Bringing the Planetarium to Earth

Summative Evaluation of the Worldviews Network Project

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Executive Summary

Background

The Worldviews Network is comprised of institutions trying to create an innovative approach for engaging the public with topics of human-induced global change. The project's approach sought to 1) leverage the power of immersive environments within informal science institutions (ISIs), such as planetariums and portable domes, by 2) incorporating visualizations of scientific data sets about relevant social-ecological issues as they relate to "planetary boundaries," framed by 3) a systems-based narrative approach that incorporated cosmic, global, and local perspectives on the issues. The project sought to produce a set of products, programs, and actions:

- Creation of Digital Assets (Visualizations and Storyboards)
- Professional Development Program for Informal Science Educators (PD)
- Production of Bioregional Community Dialogue (BCD) Events at each ISI
- Engage Scientific and Community Organizations for Future Action

Summative evaluation was designed to address four overarching questions about the process, outcomes, and generalizable lessons from the three-year experimentation with this model:

1. To what extent were short- and medium-term outcomes achieved with each of the target audiences: ISI professionals, advisors, and members of the public?
2. In what ways did the Worldviews Network process, approach, and model work well to support ISI professionals and public audiences in achieving these goals? In what areas could the model be further strengthened?
3. How have the processes, strategies, and approaches promoted by the Worldviews Network been sustained within institutions after the project?
4. How did contextual factors at each ISI site relate to or influence implementation, outcomes, and sustained change?

Summative evaluation used a multiple-case study approach. This methodology allowed the collection of both qualitative and quantitative data from a variety of stakeholders connected to each ISI in the Network. The analysis allowed for findings at two levels: 1) a portrait of the nuanced process and outcomes within each Network site, and 2) a cross-case analysis of all eight sites, which results in generalizable conclusions about the outcomes and efficacy of the Worldviews model as a whole. Methods used included interviews (with Leadership, staff at ISIs, and advisors), web surveys (of staff at ISI and advisors), questionnaires at events, event observations, and project management document analysis.

Overview of Worldviews Event Development Process

Looking across the eight ISI cases within the Worldviews Network, a generalized process for the project emerged, which is important context for understanding the findings of the study:

1. **Leadership Kicks-Off Production Process with the ISI.**
    a. ISI Defines the Topic.
    b. Leadership and ISI Begin the Story Outline, using the "cosmic-global-local" story framework and models from prior Network storyboards.

c. Leadership and ISI Identify Potential Advisors or Sources

2. **The Team Involves Outside Advisors to help:**
    a. Shape the Story
    b. Provide Story Information, Fact-checking, or Background
    c. Provide Data for Visualizations
3. **ISI Takes Responsibility & Leadership Identifies and Fills Gaps to Create Final Result**:
    a. Event Logistics
    b. Content (when content advisors were difficult to identify/involve)
    c. Technical Troubleshooting
    d. ISI Staff Coordination/Point-Person Role
4. **The BCD Event:** Dome presentation (data visualizations with live narration based on the script/storyboard); one to three presenters. After the presentation, some events had Q&A sessions, some held discussion groups, and some did not have formal audience interaction.
    a. Audiences – Some events focused on specifically invited stakeholder groups (while also being open to some interested members of the public). Other events were primarily open to the public, with a list of community stakeholders receiving specific invitations (but the majority of the audience was general public).
    b. Presenters – Usually ISI staff gave part or all of the presentation. In a number of cases, members of the Leadership Team co-presented with the ISI rep.
    c. Dialogue – Seven events included post-presentation dialogue/discussion sessions.

Key Findings

Audience Outcomes

- **Learning Ecological Content:** 93% of audience survey respondents reported they learned something new at the BCD Event. Most reported learning about key ecological concepts– either general facts, changes occurring over time, or the expansive scale of ecological systems. Another main area was audiences' understanding of human interactions with natural systems.
- **Main Takeaways of Understanding, Visualizing, and Perspective:** In a closed-ended item to measure individuals' three primary thematic connections with the presentations, four items were the most pervasive takeaway messages, each of which relates to important project goals. These results differ quite substantially from those collected from Science On a Sphere® (SOS) Network sites in previous evaluation:
    - Thinking about the complex interrelations in Earth systems (41%)
    - Visualizing certain concepts of time and scale (35%)
    - Learning or being reminded how the Earth is always changing and evolving (28%)
    - Feeling a sense of how small the Earth is compared to the greater universe (27%)
- **Evidence of Feeling Responsibility:** In this same question, the two statements that were most frequently ranked as the #1 takeaway by audiences were *thinking about complex interrelations in Earth systems* (15%) and *feeling a need to take better care of the Earth* (13%). Those who selected the latter item tended to experience that message very strongly. Again, these results different from prior results of visitors to SOS programming, indicating some distinct impact of the Worldviews Network model.

- **Influence of the Dome on Reaction:** More than three-fourths of respondents (79%) reported the dome changed the way they understand the material; these focused mainly on the visual aspect of the environment in "giving perspective" or that it helped to see the visuals.
- **Mixed Emotional Reactions:** In the last four events, visitors reported how the show made them feel, and reactions indicated substantial diversity in reactions. While some connected to positive messages of hope for change, others were affected by feelings of concern and the overwhelming scale of problems, while still others focused on the neutral feeling of having learned more about an issue.
- **Like the Visuals and the Speakers:** Of the 86% of visitors who indicated what they liked about the presentations the visuals/images were most mentioned, followed by the quality of the presenters. **Suggested Improvements** were made by 60% of respondents, focused on specific improvements for a particular show. Audiences were most concerned about content that could have been added or clarified, how visual images could be improved, and technical glitches that occurred. These suggest areas for future productions to focus energy on polishing in advance of a public event.

ISI Partner Outcomes

- **Collaboration:** The most common ISI outcome, mentioned by five of the eight ISI sites, was engaging and developing new collaborations with outside institutions or partners – community advisors and the Leadership Team. Two sites indicated that cross-departmental collaboration was a significant outcome, which was notable for departmentally "siloed" institutions.
- **Technological, Content, and Pedagogical Learning:** Staff from seven ISIs reported significant gains across all technological, pedagogical, and content knowledge and skill areas. The greatest reported gains were in technological knowledge/skills. The areas of content and pedagogical knowledge were where ISI staff had the highest levels of *prior* preparedness; but slight gains were still shown. Staff interviews indicated that technological skills and learning the content of the social-ecological themes were the most notable learning.
- **Institutional Buy-In:** Seven of the eight sites reported at least one area of impact on the institution since their engagement in Worldviews, with the most common being some degree of buy-in to the ideas behind Worldviews Network. Over time, many sites identified some degree of institutional or departmental commitment to telling these types of stories in the dome.
- **Reuse and Repurposing of Products or Approach:** Five sites have already repurposed the visualizations, datasets, or storylines created through Worldviews. This has included using the materials for internal professional development; use with classrooms, teachers, or students; and use for new audiences or venues. Two sites emphasized a continued focus on the approach, creating new stories and products beyond those initially created.
- **Commitment to Ongoing Relationships:** About half of the sites reported they have worked with an advisor/attendee from a BCD Event since the event, and could describe outside relationships that have been maintained or developed as a result of the project. No ISI reported they had yet engaged community partners in a new project, but four reported plans to do so.

