Science on a Sphere Exhibit Program Evaluation

Forecast: Tropical Cyclone

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Introduction

In this report we detail the results of one phase of formative evaluation on the NOAA funded Ocean-Atmosphere Literacy Partnership – a cooperative partnership between the American Museum of Natural History (AMNH) and The Science Museum of Minnesota (SMM). The American Museum of Natural History produced the first draft of a video program for the Science on a Sphere (SOS) exhibit called *Forecast: Tropical Cyclones*.

The program was designed to inform visitors about tropical cyclones (a.k.a. typhoons, hurricanes) and to illustrate how technological advances in weather observation have allowed scientists to develop weather models that can predict the path of tropical cyclone. The video was shown to visitors at SMM to test visitor reaction.

The SOS exhibit is a large spherical screen suspended in the middle of a darkened room with four projectors discretely located at four congruent points around the sphere. Projectors are high enough so that people passing around the sphere do not interfere with the projection, and they produce a seamless 360-degree image around the sphere screen. Benches and chairs are placed around the sphere at intervals allowing room for people to sit, stand, or walk around the sphere without obstructing the view of each other.

Methods

Evaluators at SMM unobtrusively observed visitors watching *Forecast: Tropical Cyclone* on SMM's SOS and conducted interviews with visitors who watched at least 30 seconds of the film (total run time 7 minutes 46 seconds). Participants were selected following the random selection convention of drawing an imaginary line across the threshold of the exhibit space and selecting every third adult visitor to cross over. The evaluation was conducted at various days and times of days to further ensure a representative sample of SMM visitors who choose to enter the SOS space. Evaluators recorded the behavior of selected visitors as they watched the film, and the point at which they entered the film.

Ninety-four visitors were observed while watching the program; forty of these visitors watched less than 30-seconds of the program and were not eligible to be interviewed; three visitors who watched the program for more than thirty seconds and were eligible to be interviewed refused to be interviewed. The remaining fifty-one visitors (51% male and 47% female) were observed and interviewed; the demographics are from information visitors provided and represent only those visitors who were interviewed. Visitors ranged in age from 10 to 77 with a mean age of 38. Visitors were 88% Caucasian, 6% Hispanic, 4% Asian, and 2% Indian.

A message to visitors that they might be observed and/or interviewed for feedback on the new presentation was projected on a wall visible at entrance of the exhibit.

For the purposes of evaluation, the program was portioned into 12 thematic sections. This division into 12 sections allowed evaluators reference points to note when a visitor entered and also exited the viewing area, and did not represent actual segments in the program. In other words, evaluators determined when one section ended and the next began, and the visitors were unaware of this scheme.

Evaluators noted at what point in the program a visitor entered the exhibit and how many of the 12 sections the visitor watched. Visitors were also observed for certain behaviors during the

program including sitting or standing, circling or remaining stationary, pointing and talking about the program or the exhibit.

Findings

Forecast: Tropical Cyclones—Content and Message

A main goal of this phase of formative evaluation was to test the video's ability to convey the intended content and main messaging. Visitors' understanding of the content and main message of a program is critical in creating a successful interaction between exhibit and visitor. In order to assess this, visitors were asked an open-ended question about what they thought this exhibit was trying to show. Visitor responses were coded into five main themes, one "other" and one "don't know" theme. These responses were compared to the intended main messages:

1. People have been trying to predict tropical cyclones for a long time.
2. There have been significant advances in how people study Tropical Cyclones since the days of only shore-based and shipboard observations.
3. Climate models are the newest tools being used to help make forecasts more accurate.

Content

About a third (30%) of visitors surveyed reported that the program was about history, technological advancements, or systems used in understanding, tracking or predicting storms or the weather (Table 1). About half (48%) said the exhibit was either about the weather (26%) or storms (22%) without being much more specific. One quarter (24%) of visitors said the exhibit was about cyclone or storm formation. A small group (14%) talked about forecasting and predicting, but related to storms or the weather in general.

Table 1: Visitors Thought Exhibit was Trying to Show (n=50*)

	Percent of Visitors
Advancements/Progress/Technology	30%
Weather	26%
Storms	22%
Storm Formation	20%
Forecasting/Predicting weather or storms	14%
Other	8%
Don't know	4%

*Percentage totals more than 100 because multiple responses were possible.

Message

Visitor responses were also coded to assess whether a visitor was able to correctly relay what the program was trying to show. A response that mentioned cyclones (or some other version of these extreme storms) as well as some aspect of the history, advancements, or technologies involved in predicting these storms, was coded "yes" and considered to have articulated the main message of the program (Table 2). Responses containing only one of these elements were coded as "partially" relaying the message. Responses like "the weather" were coded "no." Also of

note when considering the effectiveness of the programs message is that only eight visitors (16%) watched the program in its entirety.

More than a quarter (28%) of the responses said only that the program was about the weather or weather patterns around the globe and did not express the program message. About half (46%) of visitor responses partially reflected the main message of the tropical cyclone program. Just over a quarter (26%) of the responses reflected the message of the program identifying both that the video was about cyclones, hurricanes, typhoons or extreme storms, and the ways in which humans have come to predict them (see the appendix for complete visitor responses). Although a number of visitors mentioned prediction and forecasting, no visitor interviewed used the word "model." While this may be a matter of semantics, developers have repeatedly mentioned the necessity of observations, theories, and models for accurately predicting tropical cyclones.

