beauty to gain a deeper understanding of their importance. Tools such as the Hubble Space Telescope, the Keck Observatory, and the Cassini spacecraft are helping us understand the origins of our Solar System and the formation of stars and planets. The National Science Foundation provided major funding to SSI to develop a 3,500 sq. ft. traveling exhibition about the giant planets that is bringing these new discoveries to the public and the classroom (particularly mid-sized venues that serve both urban and rural areas). The exhibition began its national tour on February 15, 2008 at the Orlando Science Center.

Giant Worlds includes a number of hands-on, interactive components and incorporates data, imagery, and animations from the Pioneer, Voyager, Galileo, and Cassini missions. Exhibit areas include: Family of the Sun, Meet the Giants, and New Frontiers. Quatrefoil designed the exhibit and Randi Korn and Associates conducted the evaluation. The Association of Science-Technology Centers (ASTC) is managing the national tour. NASA's Cassini and Juno missions are project partners. SSI collaborated with educators and scientists to create an education program to accompany the exhibit that consists of workshops for museum educators and local teachers. Dr. Heidi Hammel, a Senior Research Scientist at SSI, served as the science coordinator for the project. SSI has also created a virtual exhibit website for the project that extends the exhibit's scope and reach and provides resources and dissemination for the education program (www.giantworlds.org). The project took about three-years to develop.

1.2 Asteroids

Have you ever looked at the stars at night and wondered where asteroids and comets came from? Have you ever seen a shooting star and wondered about its journey? Asteroids and comets aren't just subjects for movies or incitements to the imagination like the "comet

madness" that arose with the approach of Hale-Bopp; they're also the subjects of scientific research. In 2001, the NEAR Shoemaker spacecraft actually landed on the asteroid Eros. In 2005, the Deep Impact's probe collided with Comet Tempel 1 to explore beneath its surface. In 2007, NASA launched the Dawn spacecraft to the Main Asteroid Belt. With all this interest, asteroids and comets are compelling subjects for an exhibition. They also provide a rich subject for science, math, and even psychology.

In 2008, NSF awarded SSI a grant to develop the Asteroids exhibition. Additional funding is coming from NSF and NASA support of SSI's *Finding NEO* project. NASA's WISE and Dawn missions are project partners. The centerpiece of this comprehensive informal education project is a 2,500 s.f. traveling exhibit that uses the engaging story of asteroids and comets as the context for integrating astronomy, mathematics, and psychology topics. As a way to maximize audience reach, the *Asteroids!* project also includes three Small Exhibits (SEs) that will be used in a host venue's community and at small science centers and libraries across the country (about 300 s.f. in size); an Education/Outreach Program for museum educators, docents, and amateur astronomers across the country; a Professional Development Program for science center, library staff, and other ISE professionals; and an Educational Website that connects all elements of the project together. This integrated informal education program will address three content areas: (i) *Asteroids – Up-close & Personal;* (ii) *Deep Impact* (Solar System formation and early bombardment; craters on Earth, Moon, & Mars; life altering events like the dinosaur killer); and (iii) *Planetary Protection* (Tracking asteroids; energy and power of a collision compared to human/earth scales; probability and risk; Earth protection schemes). The project will use the perceived threat of an asteroid impact to address various math concepts as well as explore the interplay between people's everyday emotional experience, intuitive judgments, and decision-making processes from a psychological perspective.

Jeff Kennedy Associates has been selected to design the exhibits and three teams of middle school students from North Carolina, New Mexico, and Colorado are assisting with the development process and each team will create an exhibit or multimedia piece for their communities. The Institute for Learning Innovation (ILI) is conducting all phases of program evaluation including a research project about the use of Web 2.0 in the development process.

2. Workshop Design for the 90-minute Oral Session

The workshop facilitators (P. Dusenbery and B. McLain) decided to adopt a experiential approach to the session which modeled what actually happens in exhibit development as well as being more fun and educational for the participants (numbering about 22). The outcomes for the session were that participants would:

- Learn about informal science education and exhibit development
- Get hands-on experience working in breakout groups to design a mock exhibit

- Learn how to use a logic model in defining exhibit success and better understand the importance of evaluation and education research

Each participant was assigned to a table (4-5 participants per table). Each table/team was given an exhibit topic from the following set: Space, Earth, Health, Technology, and Math. These topic areas span the Science, Technology, Engineering, and Math (STEM) spectrum and led to some fascinating and lively discussions (see the following section for details). The session began with participants sharing what memorable exhibits they have experienced. This discussion naturally led to a discussion of the characteristics of an exemplary exhibit. The workshop led each team through the development process from concept planning to design development. The hard part of this process is to settle on a concept that can be designed. For example, it is impossible to really design an exhibit about space – the topic is far too big to design; it would be an awful experience for visitors. It should be noted that some organizations have attempted to tackle this broad topic but none have been successful. So the challenge is to select that aspect of space that interests the team and one that would be interesting to public audiences (e.g. topics like black holes, Mars exploration, asteroids and their impacts on Earth). Good concept planning begins with divergent thinking (i.e. brainstorming) but must end with convergent thinking that will help the team narrow their focus and helps them select an appropriate subtopic. A good development team should conduct some marketing to really assess visitor interest in a given subtopic. The agenda for the workshop is below.