Cross-Case Patterns and Themes

- The underlying concept of Worldviews was ambitious and innovative, as it created and tested a new model for programming. The sites that were engaged in the first year were on a steep learning curve, in which their experimentation, testing, and reflection on what worked and

what could improve was necessary to develop tools and approaches that operationalized the vision of Worldviews Network into a defined process.

- When BCD Events were primarily framed as events for the general public, with a number of expert stakeholders also specifically invited, there was some evidence that these two audience-types responded differently to the content. While experts felt the show was easy to understand, and sometimes wanted greater depth presented, non-experts sometimes felt elements were "over their heads." This presents a challenge for events seeking to meet the needs of both types of audiences simultaneously, rather than focusing on one or the other at the outset.
- Each instance of experimenting with post-show dialogue provided positive experiences for attendees and did actively engage audiences and presenters. The content of those dialogues varied, pointing to a few key lessons for creating more successful dialogue sessions: 1) Having enough "expert" or knowledgeable attendees in the room to sustain dialogue (those with more non-experts tended to fall more toward Q&A); 2) having an experienced facilitator with skills to initiate and support this format; and 3) ensuring the facilitator is comfortable with the purpose of the solution-oriented, design-process dialogue in the Worldviews model.
- The incoming resources, strengths, and assets of an ISI partner affected their implementation approach. Each site worked from a set of institutional constraints and opportunities, building on strengths and receiving project support to compensate for weaknesses and to build new skills. For instance, large ISI sites could leverage robust planetarium facilities, technical knowledge, and programming models; but they generally had to face barriers of often-siloed departments and staff when seeking internal collaboration. Smaller ISIs, in contrast, tended to be more used to internal collaboration, but were more likely to face a lack of resources, tools, or staff capacity to make vision a reality. In both cases, the barriers were overcome, but strategy had to adapt to strengths and weaknesses.

Recommendations for Future Network Sites

- The TPACK (Technological-Pedagogical-Content Knowledge) framework is a useful organizing device for understanding incoming strengths and supporting Worldviews Network sites in development. Looking forward, new sites would be advised to engage in a self-assessment of individual competencies along this framework, as well as institutional priorities and assets that can be leveraged. Resources are available to support this on the Worldviews.net website.
- For future sites working independently, pedagogical skills around creating and facilitating true dialogue with an audience should be an area of development and training. Facilitation of dialogue is a specialized skill-set, which is not often the core focus of the work of many types of ISI professionals, even those who are educators, who approach this type of project.
- In what ways can the Worldviews Network approach be adapted to non-dome settings? For a broader reach, some current Network sites have already pushed on the need to apply the techniques to flat-screen environments. The Network may want to advise future sites on trade-offs of the two formats and any critical decision-points to consider if both formats are an option.
- Patience is a virtue for advocates of this approach. At most of the sites in the Network, there were one or two advocates of the approach, who were willing to invest a lot of their own time and passion to go with the experiment and seek to bring others on-board through the experience. In those cases where institutional-level interest has mounted, there was generally some strategic alignment of the program with a larger institutional goal (such as the program's ability to promote internal research achievements or provide a unique, marketable product for educational outreach).

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Introduction

Background

Proposed Project Vision

Worldviews Network is an initiative funded by the National Oceanic and Atmospheric Administration's (NOAA) Environmental Literacy Grants Program in 2010. The Worldviews Network is comprised of a network of institutions with a goal of creating an innovative approach for engaging the American public with topics of human-induced global change. **The project's interpretive approach sought to 1) leverage the power of immersive environments within informal science institutions (ISIs), such as planetariums and portable domes, by 2) incorporating visualizations of scientific data sets about relevant social-ecological issues as they relate to "planetary boundaries," framed by 3) a systems-based narrative approach that incorporated cosmic, global, and local perspectives on the issues.** This approach was intended to create a transformative educational process that integrated the benefits of visual thinking, systems thinking, and design thinking. Through the project's interdisciplinary Leadership Team working closely with the ISIs to create these models, the project intended to empower informal educators with tools and techniques to help audiences visualize, comprehend, and address complex social-ecological issues from a whole-systems perspective. The vision of the Worldviews Network was that programs would make explicit the interconnections of Earth's life support systems across time and space, as well as inspire community participation by providing real-world examples of successful projects that are increasing the healthy functioning of regional and global ecosystems.

The ISIs[1] that are part of the Worldviews Network are shown in Table 1.

Table 1. List of Worldviews Network ISI partners and abbreviations used to refer to them throughout the report.

ISI	Abbreviation	Location	Project Role
California Academy of Science	CAS	San Francisco, CA	Co-PI
Denver Museum of Nature & Science	DMNS	Denver, CO	Co-PI
American Museum of Natural History	AMNH	New York, NY	Partner
Journey Museum	Journey	Rapid City, SD	Partner
Minnesota Regional Planetarium Network	Minnesota	Minneapolis, MN	Partner/Advisor
Perot Museum of Nature and Science	Perot	Dallas, TX	Partner
Renaissance Computing Institute	RENCI	Chapel Hill, NC	Partner
University of Michigan Museum of Natural History	Michigan	Ann Arbor, MI	Partner

[1] The term "informal science institution" is used throughout this report to refer to all Network sites. While most partner sites were traditional science centers, museums, or planetariums, not all typically fall into this definition. However, because each site served as informal science education venue through its work in this project, we will use the term ISI to refer to all eight sites.

As proposed, the project sought to accomplish several tasks with and for each ISI and across the Network:

- **Creation of Digital Assets (Visualizations and Storyboards):** Develop a library of digital planetarium visualization story templates that leverage existing scientific data from NOAA and other sources, each with identified learning goals aligned to climate and Earth science literacy principles;
- **Professional Development Program for Informal Science Educators (PD):** Design and deliver a professional development program that trains informal science educators and planetarium professionals with the necessary knowledge of content, technology, and pedagogy to deliver these public programs;
- **Production of Bioregional Community Dialogue (BCD) Events at each ISI:** Create regional networks between planetariums and researchers to allow the creation of geographically and culturally relevant immersive dome experiences;
- **Engage Scientific and Community Organizations for Future Action:** Establish connections with agencies and community-based organizations that will give the public opportunities for continued, meaningful engagement;
- **Evaluation:** Evaluate the impacts of training and events on professional and public audiences.