Table 2: Visitor Correctly Relaying Message of Video (n=50)

	Percent of Visitors
Partially	46%
No	28%
Yes	26%

Visitor Suggestions for Change

In formative evaluation, one way to identify elements of exhibitions or productions that visitors find confusing or unclear is to ask them what they would change to improve the production. Since SOS is a relatively new and novel medium, many of the comments are about the medium and not the specific production. All suggestions, pertaining to the show and the sphere, are reported here. Following our usual protocol for open-ended questions, we coded responses using an open, iterative coding scheme where codes and themes emerge from the data. Four themes emerged from the responses, with the vast majority of suggestions (85%) focusing on the video content or production (Table 3).

Nearly half (46%) of visitors surveyed made suggestions for changing the content of the video including fewer animated images, better placement and distribution of screen images, as well as a better indicator of where one was (beginning, middle, end) during the program. Two fifths (39%) of responses concerned how the information was presented. These included suggestions to turn the globe or rotate the content being shown (already planned for the final production), as well as projecting text of the program on an adjacent wall (see appendix for complete visitor responses).

Table 3: Changes Suggested by Visitors to SOS Presentation (n=26*)

	Percent of Visitors
Video content	46%
Video presentation	39%
Exhibit environment	19%
Video audio	15%

*Percentage totals more than 100 because multiple responses were possible.

Interest and Enjoyment

In informal learning environments where learners are free to choose whether or not they interact with exhibits and other learning media, holding visitors' interest and providing enjoyable content is of the utmost concern. Fifty visitors rated the program on both level of interest and level of enjoyment. Well over four fifths (88% for interest and 84% for enjoyment) of visitors surveyed rated the program as both interesting and enjoyable (Tables 4 and 5). No visitor gave the program the lowest ratings (not at all interesting or not at all enjoyable). However, it is important to note that only visitors who stayed more than 30-seconds were interviewed. It is reasonable to conclude that many of those visitors, 43% of those observed, who stayed less than 30-seconds did not find the program interesting or enjoyable.

Half (50%) of all visitors surveyed said that they were so interested they would come see the program again. A little over a tenth (12%), stated that they were not really interested.

Table 4: Interest in SOS Cyclones Presentation (n=50)

	Percent of Visitors
I was so interested; I'd come see it again.	50%
I was interested, but I would not come see it again.	38%
I wasn't really interested.	12%
I didn't find this interesting at all.	0%

In terms of enjoyment, over a third (36%) rated the program as so enjoyable they would encourage others to see it; while about half (46%) stated it was enjoyable. The smallest group (16%) of visitors surveyed said they did not really enjoy the program.

Table 5: Enjoyment of SOS Cyclones Presentation (n=50)

	Percent of Visitors
It was so enjoyable; I'd encourage others to come see it.	36%
It was enjoyable.	48%
I didn't really enjoy it.	16%
I didn't find this enjoyable at all.	0%

Entry Points

The program was divided into 12 thematic segments (Table 6) to facilitate observation. Evaluators noted the segment that was playing when visitors began watching the program and which segments of the program they stayed to watch.

The largest cluster (14%) of visitors surveyed entered the SOS cyclones program at the beginning, *Storm Names*, at part 2, *New Devices*, and at part 5, *Storm Tracks* (Table 6). The next largest group, a tenth (10%) began watching the program at part 10, *Model and Satellite*. Otherwise, visitor entry points were distributed throughout all parts of the program with the exception of part 12, *Forecasting*, where no visitors were observed to have begun watching the program. Since a continuous random sampling method was used, visitors' entry times should have been proportionally distributed throughout the segments, but they were not. Chi-squared

analysis of visitor entry point indicates that the distribution of visitors is significantly different than would be expected based on the length of each segment. Since visitors who did not stay longer than 30-seconds were not approached for an interview, this indicates that some segments may be better at keeping visitors engaged with the program than others. Some of this effect can be attributed to the structure of the video, if visitors entered during Part 12 (a section less than the 30-second threshold) at the end of the presentation it is reasonable to think that these visitors would be less inclined to stay than visitors who entered the exhibit earlier in the program. Seeing the end of the presentation, when many other visitors choose to leave may be a powerful disincentive to stay at the sphere for the program to start again. However, other results are not explained so easily. For example, Part 10 – Model and Satellite is the shortest section by far (only 9-seconds), yet one tenth of visitors who stayed longer than 30-seconds watched this section first.

Table 6: Thematic Segments of the Program & Visitor Entry Points (n=51)

Segment	Running Time	Segment Time	% of Video	Entry Points % of Visitors
Part 1 – Storm Names	0-0:53	53 seconds	12 %	14%
Part 2 – Taino	0:54-1:42	48 seconds	10 %	14%
Part 3 – Observing Storms	1:43-2:48	65 seconds	14 %	8%
Part 4 – New Devices	2:49-3:14	25 seconds	5 %	6%
Part 5 – Storm Tracks	3:15-3:45	30 seconds	6%	14%
Part 6 – Satellite Era	3:46-4:03	17 seconds	4 %	4%
Part 7 – Understanding Storms	4:04-4:48	44 seconds	10 %	8%
Part 8 – Inside a Tropical Storm	4:49-5:54	65 seconds	14 %	8%
Part 9 – Modeling Storms	5:45-6:41	56 seconds	12 %	8%
Part 10 – Model and Satellite	6:42-6:51	9 seconds	2 %	10%
Part 11 – Predicting	6:52-7:22	30 seconds	6 %	8%
Part 12 – Forecasting	7:23-7:46	23 seconds	4 %	0%

Entry Point and Interest

Visitors who rated the SOS cyclone program as 'so interesting I would see it again' (high interest visitors) entered the program at all but two points: part 6 and part 12 (Table 8). Otherwise, this group's entry points were fairly well distributed from the beginning to part 10. The fewest number (4%) of high interest visitors entered just before the end of the program at part 11. High interest visitor entry points were distributed evenly between the first half and the second half of the program.