Workshop Agenda:

3:30 – 3:45	**Introductory Remarks & Survey** of participants about the kinds of exhibits they have produced or seen. What made them memorable? Write answers on a flip chart.
3:45 – 4:05	**Task #1**: Define Exhibit/a Marketable Name/Desired Outcomes & report to group
4:05 – 4:15	**Task #2**: Define your exhibit themes & subtopics – a conceptual framework
4:15 – 4:30	**BREAK**
	Invited Guest Rotation
4:30 – 4:50	**Task #3**: How do you develop an exhibit from concept through completion? What is your Development Process? Report findings to group.
4:50 – 5:00	**A Logic Model**: an important tool for development and evaluation (Brad Mclain)
5:00 – 5:05	**Alien Earths Video Trailer** (Brad leads discussion)
5:05 – 5:15	**A Synthesis** (Paul Dusenbery)

Before we discuss the results from the exhibit teams (Section 3), several points need to be made. As mentioned previously, we did not tell participants about our exhibit development process. In fact, we do not claim that our approach is the only way to develop exhibits. We do claim that this approach has been successfully used by SSI to produce many exhibits of different size from 300 square-feet to 5,000 square-feet. Evaluations of the workshop showed that teams learned from our process but that the experience was stressful because we made such a fess on the exhibit opening event. Toward the end of their development, the teams were told that billboards were starting to appear on highways near the opening venue, host museum personnel were calling about how the fabrication was going, funders were interested in their progress, and so forth. This stress was purposely added to the workshop to give the experience a reality. We used an analogy in the beginning of the workshop that compared an exhibit opening to a broadway play opening in New York city. After the Break period, each team selected one of their members to visit another team (Invited Guest Rotation). These individuals could see what other teams were producing and provide insights on their team's approach. This dialogue had the potential to be valuable for both teams. The guests returned to their teams toward the end of Task #3. Finally, the facilitators used the experience the participants has just gone through to emphasize the importance of evaluation and education research. The purpose of the final presentation was to put the exhibition development process into a solid educational framework that included The Big Idea, selecting an Organizing Principle and Integrating Themes, and so forth. Exhibition development and the importance of evaluation will be discussed in Sections 4 and 5, respectively.

3. Workshop Results

Prior to developing their exhibit concept, participants were asked whether they had produced any exhibits in the past (very few had) or had seen exhibits at various informal learning venues like science centers and zoos (everyone had). The facilitators then asked what made their exhibit experience memorable. This is an important question because it defines the characteristics of an exemplary exhibit experience that can be used as a guide in developing any exhibit (e.g. interactive, kinesthetic). This approach was similar to what SSI did in its very successful four-day education workshop for scientists, engineers, and EPO managers (ref.). There we asked participants to name the characteristics of an exemplary formal (K-12) education program (e.g. foster critical thinking). We then discussed examples of exhibits that possessed one or more of these defining characteristics. Examples included exhibits at aquaria like the Monterrey Bay Aquarium (e.g. their stunning jelly fish display), the newly launched Black Holes exhibit produced by Harvard's Center for Astrophysics, and timely exhibits on climate change. The characteristics of a good exhibit and examples of interesting exhibits are listed in Table 1.

Table 1: Survey Results

Characteristics of a Good Exhibit	Interesting Exhibits
Experiential	Aquaria
Interactive	Black Holes
"Ah-ha"	Astronomy
Kinesthetic	Climate Change
Hands-on	Green Exhibits
Fosters Play	Earthquakes
Interesting Objects/Artifacts	Body Worlds
Beauty and Wonder	Grossology

Participants were now ready and hopefully excited to roll up their sleeves and begin to design their very own exhibit. They began by defining what sub-topic they were going to develop. As described in the previous section, each team was given a very broad topic (e.g. health). They needed to decide as a group what their more narrowly focused topic was going to be. This is not an easy process. It is what SSI calls creating a "sand box". Once they determined what their exhibit idea was going to be they then had to select a marketable name and define several important visitor outcomes. While this process usually takes several months for a real exhibit, our teams were able to accomplish this herculean feat in a mere 20 minutes! The following focused exhibit topics were selected:

- You Are What You Eat (health)
- Go Mars! (technology)
- Beauty and the Beast (math)
- Poor Pluto: the solar system misfit (space)
- Blue Marble (earth)

Visitor outcomes for each team are listed in Table 2. Notice how important these outcomes are in terms of constraining the exhibit development. This approach uses what is called a backward design process. It's what Covey (1989) called "beginning with the end in mind." For example, the math exhibit, *Beauty and the Beast*, will result in visitors learning about symmetry and asymmetry and gaining an appreciation of math in both nature and art. Backward design is

the most important project development principle from building spacecraft to producing exhibits. Many people mistakenly think they can build a project from the ground up, adding details as they go. It would be like trying to build a house without an architectural plan or a curriculum without knowing what your intended audience was suppose to achieve (by defining clear and measurable learning goals).