To achieve these deliverables, the **Worldviews Network Leadership Team** had a strong and deeply integrated role. The Leadership Team was a collaborative, interdisciplinary group leading the project and providing ISIs with overall project management, a production process, technical support, scientific/data resources, professional development, and connection with the professional community of practice. As an interdisciplinary team, each member brought specific expertise and a shared vision of the project's goals:

- Ka Chun Yu, Ph.D. (Denver Museum of Nature and Science) -- Astrophysicist; Technical expertise in Uniview, adapting visualizations for the dome environment
- Rachel Connolly, Ph.D. (WGBH) -- Professional development lead with expertise in informal science education, training educators, and the TPACK model; additional experience in planetarium education
- Ned Gardiner, Ph.D. (NOAA; independent consultant) -- Ecologist; Scientific expertise on bioregional ecology issues and systems, connections to scientists and data sets, particularly from NOAA
- Healy Hamilton, Ph.D. (California Academy of Sciences; independent consultant) -- Ecologist; Scientific expertise on bioregional ecology issues and systems, connections to scientists and data sets.
- David McConville, Ph.D. (The Elumenati) – Media artist; Creative director with technical expertise in Uniview and visualizing data in the dome; Pedagogical expertise in the see-know-do approach and live presentation in a dome of the cosmic-global-local narrative style
- Ryan Wyatt (California Academy of Sciences) -- Planetarium professional; Technical expertise in creating, planning, delivering planetarium presentations
- A project manager (California Academy of Sciences) -- responsibility filled first by Lindsay Irving, followed by Kathi Koontz; Oversaw production process for every site and daily management of the overall project.

Logic Model & Intended Outcomes

As part of this process, the Leadership Team engaged in a logic modeling workshop around the start of project Year Three. The logic modeling process was an effort to refine the program's underlying theory of change informed by the learning of the first two years. Two versions of a program logic model emerged. One was a detailed, traditional logic model representation of all aspects of the complex project and its efforts to impact its target audiences (i.e., ISI professionals, community partners, and public audiences), which is provided in Appendix A. From this model, a second iteration created a simplified overview of the theory of change, incorporating more of the project's theoretical constructs and visualizing its cyclical nature, appropriate to the development cycle (Figure 1, next page; Appendix A).

As the project developed, it became clear that the main focus for outcomes were the ISI/Planetarium professionals who comprised the Network, as well as their institutions. The project was largely about building their capacity and abilities to do this kind of storytelling. Intended outcomes for ISI professionals included:

- Building technical skills to use dome technology to create visualizations;
- Building knowledge of social-ecological issues;
- Building ability to deliver a presentation about Earth sciences;
- Viewing domes as a tool for communicating about social-ecological issues and systems (not just space science);
- Increasing programming about Earth-related topics in planetarium;
- Continuing to work with community partners and external advisors

Intended outcomes for the community partners and external advisors who worked with ISIs, secondary audiences, included:

- Viewing the ISI as an important resource
- Continuing to collaborate with the ISI in the future

For public attendees of Worldviews Network BCD events, which included invited members of influential public (i.e., people already connected to the issue in some way) and/or interested members of the general public, intended outcomes included:

- Increase in awareness of core ecological content
- Have a positive affective/emotional response (i.e., awe, inspiration, amazement)
- Understand new relationship(s) of ecological problems to larger systems
- Have awareness of community resources / opportunities to work toward addressing the social-ecological problems.

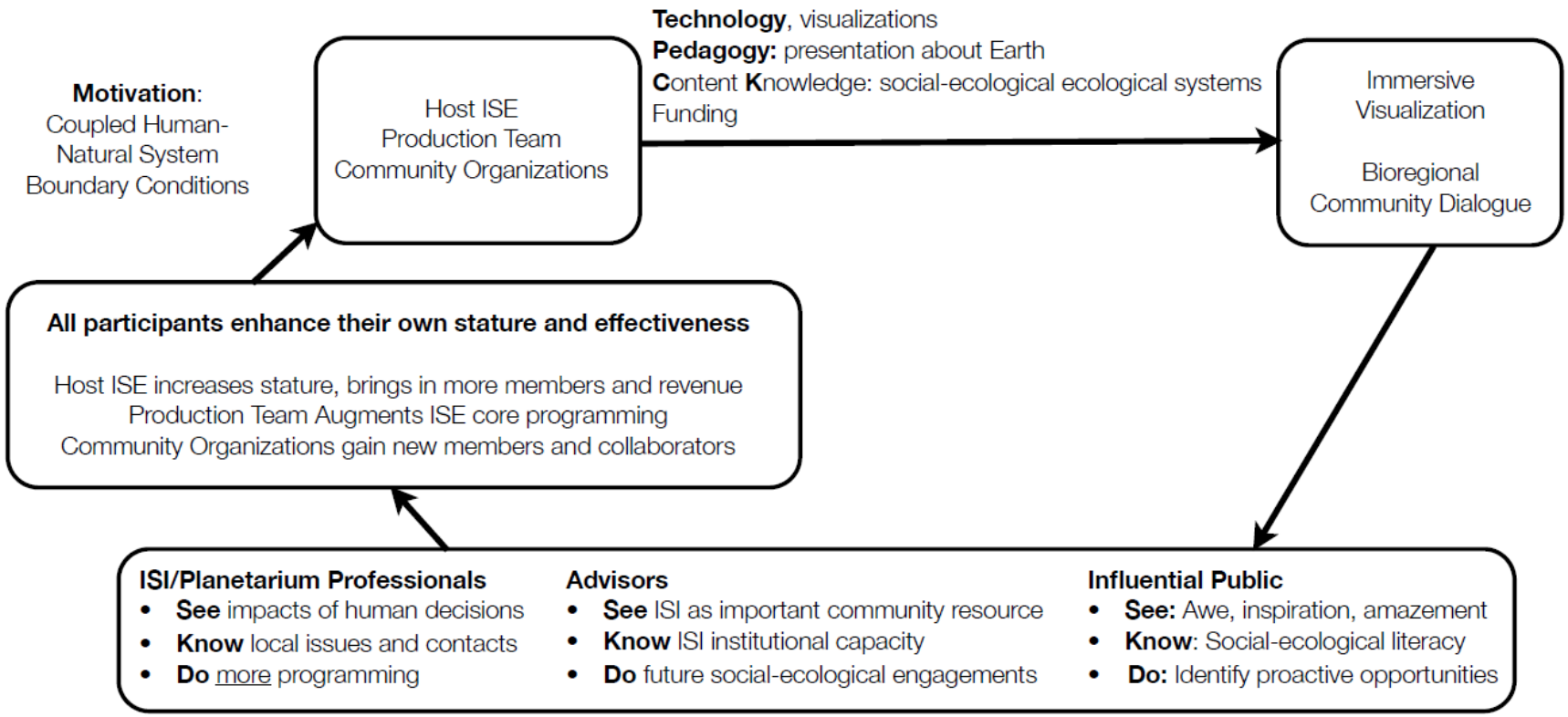

Figure 1. Second iteration of Worldviews Network logic model diagram; overview of the project's ideal theory of change (February 2013)