Visitors who rated the program low on the interest scale (low interest visitors) came in primarily at the first half of the program. None of these visitors had an entry point corresponding to parts 9 and 10, the only consecutive parts where no low interest visitors entered. Four of the six visitors (67%) who reported that they were not really interested in their exhibit experience entered in the first half of the cyclone program.

Table 8: Entry Point and Interest (n=50)

	Percent of Visitors		
	High (n=25)	**Medium (n=19)**	**Low (n=6)**
Part 1 – Storm Names	12% (3)	16% (3)	17% (1)
Part 2 – Taino	12% (3)	16% (3)	17% (1)
Part 3 – Observing Storms	8% (2)	5% (1)	0
Part 4 – New Devices	8% (2)	0	17% (1)
Part 5 – Storm Tracks	12% (3)	21% (4)	0
Part 6 – Satellite Era	0	5% (1)	17% (1)
Part 7 – Understanding Storms	12% (3)	5% (1)	0
Part 8 – Inside a Tropical Storm	8% (2)	5% (1)	17% (1)
Part 9 – Modeling Storms	12% (3)	5% (1)	0
Part 10 – Model and Satellite	12% (3)	11% (2)	0
Part 11 – Predictions	4% (1)	11% (2)	17% (1)
Part 12 – Forecasting	0	0	0

Entry Point and Enjoyment

Visitors who said the video presentation was so enjoyable they'd recommend it to others (high enjoyment visitors) were distributed more evenly across the twelve sections than were visitors who rated it as not really enjoyable (low enjoyment visitors) (Table 12). The high enjoyment crowd entered and began watching the program at all but three parts (6, 11, and 12). An equal number of these visitors, representing the three largest chunks of this group, about a fifth (17%) each, entered and began watching the cyclone program at three varied parts: the beginning, the middle (Part 5 – *Storm Tracks)*, and the end (part 10 – *Model and Satellite)*.

The low enjoyment crowd had fewer entry points with none of this group entering the SOS exhibit at consecutive parts 4 and 5, and 7, 8 and 9. Of the eight visitors in this group, about two thirds (63%) entered during the first half of the cyclone program, and half (50%) entered at the beginning three consecutive parts.

Table 12: Entry Point and Enjoyment (n=50)

	Percent of Visitors		
	High (n=18)	**Medium (n=24)**	**Low (n=8)**
Part 1 – Storm Names	17% (3)	8% (2)	25% (2)
Part 2 – Taino	11% (2)	17% (4)	13% (1)
Part 3 – Observing Storms	6% (1)	4% (1)	13% (1)
Part 4 – New Devices	11% (2)	4% (1)	0
Part 5 – Storm Tracks	17% (3)	17% (4)	0

Part 6 – Satellite Era	0	4% (1)	13% (1)
Part 7 – Understanding Storms	6% (1)	13% (3)	0
Part 8 – Inside a Tropical Storm	11% (2)	8% (2)	0
Part 9 – Modeling Storms	6% (1)	13% (3)	0
Part 10 – Model and Satellite	17% (3)	4% (1)	13% (1)
Part 11 – Predictions	0	8% (2)	25% (2)
Part 12 - Forecasting	0	0	0

Time Spent at the Exhibit

Time spent at the exhibit is one measure of visitors' interest in the film. In a society where people perceive that they are 'running out of time,' free time becomes a valuable commodity (Godby, 2001). Although time spent at an exhibit cannot be equated to learning in any definitive way, it is nonetheless an important measure of the effectiveness of an exhibit or program. Watching patterns varied widely from visitors who did not watch any full segments, to those who watched several sections, to those who watched the entire show more than once. Of the 94 visitors observed, 8 watched the entire 7 minute, 46 second program. Visitor time spent watching *Forecast: Tropical Cyclone* ranged from 4 seconds to 15:39 minutes (Figure 1). The median time was 1:01 minutes.