The next task (#2) asked each team to define exhibit themes and subtopics. Themes are concepts that tie exhibit areas together. For example, symmetry/asymmetry might be a good theme for a math exhibit. Certain themes can become great organizing principles. Again, one could imagine an interactive math exhibit that had the concept of symmetry as its organizing principle. The important elements described above form key parts of what SSI and other exhibit developers call a "concept plan". One other critical element is usually included in the plan: front-end evaluation. This phase of evaluation focuses on understanding the target audience(s) for an exhibit. For example, some exhibits may be geared for elementary-aged visitors. Others might target high-school aged visitors and the general public. For *Giant Worlds* and *Asteroids*, SSI targeted upper elementary and middle-school aged audiences as well as adults. Developers may have some very specific questions they would like to answer about their target audience such as their content knowledge about the subject as well as their emotional responses to various exhibit ideas (so-called affective responses). This important audience research is what front-end evaluation contributes to the project. See Section 4 for more details on the phases of evaluation.

Table 2: Desired Outcomes

Exhibit	Desired Outcomes
You Are What You Eat	Energy, Nutrients, Choices, Consequences
Go Mars!	Getting to Mars, Health & Safety, Habitat, Design Engineering Process
Beauty and the Beast	Symmetry & Asymmetry, Patterns, Appreciate Math in Nature & Art
Poor Pluto	Solar System Story, Process of Science, Scientists can Disagree
Blue Marble	Eco-systems, Compare to other Planets, How do we Know, and Technology

The final task (#3) asked each team to outline their complete development plan from the conceptual stage through design development, fabrication, and opening. While this usually takes at least 1-2 years, our amazing teams were able to accomplish this task in just 20 minutes. We did not give too many details about this last activity because we wanted the teams to explore some of these difficult aspects of exhibit development. Few teams were able to really

navigate these challenging waters. It did not help that we kept mentioning that their exhibit was to open soon and their funders were asking how their project was progressing. SSI always hires professional evaluators, designers, text writers, and fabricators to produce its exhibits. That allows SSI to concentrate on other important details such as the education and outreach programs, developing various software pieces, and building an exhibit website, and of course project management.

Several of the teams mentioned another very important milestone that needs to be inserted into the development process: prototyping. After all, a concept plan is just that – ideas floating around in the heads of the developers. These ideas become transformed into a physical exhibit through creating relatively low cost versions of exhibit components that can be tested on potential audiences. Visitor feedback is part of the second evaluation phase: formative evaluation. This phase also explores how well potential audiences respond to the organizing principle (if there is one), exhibit themes, and other aspects such as the storyline and graphics. More about the evaluation process can be found in Section 4.

It should be noted that SSI does not really produce exhibits such as *Giant Worlds*. It does, however, produce "exhibitions" but this fact was not shared with participants until the very end of the workshop. An exhibition includes a physical exhibit (sometimes several) as described above as well as an education/outreach program and an interactive public website that extends the scope and reach of the exhibit to much broader public audiences. The education program is designed to reach museum educators and museum volunteers (called docents). It relies upon the exhibit framework. In fact, for in-person workshops, the physical exhibit is used in the training. Materials for educators can be downloaded from the website. The outreach program could include additional audiences such as amateur astronomers and the informal education community (as in the *Asteroids* exhibition). The rich interconnections of these elements are illustrated in Figure 1 below.