Implementation Realities

In practice, the goals and broad deliverables were distilled into a number of specific outputs and processes to be achieved with each site. The process is analyzed in detail at the start of the Findings section, but essentially, the team sought to complete the following with each site:

- Identify a bioregionally important story topic and creating a corresponding storyboard, followed by a narrative or script outline (Digital Asset);
- Identify scientific data sources and translating them into visualizations for the dome environment (Digital Asset);
- Identify and collaborate with local Science Advisors and Community organizations on the story, visualizations, event, and possible future steps (Regional Networks & Future Action);
- Hold a Bioregional Community Dialogue Event, which consisted of the live narrated dome presentation (or show), and could (but was not required to) be followed by dialogue sessions (BCD event);

As the project moved through its three years, the Leadership Team engaged in an ongoing process of reflection and adaptation to make each of these substantial tasks achievable. For example, the project began with a vision of regularly using *Octopus* technology to simulcast BCD event shows from one location to the domes of several other Network sites, allowing a single production to reach a larger number of audience members. While the Network experimented extensively with this technology, they learned that it was not as flexible or robust as was needed to broadcast the Worldviews shows regularly. Other shifts included staffing changes within the Leadership Team, such as a change in the project manager, who served as the "hub" of the Network.

The project also adapted to external factors, one of which inherently changed the initial plans around both professional development and evaluation. Due to administrative circumstances outside of the control of the project or Leadership Team, there was a significant delay to the official engagement of WGBH as a partner; this organization was responsible for the ISI professional development program (Connolly), as well as contracting for external evaluation services (Lifelong Learning Group). The impact of this delay was that the original plans for both professional development (i.e., a series of workshops, webinars, and actively building the community of practice) and evaluation (front-end, formative, and summative evaluation engaged actively with the Leadership Team throughout the three years) had to be drastically modified because the appropriate team members were not administratively in place to contribute fully to the project in the first years.

In this context, the Leadership Team adapted their approach and work to progress toward their goals and accommodate barriers and lessons learned. As reported here, the professional development model shifted from a plan of formal training programs to a process of one-on-one mentoring and “just-in-time” training between individuals on the Leadership Team and those at partner sites. Formal training modules shifted to be produced after the completion of events, in order to serve broader ISI professionals interested in entering the Worldviews Network. For the formative evaluation, members of the project team, with some offline consultation from evaluators, instituted an audience survey to use in the interim (see methods below) and engaged in ongoing reflective conversations about lessons learned informally. Connolly provided quick data summaries after each event to the team. Ultimately, the summative evaluation approach that is reported here was an adaptation that sought to adjust to the timeline limitations (evaluators were

contracted about 2.5 years into the 3-year project) and take advantage of retrospective opportunities provided by the extension of timeline.

Summative Evaluation Questions

Summative evaluation was designed to address four overarching questions about the process, outcomes, and generalizable lessons from the three-year experimentation with the Worldviews Network model. These questions were honed in April 2013, with official entry of the summative evaluator to the project team.

1. To what extent were short- and medium-term outcomes achieved with each of the target audiences: ISI professionals, advisors, and members of the public?

2. In what ways did the Worldviews Network process, approach, and model work well to support ISI professionals and public audiences in achieving these goals? In what areas could the model be further strengthened?

3. How have the processes, strategies, and approaches promoted by the Worldviews Network been sustained within institutions after the project? For example:
   - Content: global-local connections and/or Earth science focus in planetariums
   - Pedagogical: working with collaborators, advisors from the community
   - Technical: use of other Worldviews-created assets
   - Institutional: change in value/approach to programming

4. How did contextual factors at each ISI site relate to or influence implementation, outcomes, and sustained change?

Methods

The summative evaluation questions sought to document and understand the successes, challenges, and ongoing relevance of the Worldviews Network model, which used a site-specific, community-based approach in working with each ISI partner in the Network, as well as seeking longer-term change within those ISIs, beyond the completion of their BCD events. These summative evaluation questions necessitated an approach that could examine holistically the experiences, strategies, successes, and challenges of the Worldviews model for 1) creating meaningful partnerships between ISIs and community-based organizations, and 2) creating sustained culture shift at ISIs around globally-focused programming and storytelling within real-world ISI and community contexts.

The goal of evaluation was to capture the complexity and variation of experiences at each individual site, while also systematically assessing commonalities and patterns across the Worldviews Network model to understand the extent of change it created in its target audiences. To this end, we used a **qualitative multiple-case study approach to the summative evaluation**. This methodology allowed the collection of both qualitative and quantitative data from a variety of stakeholders connected to each of the partner ISIs in the Network. The analysis of these data allowed for the presentation of findings at two levels: 1) a portrait of the nuanced process and outcomes within each Network site, and 2) a cross-case analysis of all eight sites, which results in generalizable conclusions about the outcomes and efficacy of the Worldviews model as a whole (Yin, 2009).

Theoretical Framework

A theoretical framework was necessary to structure the analysis and interpretation of the case study data in order to address the evaluation questions systematically. Because this case study was in service of a summative evaluation, rather than empirical research, the Worldviews Network's own theory of change model (Figure 1) was the most relevant to guide this analysis. This model reflects the project team's implicit theory of how the Worldviews Network specifically believed it could accommodate a highly diverse set of sites, programs, and processes, produce a set of similar products/outputs, while seeking to achieve similar outcomes.

Structured around several common pillars of a program logic model (e.g., resources, outputs, outcomes), the theory of change model also showed the cyclical, self-reflective nature of the process. Further, the Worldviews theory of change model cohesively included and reflected other research theories which informed its design and execution. There were three separate theories interwoven into the process. One was the Technological Pedagogical Content Knowledge Framework (or TPACK; see Figure 2) from the realm of teacher education, which articulates three overlapping domains of knowledge that teachers need to be effective in a technology-rich environment (Mishra & Koehler, 2006). This theory primarily applied to the Leadership Team's vision of how it would train and build skills among the ISI professionals at Network sites, as well as the skills they would demonstrate in a BCD event.