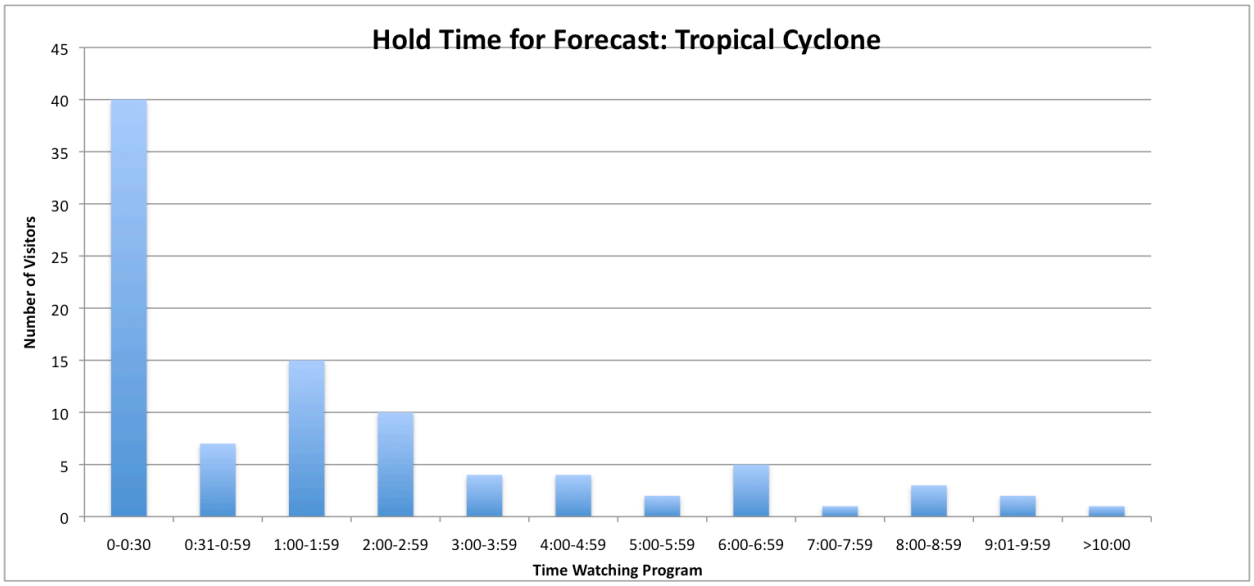

Figure 1: Visitors and Time Spent at the SOS Cyclone Program

Because the show was continuously running during formative evaluation, visitors did not necessarily begin watching the show at the beginning. The following graph shows the percentage of visitors who were present at any of the twelve parts of the program. Over half of visitors surveyed watched parts 5 through 11 with the highest number of visitors, over half (56%), present for parts 7 and 8 of the program (Figure 2). Less than half (44% to 46%) of visitors were

present for parts 2, 3, 4 and 12, with the fewest number of visitors, only two fifths (40%), present for the beginning of the program.

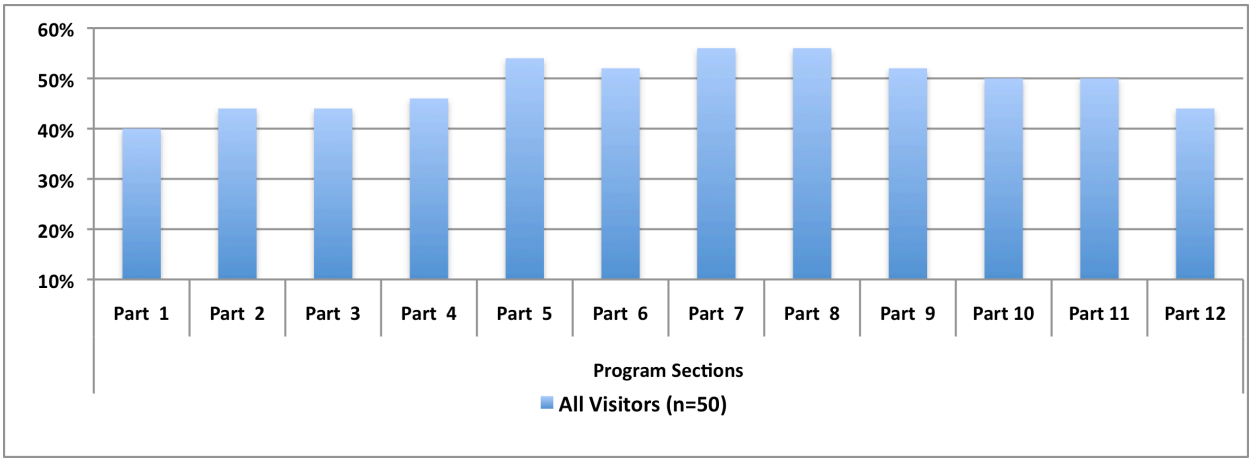

Figure 2: Visitors and Parts of Program Viewed

Interest, Enjoyment, and Viewing Patterns

Because different visitors viewed different sections of *Forecast: Tropical Cyclones*, their levels of interest and enjoyment could be correlated with the sections of the show they viewed. Since this program is longer than the 6-minute presentation specified in the grant proposal, these comparisons may be useful for paring down this test version of the program.

Twelve Parts and Interest

Visitors who rated the program as "so interesting I would watch it again" (high interest visitors) saw more of the second half of the program than did visitors who said they were "not really interested" (low interest visitors) (Figure 3). Roughly half (48%) or more of high interest visitors viewed parts 8 through 11 (Figure 2). Only about a third (32% to 36%) were present for the beginning parts 1, 2 and 3. The part most viewed by over half (56%) of the high interest group was part 9, *Modeling Storms*.

Half (50%) of the low interest visitors were present for parts 2 through 7. After this, the number of low interest viewers fell off significantly with no more than a third (33%) present for sections 8 through 12, and an even smaller number (17%) present for parts 9 and 10.