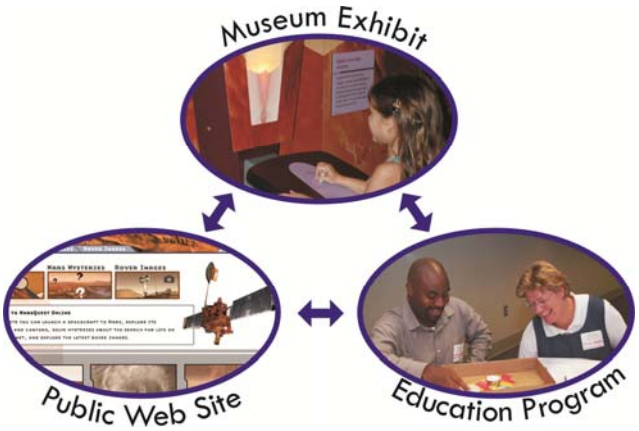

Figure 1. A connected exhibition project

4. The Role of Evaluation & Research in Informal Education Programs

The final section of this paper explores the role of evaluation in developing a successful exhibition (including a logic model) as well as conducting an educational research project that has the potential to impact our understanding of how people learn in various informal education environments such as science centers, zoos, giant screen theaters, and libraries. Education research projects can even be used to investigate learning that takes place in virtual environments such as websites and social media networks like YouTube. Two recent publications provide a solid foundation for assessing the impact of an informal education project as well as creating a common framework for researchers to evaluate various aspects of informal learning (NSF, 2008; NRC, 2009).

Evaluation and educational research are important elements of an effective exhibition project. Findings from this activity are critical to advancing the field of informal learning by providing a published research base where experiences are based on evidence not just compelling antidotes. This foundation enables project developers to build on lessons learned and it allows the field to better understand informal learning and how that compares to other types of learning (e.g. formal, classroom learning). There are good websites that provide a database on informal learning (www.informalscience.org). The key phases of evaluation are listed below along with the primary focus of the phase. The summative evaluation can also be a time where fine-tuning of the exhibit can take place. We have discussed the first two evaluation phases above. The rest of this section will focus on summative evaluation phase.

Phases of Evaluation:

- Start of project (Front-end) — Define Learning Goals & Your Audience
- Middle of project (Formative) — Refine Deliverables
- End of project (Summative) — Project Impacts on Target Audiences

NSF (2008) has defined a number of important impacts for its informal education projects that could benefit all informal projects. The NSF impact categories are (1) Awareness, (2) knowledge or understanding, (3) Engagement or interest, (4) Attitudes, (5) Behavior, and (6) Skills. These impacts can be applied to both public (e.g. museum visitors) and professional audiences (e.g. museum educators). Not all projects will have all 6 impact categories. In fact, some impacts like Behavior are very difficult to assess and would probably be impossible for a short-duration informal education project to achieve. However, there might be some situations where behaviorial changes are the focus of the project. For example, the health team designed an exhibit called “You are What You Eat” which did in fact list outcomes like choices and consequences of eating habits (see Table 2). This type of exhibit could impact behavioral

changes in its target audiences. The challenge for this project would be to design a longitudinal study that was able to track behavior over time.

How does one really know what impact a particular project should have? As we discussed in Section 3, a project relies on its conceptual plan which describes the broad impacts that the developers intend to occur. But how do you demonstrate in a measurable way that these impacts have actually occurred? An important tool that can be used is called a Logic Model. This model provides a visual representation of the linkages between and inputs and outputs of a project. Thus one could look at a specific activity (say an exhibit) and see how that exhibit would impact a specific audience (e.g. children). The model specifies what kinds of outcomes (e.g. enhancing their understanding of a STEM topic) and the measures that would be used to assess whether a given outcome has been achieved. The key elements of an Exhibit Logic Model are:

Initial Activities – Short term Audience Outcomes – Long-term Outcomes

The example below is a simplified version of a Logic Model from *Asteroids*. The set of activities are listed in the left column (e.g. the large 3,500 square-foot exhibit). The target audiences are listed in the middle column. Amateur astronomers (AAs) play an important role in the project's outreach program led by the Astronomy Society of the Pacific. The Student Advisory Teams (SATs) are 8th grade students who are part of the development team (three teams were involved). The outcomes/impacts are listed in the right column. An example of an outcome is to increase awareness of solar system objects like asteroids and comets and the role that they have played in Earth's evolution. A real Logic Model would show all the connections between the inputs (activities) and the project's outcomes. This helps the project team identify how the assessment activity will be related to all of the project's components.

Activities	**Audiences**	**Outcomes/Impacts**
Large Exhibit	General Public	Increase Awareness
Small Exhibits	Targeted Groups:	Develop Understanding
Outreach	AAs	Practice Skills
Education/PD	SATs	Increase Positive Attitudes
Development Process		Improve Communication

5. Summary

The workshop provided the facilitators and the participants a lively forum for discussing the range of activities that occur in an exhibition development process. Having participants work in teams to create a mock exhibit was a useful exercise because it allowed each member to engage more deeply in the design process. The framework (including evaluation and a Logic Model) that was discussed at the end of the workshop made much more sense because of this approach. The purpose of the workshop was not only to share how an exhibition can be

designed (from concept plan to opening) but to emphasize the importance of the phases of evaluation (e.g. front-end) to the ultimate success of a project. The impacts of informal education programs need to be rigorously assessed and the results need to be disseminated to the broad informal education community in order for our field to flourish.

6. References

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