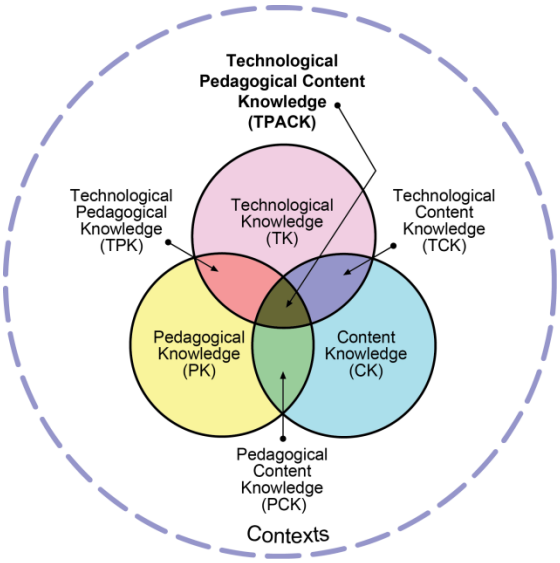

Figure 2. TPACK diagram (from TPACK.org)

Another key theory in the project's model is the Seeing-Knowing-Doing framework from sustainability education (Sterling, 2011; 2014). This framework presents an overlapping, three-part composition of individuals' worldviews, with the contention that all three domains need to be addressed in order to affect change. These three components include: 1) Seeing, or perception, defined as an affective realm of how people view and feel about the world; 2) Knowing, or conception, defined as how people conceptually understand the world; and 3) Doing, or practice, defined as how people participate and interact with the world (Sterling, 2014). This theory drove the design and outline of the narratives, visualizations, and stories of the BCD events and subsequent dialogue sessions, with the theory that the events and/or dialogues would support shifts in these three domains for attendees.

A final organizing idea within the Worldviews Network theory of change was the use of a specific narrative structure that examined and connected a single ecological issue from three perspectives: cosmic, global, and local. This idea was connected to the Seeing-Knowing-Doing framework, in that the theory proposed this narrative approach would influence perceptual and conceptual views of the world, but it was an additional strategic approach defined by the team to achieve these goals.

From this context, the theory of change became a highly relevant and theory-driven tool for framing the analysis, as it presented the idealized framework against which each case and the whole Network system could be analyzed.

Analysis

Table 2 outlines how this theory of change model was operationalized into an overarching data analysis framework used to code and analyze each case study site within the project. The unit of analysis was the site (the eight ISI partners in the Network); the process, products, and outcomes all revolved around the ISI as the center. Some sites created multiple productions/events at different times over the course of the project; while some production-specific features are reported separately within a case (e.g., audience reactions from each event), they are generally compiled into the overall analysis for that site.

Table 2. Analytical framework for approaching case study data, based upon the Worldviews Network theory of change model.

ISI Site Context	Approach	Outputs	Outcomes	
Pre-Resources & Barriers	**Activities and Process**	**Outputs: Show & Event**	**Immediate Outcomes**	**Extended Outcomes**
-Technology -Skill-sets -Prior experience -Prior relationships -Role (co-PI v. partner) -Motivation to participate	-Roles played by: Production Team (leadership) ISI Site staff Community Advisors -Process for arriving at data visualizations (tech); narrative/story (pedagogy); ecological topic/data sourcing (content)	-Show topic -Included dialogue or not? -Audience type (heavy presence of invited experts vs. mostly wider public) -Who delivered the narration	-Audience reactions -ISI staff outcomes -ISI institution outcomes -Advisor outcomes	Ongoing change persisting months/years after event -use of resources -use of approach -working with partners -more collaboration

With this framework, data were analyzed at three levels. The first level analysis was by individual case (ISI site). From this lens, the data from each stakeholder connected to a single ISI was coded and triangulated against one another to arrive at a summary case description that outlined the core attributes of each ISI site's context, approach, outputs, and outcomes within the Worldviews Network model, with specific attention to unique attributes.

The second level of analysis was looking at a general, overarching Network level, where data from all eight cases were examined in aggregate to document the overarching outcomes from across the eight partner sites of the Worldviews Network.

The third level examined the deeper summative evaluation questions about generalizable patterns about relationships between outcomes or challenges and factors of an individual institution, its staff, or its process. This cross-case analysis used analytical matrices to examine case profiles side-by-side for similarities and differences. Throughout this process, evaluators looked for discrepant data and rival explanations to emerging patterns to test emerging generalizations about the program to arrive at those that could be sustained by the evidence.

Data Sources

As a case study, the evaluation sought as many different data sources as possible to document thoroughly the experience of the cases. Due to the timing of the formal engagement of evaluators in the project, much of these data were collected using a retrospective lens; those sites who had produced events prior to spring 2013 were asked to provide reflections months or years following their experience within the Worldviews Network. This lens, while necessary, had the added benefit of allowing the capture of more data about extended and longer-term impacts. For events produced after spring 2013, data were collected immediately following the event. In addition, data and documentation made available by the Leadership Team from the production process between 2010 and 2013 were also used to document the cases.

Table 3 presents the data sources used in the cases, as well as the number of people in the population (invited to participate) and the number responding. Each type of method is described in more detail below.

Table 3. Evaluation data sources for the case descriptions

Data Source	# in Population	# Responding
Phone interviews - Project Leadership	8	6
Phone interviews – ISI staff	16	8
Web survey – ISI staff at sites	16	9
Phone interviews – Advisors	18	1
Web survey – Advisors	18	3
Audience questionnaires at events - collected by program staff (2011-2013)	Unknown	448
Audience questionnaires (revised version) at events - collected by evaluator (2013)	Unknown	153
Event/Dialogue observations (2013)	3 events	3 events
Project management document archive	n/a	n/a

Semi-structured interviews were a major data source for the case study. Evaluators attempted to engage as many stakeholders from the sites in interviews as possible, including ISI staff members, science advisors, and the project Leadership Team. Nearly all members of the project Leadership Team participated in interviews. At least one representative from all ISI sites, with the exception of AMNH, agreed to participate in a one-on-one interview; AMNH context was gathered from interviews with Leadership Team members who worked closest with that site. Eighteen scientific advisors were identified by the Leadership Team as having worked on various productions; unfortunately, only one responded to invitations to participate in a telephone interview. **Online surveys** were used to collect data from as many ISI staff and scientific advisors as possible and used more closed-ended questions about outcomes and response from ISI staff and advisors. The population was the same as the interview, but this was also an effort to gather perspectives from those not interested or able to engage in a telephone interview. In total, nine ISI staff (from all but one ISI, AMNH) and three scientific advisors (representing work with AMNH and Minnesota) responded to this request.