Twelve Parts and Enjoyment

Over half (56%) of visitors who rated the program as "so enjoyable I would encourage others to see it" (high enjoyment visitors) entered the SOS exhibit at or before part 7 and stayed through the end of the program (Figure 4). Two thirds (67%) of these high enjoyment visitors were present from part 8, *Inside a Tropical Cyclone* through part 11, *Predictions*. Almost three quarters (72%) were present for parts 10, *Model and Satellite* and part 11, *Predictions*.

Visitors who said they "did not really enjoy it" (low enjoyment visitors) were spread out across the program with just about two thirds (63%) of them present for parts 2 and 3, parts 6 and 7, and parts 11 and 12. Half (50%) of the low enjoyment visitors watched parts 4 through 8, but did not finish the rest of the program. In contrast to the high enjoyment visitors, the fewest number

of low enjoyment visitors were present at parts 8 through 10, an area of great concentration for high enjoyment visitors.

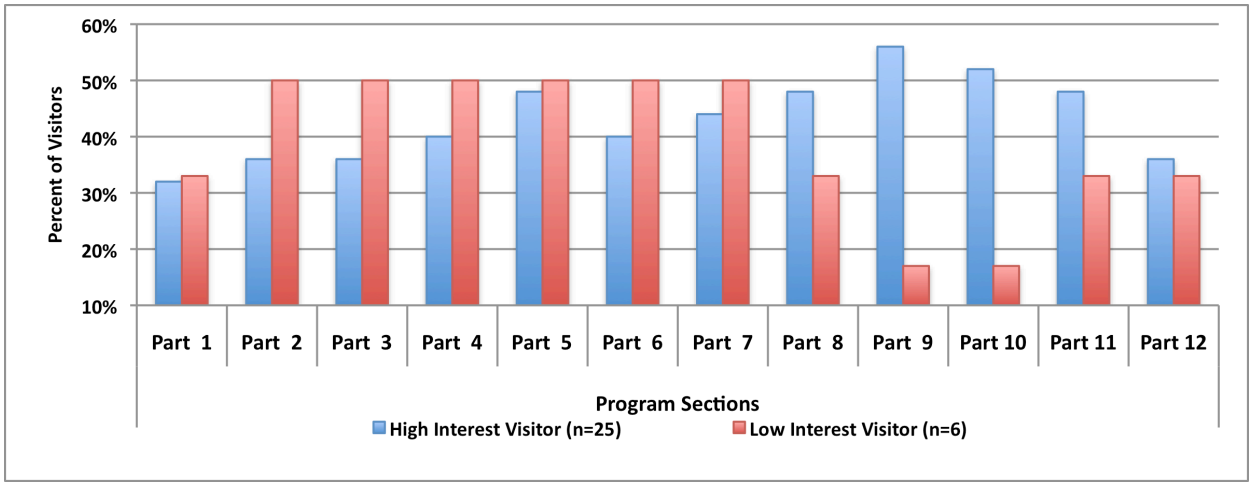

Figure 3: Sections of Program Viewed and Visitor Interest Rating

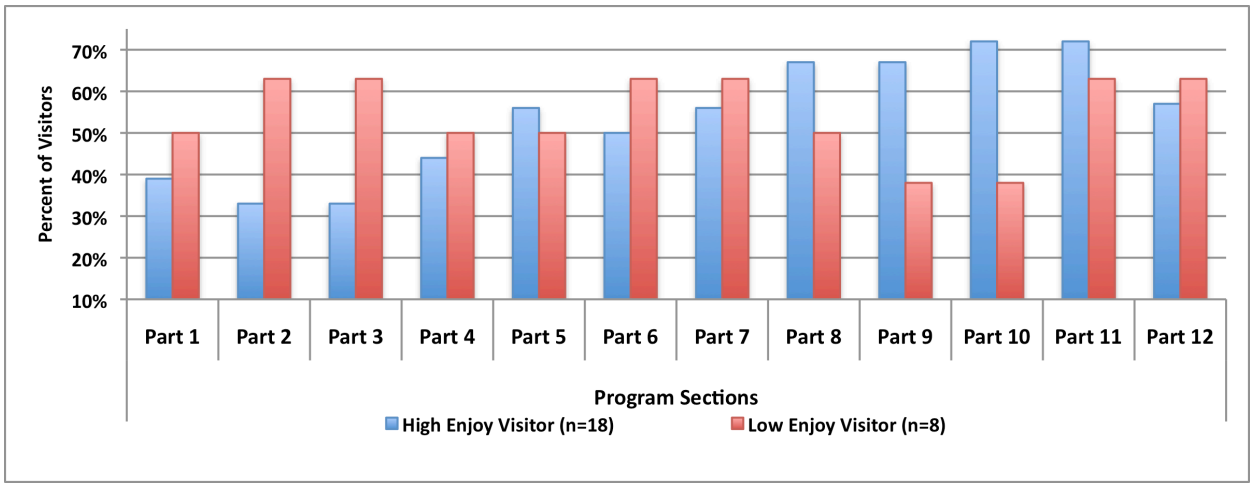

Figure 4: Section of Program Viewed and Visitor Enjoyment Ratings

Visitor Interaction with SOS Exhibit

Positioning and Behavior at Sphere

The SOS exhibit is a large spherical screen suspended in the middle of a room with four projectors discretely located at four congruent points around the sphere. Projectors are high enough so that people passing around the sphere do not interfere with the projection. Benches and chairs were placed around the sphere at intervals allowing room for people to either sit or stand without obstructing the view of each other. Additionally there is a floor puzzle of the earth

provided for small children in an effort to encourage older members of their groups to watch films on SOS for longer periods of time.

It has been observed that visitors who sit at an exhibit stay longer than visitors who stand (Reference study here). Evaluators observed where visitors positioned themselves by noting whether they sat or remained standing, whether they watched the presentation in a stationary position, or whether they circled the sphere and to what extent the sphere was circled.

Nearly three quarters (73%) of visitors stood or sat without walking around the sphere (Table 1). About a fifth (18%) circled less than half the sphere before sitting or standing to view the presentation. The remaining tenth of visitors circled half or more of the exhibit with only a small number (6%) of observed visitors circling the entire sphere. This pattern emphasizes the need to rotate the image on the globe if the entire image should be observed, or duplicate images so they can be seen from all positions.

Table 13: Visitor Positioning at Science on a Sphere Exhibit (n=51)

	Percent of Visitors
Stood or sat in one place	73%
Circled less than half the exhibit	18%
Circled half or more of the exhibit	4%
Circled the entire exhibit	6%

What do visitors do as they watch *Forecast: Tropical Cyclone* on SOS? Evaluators noted the presence or absence of three behaviors: talking about the content on the sphere, talking about the technology of the sphere, and pointing at the sphere. A quarter of visitors (26%) pointed at the sphere. Although we attempted to record instances of visitors' talk, visitors often spoke too softly to be heard so these findings are compromised and will not be reported.

SOS Exhibit Technology

Because of the novelty of the sphere as a medium for projecting programs, many visitors have questions about the sphere and the technology that runs it. These questions are important to document because these sorts of questions can hinder visitors' ability to focus on the programs presented on the sphere. Visitors' questions about the SOS exhibit can be grouped into four categories. The most frequent questions dealt with how the video was projected (52%), and one third (33%) wanted to know more generally how the exhibit worked (Table 15). Another quarter (24%) of visitors were unsure and wondered about the role of the sphere itself, asking questions like "Was the globe a green screen?", and other questions about whether the projection emanated from within or out of the sphere. Visitors also wondered if other people were seeing something they were not. (See appendix for a complete list of responses.)

Table 15: Visitors Want to Know about Technology of Exhibit (n=21*)

	Percent of Visitors
How it is projected	52%
How it works	33%
Role of the sphere	24%

Other	10%

*Percentage totals more than 100 because multiple responses were possible.

Conclusion

The SOS Exhibit program *Forecast: Tropical Cyclones* engaged the visitors interviewed (those who stayed for more than 30-seconds) for a median time of 2 minutes and 46 seconds. In the entire sample of visitors observed (including those who watched less than 30-seconds) the median time spent watching the program was 1 minute 2 seconds. Of the visitors observed, about two fifths (43%) stayed for less than 30-seconds, and 16% stayed for less than 10-seconds. Although the vast majority of the visitors interviewed reported positive ratings for both interest and enjoyment, a large portion of the sample left before they qualified to be interviewed. Eight visitors (9% of all visitors observed and 16% of the visitors interviewed) observed stayed to watch the entire program. However, those who watched the entire program did not show any different rates of interest or enjoyment than did the entire sample of visitors.

Interest and enjoyment rates correlated with particular sections of program viewed. Visitors who rated the program as highly interesting were grouped mostly at program parts 9 - *Modeling Storms*, and 10 - *Model and Satellite*. Visitors who rated the program as highly enjoyable were grouped mostly at program parts 8, *Inside a Tropical Storm*, 9, 10, and 11, *Predictions*.

In contrast, visitors who rated the program low for both interest and enjoyment were grouped at earlier parts of the program, parts 2, *Taino* through 7, *Understanding Storms*. Ratings for interest and enjoyment appear to be delineated by parts 7 and 8 with higher rates of interest and enjoyment reported by those present for the latter sections of the program.

Comments and suggestions for change were mainly in regard to content. Visitors did not like the animated images in the program, some of which appear, among other places, at the beginning of part 7. Visitors commented on their inability to distinguish where they were in the program. This confusion may have contributed to visitors walking away from the exhibit unsure of the amount of time they would need to invest in the presentation.

Visitors also expressed confusion over the content projected around the sphere and were unsure if they were missing something. Some wondered why the globe or the projection on the sphere did not rotate. Many visitors were unfamiliar with the exhibit and expressed some confusion at the new experience. A few visitors suggested signage in the exhibit area, or a projection on one of the flat walls in the exhibit area where one could read text related to the program or access other useful information, such as a measure of how far along they are in the program.

Finally, it should also be noted that the SOS exhibit itself leaves many visitors with a feeling of wonderment. While some have a good idea of how it works, others are perplexed and marvel at it. Most come away from their experience unsure of how it works but impressed by the ability to project a seamless video around a sphere screen.

Recommendations

Forecast: Tropical Cyclone was well received by visitors to The Science Museum of Minnesota who watched more than 30-seconds of the program. Although the program received high marks for interest and enjoyment, most visitors did not watch the entire program and the parts of the program watched affected visitors' levels of interest and enjoyment. Visitors who saw the second

half of the program were more likely to rate the program highly interesting and highly enjoyable than those who watched the first half of the program. This finding suggests that future iterations of the program should emphasize the themes of the second half more strongly and spend more time focusing on these topics at length. Another possible shift would be to present the story 'backwards' starting with the current state of forecasting tropical cyclones and then looking back to the historical methods since those part of the video were less popular than the sections about current forecasting methods.