For the audiences who attended the BCD events, most of the data were collected by the program team prior to the start of external evaluation. A paper **questionnaire** was distributed by program staff to all attendees at nearly all of the events (with the exception of Minnesota[2]) between 2011 and spring 2013. The instrument made slight modifications of an interview protocol previously used in evaluation of Science On a Sphere® programs (Goldman, Kessler, & Danter, 2010), changing language to reflect the dome (rather than sphere) environment, adding some formative evaluation questions (about strengths and improvement areas of the show), and modifying generally to fit a self-complete questionnaire format, as opposed to an interview. When the evaluation team joined the group in spring 2013, the questionnaire instrument was modified for the final events, based upon analysis of the prior collected data. Many questions were kept the same, to allow for comparison with the larger-than-anticipated dataset collected with the interim form. However,

[2] Minnesota programming did not collect data from audiences to its BCD event using this tool, due to the cultural sensitivities concerning the event's approach of storytelling and engagement with indigenous participants.

other questions that had shown less useful data were eliminated, and a new retrospective pre/post question was added to intentionally assess audiences changes in understanding and perspectives related to the project goals. (See Appendix B for instruments.) **Observations of the final events** of the program (DMNS, CAS, and Perot) were also conducted. Observational notes were recorded in running-record style of the presentations and during any follow-up discussion or surrounding programming.

Finally, evaluators included a number of **project documentation sources** as data for the analysis. The Leadership Team and ISI sites used Google Drive to store and organize much, if not all, of the documentation around their process, storyboards, and development. Similarly, other program-led efforts at evaluating needs, process, or outcomes (such as surveys of ISI professionals before the first kick-off meeting) were stored in these files. In addition, the Network had used an email listserv for informal discussions and sharing amongst the many Network members and Leadership Team. All of these document archives were used to more objectively document the process and tools of production development, as well as triangulate against interviewees' retrospective reports and to fill in gaps where participant memories of process were lacking due to the time lag.

Interview data were transcribed and observation notes typed. Questionnaire data were analyzed using the statistical analysis software SPSS. Qualitative analysis software NVivo was used for coding and analysis of cases. Coding included both deductive categories (derived from the theoretical framework), with specific codes created inductively from themes in the data. Quantitative data were analyzed for frequency distribution, central tendencies, and statistical comparisons between samples made when appropriate.

Results: Individual Case Descriptions

The results are presented first as individual case descriptions of ISI sites, to present the unique story, process, and outcomes of each site within the Worldviews Network. The sites are presented in the sequence in which they developed their productions, to capture the evolving nature of the overall Network process and growth. The next major section of the report (Discussion) presents the results of the cross-case analysis of the sites for overarching themes and generalizable findings about the Worldviews Network model.

Overview of the Worldviews Network Process

Looking across the data from the eight sites and 12 events that were prepared as part of this project, a generalized picture of the process used by the Worldviews Network to develop and deliver Bioregional Community Dialogue (BCD) events emerged. Although each site had many unique challenges, approaches, personnel, and strategies within this approach, there was an essential four-step process that led to the creation of a Worldviews Network BCD event.

1. **Leadership Kick-Off of Production Process:** Members of the Leadership Team initiated the process with the ISI site. The exact players varied from site-to-site, but the project manager and Leadership's internal ecological content advisors (Gardiner and Hamilton) played important roles at this stage. Technical advisors (McConville and Yu) also were involved in many cases. This step included working with the ISI representative to:
    a. **Define the Topic** - selecting a topic or theme that was relevant to the community (led by ISI)
    b. **Begin the Story Outline** - heavily informed by the content advisors; initially drawing on the existing "cosmic story" and then drawing on other models/examples as the Network grew
    c. **Identify Advisors or Sources** - content advisors helped identify people, places, or other sources that might be able to provide data, fact-checking, or insight on the story. Story selection was not limited to those sources or data already known by the team. At this stage, Leadership's content advisors would make every effort to find new sources, data, and information based on the ISI's desired topic.
2. **Involving Outside Advisors:** After the story was identified and a basic outline begun, outside content advisors were approached and folded into the process of story development and refinement. Advisors were generally not involved in the day-to-day development, but played one (or more) of three contribution roles, with varying level of involvement:
    a. **Shaping the Story** - some advisors would review storylines or storyboards, offering suggestions for how they might approach/change a story.
    b. **Providing Story Information** - some advisors provided fact-checking on aspects of a story, provided content background during story development, or provided information to fill in gaps in a storyline.
    c. **Providing Data** - some advisors were sources of the data needed to create the visualizations that illustrated the story. Often these individuals were not involved in the story or interpreting the visualizations, but were able to provide or help locate the data that was essential to the approach.

3. **ISI Takes Responsibility & Leadership Identifies and Fills Gaps:** At this stage, the hope was that an ISI could take the process and run with it. In reality, however, the process and skill-sets required to produce these ambitious visual productions, stories, and public events were substantial and needed more support, which the Leadership Team flexibly provided on a case-by-case basis. Because the needs of developing a production (e.g., scripting, gathering data, creating visualizations etc.) and the capacities of staff at each ISI were highly variable, members of the Leadership Team acted in whatever capacity was necessary to ensure a given event's success. It was at this stage that any PD for ISI sites occurred through 1:1 mentorship of working directly with members of the Leadership Team. Key roles that Leadership Team members tended to fill, depending on the gaps in skills at the sites, included the following:

    a. **Event Logistics** - This included everything from ensuring a portable dome got to the venue where it needed to be, to identifying and inviting audiences.

    b. **Content** - At a number of sites, content advisors were difficult to find or were unable to commit to involvement within the production's timeframe. Leadership Team content advisors stepped in to fill those gaps in the story development process, particularly when the ISI representative was not a content expert.

    c. **Technical Troubleshooting** - Translating data to the dome was challenging; it pushed the limits of what the Uniview technology was capable of doing. This often was beyond the capacity of the ISI, so Leadership Team members provided substantial services in the creation, rendering, and general troubleshooting to get the visuals of the productions – each custom-made – ready for viewing.

    d. **ISI Staff Role** - In a couple of cases, the identified ISI staff representative was unable to fully engage in the coordinating and point-person role, which required members of the Leadership Team to take on more of those responsibilities.

4. **The Event:** The culmination of the process was the event. Each event included the dome presentation, lasting approximately 45 minutes, consisting of data visualizations with live narration following a script/storyline. The scripts generally followed a progression of cosmic to global to local perspectives on social-ecological issues and systems, although this varied depending on the needs of the story. The presentations involved 1-3 presenters, perhaps interacting with one another, but audience interaction was held until the end. After a presentation, some events had Q&A in the space, some held optional discussion groups, and some did not have any formal opportunity for audience interaction.

    a. **Audiences** - Some events focused their audiences on specifically selected stakeholder groups in the community who might be able to focus on enacting change about the issue (while possibly also welcoming generally interested public). Other events were primarily open to the public; although a list of related science or community stakeholders would receive specific invitations, the event audience was not comprised primarily of or specifically for them.

    b. **Presenters** - In some cases, members of the Leadership Team presented or co-presented productions with the ISI rep, particularly when the ISI staff did not feel confident enough in the content to speak about it, even from the script/story.

    c. **Dialogue** - An ambition of the project, post-presentation dialogue/discussion sessions were held at seven of the events. An important lesson learned about production was that the dialogue component required a strong and comfortable

facilitator, enough experts in attendance to go beyond basic question and answer discussions, and institutional comfort in all other aspects of production. In short, the dialogue component of the BCD events was more or less plausible for sites depending on the extent to which there were immediate logistical needs. All of the events which included this segment involved a Leadership Team member or advisor to the project as the lead for the dialogue.

Case 1: Denver Museum of Nature and Science

Site Overview

The Denver Museum of Nature and Science (DMNS) is a large ISI with a full-dome planetarium. As an institution with a Co-PI on location, this site's team had extensive knowledge of the Uniview system and experience with translating data to the dome environment. In addition, the scale of the institution meant that there were internal scientists at DMNS who could bring Earth science knowledge and advisement to the productions. In general, the on-site contributors were experienced at delivering live presentations and using the technology involved in the Worldviews events, as well as with telling Earth science stories in the planetarium.

The DMNS institution itself had a deep connection to the central grant partnership, as it was a Co-PI institution in the project. An ISI staff member described the reason for joining the Network:

> *"…Since I don't have a background in Earth systems science, I was intrigued about learning how to make the most of our available toolsets to tell Earth stories. Such a capacity seemed to me to be increasingly important for natural history museums and science centers."* (ISI survey)

Worldviews Approach

DMNS hosted the first Worldviews Network BCD event, "A Global Water Story," in May 2011. The event, which focused on global issues of water and the specific impact on states in the Western U.S., was open to both invited guests and public audiences, and it included a dialogue component after the main presentation. The site's pre-project resources and on-site expertise meant that there were no major support needs from the Leadership Team for this event. More generally, the Leadership Team considered this first event an important opportunity for "figuring out what our production flow and process would be" (Leadership interview) and determining a target program length.

In June 2013, DMNS spearheaded the ninth Worldviews event, entitled "Forests, Beetles, and the Cycles of Life." By this time, Worldviews Network processes around storyboarding and outreach had been more fully developed and informed by Network experiences across sites. As before, the event included both invited guests and public audiences, concluded with an event dialogue, and required no major support from the Leadership Team.

For the creation of both events, the on-site Co-PI and the institution's usual dome presenter were very involved in locating and reaching out to community advisors, and they were heavily responsible for creating all event outputs, especially in developing the narrative and data for the storyboard. Community advisors tended to supply information about their specific areas of expertise, and they sometimes provided suggestions for data sets and other resources. They also helped clarify the story and locate data assets.

In contrast to resource-gathering and story development, in which tasks were "all happening at the same time," (ISI interview) the storyboarding process was described as being more linear—driven by project-guided steps. The Worldviews method of using storyboards in production represented a process change for ISI staff, whose presentation expertise had historically meant taking a "more organic" approach to show development, in which "data drive the narrative" and "the structure…isn't completely defined until we actually do the presentation" (ISI interviews). In short,

the advanced competencies and experience of DMNS presenters meant that staff were accustomed to and comfortable with speaking extemporaneously about a topic once data assets had been selected and a loose outline devised. Thus, the Worldviews approach (i.e., more formalized scripting and storyboarding) presented both challenges and opportunities for ISI staff.

While staff reported feeling some resistance to what felt like unnecessary formality of the process or moments when the project seemed too prescriptive in its approach, they also noted the project's structure also introduced them to a somewhat novel way of seeing familiar topics and presentation styles and served as a unique opportunity to reflect on their own process (ISI interview). Furthermore, staff reported that the project strategy for finding and involving advisors was a great boon, as it meant that "once we found one key critical person, that person was really helpful in getting us additional people and [became] someone that we [have] worked with since, even after that event" (ISI interview). A result of seeing the benefits associated with the project norms was that "in the end our process meshed with the rest of the process as it has been developed by the rest of the team" (ISI interview), even if there were some struggles to adjust to. For at least one member of the Leadership Team, DMNS illustrated that "both of these production processes are complementary and they show how different institutions with different skill sets can still come up with outstanding products in the end" (Leadership interview).

Project Outputs

A Global Water Story (May 2011)

Full Description: "At the premier event for the Worldviews Network, audiences across the United States plunged into a national conversation about local and global water issues using the immersive technology of Denver's Gates Planetarium. Typically the Planetarium is used to study space, but its capabilities are also ideal for a discussion about Earth systems and environmental science."[3]

Event Type: Hybrid: fit the new show into an existing public program format at the institution, but added new components.

BCD event Goals: As described in an ISI staff survey response, there were two perspectives on the event's goals. For the public programming team (which generally oversees adult-focused evening events), it was seen as another event in a series of recent Digital Earth planetarium presentations. For those working with the planetarium, the goals were more complex:

> *"... the goals were to have a successful presentation showing the viability of Earth-systems based programming in the digital dome; having a successful post-dome dialogue with audience members, helping to pave the way for more events like this; and successful collaborations with external partners, which would lead to continuing relationships with these entities."* (ISI survey)

Staff felt they achieved this goal "to a great extent."

Audience: Invited guests and public; presentation also simulcast to the Journey Museum, RENCI, California Academy of Sciences, and Como Elementary School (St. Paul, MN)

[3] Source: http://worldviews.net/a-global-water-story/

Table 4. Demographics of survey respondents to DMNS BCD event #1

Audience demographic information (66 respondents)		
Visitor group description (n=65)		
On my own	23	35%
With friends or family	41	63%
With an organized group	1	2%
Number of children in group (n=64)		
None	60	94%
One	4	6%
Two or more	0	0%
Number of adults in group (n=63)		
One	23	37%
2 to 5	40	63%
6 to 10	0	0%
11 or more	0	0%
Age (n=64)		
18-29	12	19%
30-39	7	11%
40-49	10	16%
50-59	14	22%
60-69	14	22%
70-79	5	8%
80-89	2	3%

Forests, Beetles, and the Cycles of Life (June 2013)

Full Description: "Vast stands of coniferous forest are an essential part of the ecology, economy, and character of western North America. Recent dramatic changes, such as forest mortality from insect outbreaks and increased fire activity, are occurring across huge areas of western forests. Join the Worldviews Network and the Denver Museum of Nature and Science for an immersive journey into the past, present and future of our forests. Under the dome of the Gates Planetarium, travel through space and time to understand the connections between local forest ecosystems, global forest biomes, and our cosmic neighborhood. Enter into a dialogue with scientists and educators about the pine beetles that have changed our Colorado landscapes, learn how these infestations arose, and their impacts on forests of western North America. Space scientist Dr. Ka Chun Yu, geologist Bob Raynolds, and biodiversity scientist Dr. Healy Hamilton will be the evening's presenters."[4]

Event Type: Hybrid: fit the new show into an existing public program format at the institution, but added new components.

[4] Source: http://worldviews.net/pine_beetles/

BCD Event Goals: Described as the same as the prior DMNS event. Staff felt they achieved this goal "somewhat."