Focusing more on the second section of the program may also help visitors articulate the main messages of the program. Only one quarter of visitors were able to correctly articulate the main messages. Another half of visitors were able to partially communicate the main message. A stronger focus on the main messages, which are addressed more explicitly in the second half of the program, would help visitors' comprehension.

One section of the video that could use further explanation is Part 10 – Model and Satellite (the section where the model output is juxtaposed with the satellite data). This section is the shortest in the program (only 9 seconds), yet a disproportionate percentage of visitors who stayed more than 30-seconds started watching during that section. Additionally, almost three quarters of the high enjoyment visitors saw this segment. However, evaluators who watched the segment multiple times noted that this section was difficult to 'see.' The narrator says "notice how well the tropical cyclones produced by the model match satellite views of the real storms," yet after repeated viewings it is still difficult to focus on a spot on the globe where the satellite view meets the model output and watch long enough to see something that looks very similar. Lengthening the time visitors have to compare the two visualizations would help highlight the accuracy of weather models. It would also be helpful in this section for the program to draw attention to areas of the globe to look at where satellite views and model output are particularly similar. One way of doing this would be to play a loop of the visualization where visitors are shown spots on the globe to look at and are then shown the same phenomenon again.

Visitors who watched the first three sections were less likely to rate the program as highly interesting or enjoyable, and some of the negative comments were explicitly about these sections. One visitor referred to the early graphics as "clip art," and another visitor requested less animation and more satellite imagery. In addition to visitors' comments about the early sections, there are concerns among the evaluators that the depiction and portrayal of the Taino people both as somewhat disfigured animations, and as 'less than' the later Western scientists may be perceived as offensive. We recommend significant revision of this section. Additionally, Parts 2 and 3 are disproportionately long (combined, they represent 24% of the program).

Additionally, the program refers to the models that predict tropical cyclones as "climate models" when they are really weather models not climate models. Also, in US English modeling is spelled with one 'l,' modelling is the British English spelling.

In summary, we recommend a restructuring of the program that focuses the content of the video and emphasizes the modern work and the more recent advances in satellite and model technologies. Focusing on changes and advances in the last 40 years would be a worthwhile and ambitious goal for a six-minute program and such a program would concentrate on the parts of the current iteration that was most well received by visitors.

References

Godby, G. (2001). The use of time and space in assessing the potential of free-choice learning. Falk, J., H., Donovan, E., & Woods, R. (Eds.) *Free-Choice Science Education: how we learn science outside of school. New York: Teachers College Press*.

Appendix

What do you think this exhibit is trying to show?

Advancements, progress, technology (n=15)

- Science/technology behind tracking storms.
- The advancements in weather predictions.
- Systems to figure it [weather and typhoons] out.
- Get better predictors to warn people.
- How we can use satellite data to forecast storms.
- How we have come to predict them [tropical storms].
- Using science to track hurricanes, how it has changed from early times to now and satellite use.
- Technology being able to predict weather.
- Satellites.
- Know history and progress of predicting weather patterns.
- How they've captured information on where cyclones will hit.
- How we are now able to predict storms before they hit land.
- How we learn about [it] and the tools that we use.
- Technology changes as far as the weather is concerned.
- History forecasting storms.

Storm Formation (n=10)

- How hurricanes form.
- Cyclones. How it develops from the beginning to the end.
- How and why cyclones form.
- How tropical storms work and how we have come to predict them.
- How the earth's atmosphere produces cyclones.
- About how storms form, more information about these tropical storms.
- How storms work
- How strong storms develop.
- How storms are formed.
- Conditions of storm.

Storms (n=11)

- Tropical cyclones.
- Typhoons.
- Tropical cyclones.
- Storms.
- Hurricanes.
- The cyclones and tropical storms starting in the ocean.
- Hurricanes and currents throughout the world... It was really thought out.
- Information about storms.
- Hurricanes, cyclones.
- Tropical cyclones.
- Storm cyclones.

Weather (n=13)

- Weather. (3)
- How weather works.

- Weather patterns. (3)
- Weather patterns over ocean.
- Weather patterns on the earth.
- Earth and weather.
- To explain, overall, how global weather works. How weather on one part of the world affects another part.
- How weather is affected.
- How the stuff happened, when kids weren't here. How the weather happens.

Forecasting/Predicting (n=7)

- Weather forecasting.
- World weather forecasting.
- How to forecast weather.
- Predict weather.
- Predict future weather and changes in weather and climate. Predicting extremes.
- How we are predicting weather.
- How they predict cyclones.

Other (n=4)

- Don't know.
- Don't know.
- Climate change.
- Climate change. How [it] affects people all over the world.

Did the visitor correctly relay what the video was trying to show?
Yes (n=13)

- The advancements in weather predictions and storm cyclones.
- How they predict cyclones.
- Educate you on weather and typhoons, and systems to figure it out.
- Weather patterns, how strong storms develop, get better predictors to warn people.
- How and why cyclones form, and how we can use satellite data to forecast storms.
- How tropical storms work and how we have come to predict them.
- Using science to track hurricanes, how it has changed from early times to now and satellite use.
- Weather patterns. How storms are formed, and how we are predicting weather.
- Hurricanes and currents throughout the world and satellites. It was really thought out.
- How they've captured information on where cyclones will hit.
- How we are now able to predict storms before they hit land.
- Predict future weather and changes in weather and climate. Predicting extremes.
- History, forecasting storms, conditions of storm.

Partial (n=23)

- Know history and progress of predicting weather patterns.
- Tropical cyclones.
- How hurricanes form.
- Science/technology behind tracking storms.
- Weather forecasting.
- Weather patterns, how storms work.
- Weather patterns over ocean.
- Cyclones. How it develops from the beginning to the end.

- Tropical cyclones.
- World weather forecasting.
- How to forecast weather.
- Storms.
- Hurricanes.
- How the earth's atmosphere produces cyclones.
- The cyclones and tropical storms starting in the ocean.
- Predict weather.
- Technology being able to predict weather.
- About how storms form, more information about these tropical storms.
- Information about storms.
- Hurricanes, cyclones.
- How weather is affected and how we learn about, and the tools that we use.
- Technology changes as far as weather is concerned.
- Tropical cyclones.

No (n=14)

- Weather.
- Don't know.
- Weather.
- How weather works.
- The weather.
- Don't know.
- Weather patterns on the earth.
- The global effect of whatever program is being shown at the time.
- Climate change.
- To explain, overall, how global weather works. How weather on one part of the world affects another part.
- Climate change. How [it] affects people all over the world.
- Eye catching. Gives an easier way of showing the whole globe at one time.
- Earth and weather.
- How the stuff happened, when kids weren't here. How the weather happens.

Is there anything we can do to better help you understand what you are viewing on the sphere?

Video Content (n=12)

- Diagrams are good.
- Likes satellite images rather than cartoons/animations.
- Definition of cyclone/hurricane/typhoon should be more clear. The fact that they are the same should be more clear.
- Didn't know where I was in the program. In the middle? At end?
- Sometimes there are different images projected on all sides of the sphere at once and you can't see it all even if you walk around. Don't like that.
- Show where the strongest storms have occurred on Earth.
- Less animated clip art.
- When showing the hurricane god depiction spinning, it's spinning the wrong way. Well, it's spinning the way storms in the Southern hemisphere would spin. Most people viewing this are from the Northern hemisphere. 2) "Inside a Tropical Storm" section should have bigger downward arrows in the center. It looks like just a bunch of upward moving air, but the "eye" of a storm is created by that downward travelling air. 3) We think of colors as temperatures.

In the "Observing Storms" section, the ocean is all shades of blue, which implies cool. This is not the case. There are warm spots in the ocean. 4) "Climate Model" equals long-term forecast (months and years). When we think of "forecast" we think five to seven days. This is called a "weather model," not a "climate model."

- 1) Start with some background knowledge on what is being shown on the screen. 2) Have a more clear beginning and end, some signal that this is the beginning or end.
- They talked about boats in the beginning but we did not see any boats until just the end of that part.
- Alternating a brief of the movie with the entire movie to allow those with little time to see it to assess it for staying or not.
- Indication of where it's at in the video. Middle? End?

Video Presentation (n=10)

- Turn it slowly; get the view of the whole thing. I guess the video would have to follow. [Visitor seemed to suggest that this might be more difficult to do.]
- If straight projection on wall could describe what was being talked about.
- Spin it a bit. I'm tired and didn't walk around. Lower.
- It would be nice if it rotated halfway so you wouldn't have to get up to see what's on the other side.
- I'm deaf. It's not very accessible for me. Is there a way you can project some words?
- Take advantage of the globe.
- Wondering what other people would see on the other side.
- Thought we sat in the wrong spot. Maybe more was going on at other parts of the screen.
- If we didn't have to walk around.
- North America seemed too high on the globe. Maybe make the globe lower. I was more interested in North America, I guess.

Exhibit Environment (n=5)

- Maybe some signage. Tell people what it is.
- Area is too closed off and outside activities were distracting so didn't want to stay and view the video.
- Signage would be nice.
- Explained really well. Mentioned the inside of a cyclone--make more interactive.
- Better signage to let you know you need to walk around.

Video Audio (n=4)

- Have sound system placed in a manner where the sound comes at you instead of behind you.
- The person's voice was not so engaging.
- Didn't feel the images were connecting with the audio.
- Not loud enough.

Interview question #4: Is there anything that you would like to know about the technology of this exhibit?

How it works (n=7)

- How it is done.
- How it works.
- How you make it a circle and have a video on it.

- What really is it?
- How they do it?
- How to wrap a circle. Physics of it.
- It is so cool. How is it done?

How it is projected (n=11)

- Figured it was a projection or something.
- How is it projected?
- How it is projected.
- How the image is projected onto the screen.
- Technology of the projection.
- Where is the projector?
- Does it project on all surfaces or same picture on both sides?
- How they do projection on a globe.
- Where are the pictures coming from? Inside or outside?
- Pictures from the inside out?
- How did they match so well?

Role of the sphere (n=5)

- I was curious about how the display worked.
- This is particularly impressive, the map. [Visitor pointed to the sphere.]
- Were other people seeing something I wasn't seeing?
- Green screen?
- Is the globe a screen?

Other (n=2)

- Are the 3D glasses for the movie or the wall?
- Everything--based on satellites. [He went on to talk about the technology of predicting storms, not the exhibit.]