Audience: Mostly public, likely due to similar event earlier in the year which was attended by invited guests[5]

Table 5. Demographics of survey respondents to DMNS BCD event #2

Audience demographic information (89 respondents)		
Age (n=87)		
18-29	11	13%
30-39	21	24%
40-49	16	18%
50-59	16	18%
60-69	15	17%
70-79	6	7%
80-89	2	2%
Attendance to dome presentations (n=89)		
5+ times per year	10	11%
2-4 times per year	17	19%
About once a year	20	22%
Less often than once a year	16	18%
Today was my first show	24	27%
I work here	2	2%
Special training or expertise about topic (n=84)		
Yes	26	31%
No	58	69%

Outcomes Achieved

Audience: Global Water Story

There were 66 respondents to the questionnaire distributed after the "A Global Water Story" presentation. A summary of the audience's immediate reactions and self-reported learning from the presentation is below.

Nearly all respondents (59 out of 60 who answered the question) reported learning something new from the show. The learning reported (from 49 people) indicated a split of learning related to Earth

[5] According to a member of the leadership team, "we had the event in January…and we had half a dozen folks from the Forest Service, but because they had already been to that event, I think people didn't feel like they wanted to or had to go what was advertised as a very similar event later on just a few months later" (Leadership team interview).

ecology facts and concepts, as well strong learning about human use and relationships to natural resources.

- 39% reported learning something about human use of, management of, or influence from natural resources.
- 20% reported learning a general ecological fact or concept.
- 20% reported learning about stewardship activities (things being done to address issues).

With the question asked a second way ("something you never realized"), respondents' responses were similar; 91% answered the question, and responses mainly focused on human use of resources and ecological facts.

When selecting and ranking three items that could describe what they got out of their experience with the dome presentation, attendees of "A Global Water Story" most often identified the following phrases as one of their top three takeaways (n=59):

- It made me think about the complex interrelations in Earth systems (35%).
    - This item was ranked as the #1 takeaway by 20% of the audience.
- The Dome helped me better understand the geography of Earth or other planetary objects (35%).
- It helped me visualize certain concepts of time and scale (27%).
- The Dome helped me understand global processes (27%).

The audience also reported that the dome changed their understanding in some way (92%), with the following specific language used to describe how it was changed:

- 42% said it influenced perspective: talking about relationships, connections, a systems perspective, or the cosmic-global-local connections.
- 32% said it allowed them to see: the benefit of visuals with the presentation.
- 23% said they understood: referenced content, information, facts learned.

What attendees liked most about "A Global Water Story" included technology, content, and pedagogical approaches (n=61):

- The visuals/images presented (tech) (30%)
- The presenters (pedagogy) (23%)
- The content covered (content) (20%)

What attendees suggested could be improved (n=35):

- Content that could be added or clarified (31%)
- Suggestions to improve the speaker's presentation (20%)

Audience: Forests, Beetles, and the Cycles of Life

There were 89 respondents to the questionnaire distributed after the "Forests, Beetles, and the Cycles of Life" presentation. A summary of the audience's immediate reactions and self-reported learning from the presentation is below.

Nearly all respondents (82 out of 85 who answered the question) reported learning something new from the show. The learning reported (from 80 people) indicated learning mostly about ecological concepts, but learning particularly in areas of scale and change that highlight the systems focus of the presentation.

- 29% reported learning about ecological facts that focused on geographic scale or expanse.
- 26% reported learning something about ecological changes over time (often implying human causes).
- 20% reported learning a general ecological fact or concept.

When selecting and ranking three items that could describe what they got out of their experience with the dome presentation, attendees of this BCD most often identified the following phrases as one of their top three takeaways (n=82):

- It made me think about the complex interrelations in Earth systems (50%).
- I learned or was reminded that the Earth is always changing and evolving (48%).
- It helped me visualize certain concepts of time and scale (46%).
    - This item was ranked as the #1 takeaway by 18% of the audience.
- The Dome helped me understand global processes (27%).

In response to the added retro-pre/post question to self-report the extent to which they felt their knowledge had been affected by the event, reflecting on how knowledgeable they felt they were before and after the presentation. A paired samples t-test revealed gains of 1 point or more for three of the four statements (out of a 5-point scale), and that those gains were statistically significant (Table 6).

Table 6. Attendees' ratings of knowledge before and after the DMNS BCD event #2.

Statement	N	Before Mean	After Mean	Mean Change
The ecological issue(s) addressed in the presentation***	87	3.08	4.08	1.000
The complex nature of the issue(s) presented***	86	2.87	4.05	1.174
The individuals or groups in my community working on this issue ***	86	2.09	3.43	1.337
Opportunities for me to get involved to work on this issue ***	84	2.04	3.07	1.036

*** Statistically Significant at the .001 level

The audience also reported that the dome changed their understanding in some way (78%), with the following specific language used to describe how it was changed:

- 29% said it influenced their perspective: talking about relationships, connections, a systems perspective, or the cosmic-global-local connections.
- 25% said it allowed them to see: the benefit of visuals with the presentation.

In terms of the affective response, attendees rated their attitudes to the program, as shown in Table 7, all were highly positive. Respondents were less likely, however, to get involved in work happening on this issue, giving it an overall mean of 3.9 on a 5 point scale.

Table 7. Average ratings of agreement about attitude items for DMNS BCD event #2.

	N	Mean	Std. Dev.
The ecological issue presented was relevant to my community.	88	4.78	.596
I enjoyed today's program.	85	4.73	.625
I felt inspired by the presentation.	86	4.30	.827
I intend to find out more about this topic.	87	4.28	.773
I intend to get involved in work happening on this issue.	87	3.85	.959

When describing the feelings inspired by the presentation, the most common categories of descriptions of feelings used were (n=89):

- Hope (28%)
- Informed (17%)
- Concern (15%)

What attendees liked most about this presentation included technology, content, and pedagogical approaches (n=80):

- The visuals/images presented (tech) (45%)
- The data used/shown (content) (18%)
- The presenters (pedagogy) (18%)

What attendees suggested could be improved (n=60):

- Content that could be added or clarified (33%)
- Technical glitches (32%)

ISI Professionals and External Advisors

Several staff-level outcomes seemed to be linked to the experience of creating and participating in both BCD events. **One of the most important outcomes reported by staff and the Leadership Team was increased collaboration with local organizations and institutions.** For example, in a retrospective interview, a staff member described an advisor who contributed to "A Global Water Story" as "somebody I'm collaborating with, with whom I might not have otherwise collaborated" (ISI interview). **Staff also reported learning about the environmentally-focused content and show topic,** especially when it concerned science outside individuals' areas of research. In the words of one ISI representative, "For my own particular purposes, it allows me to expand my understanding of various topics using the immersive environment of the planetarium dome" (ISI interview). An ISI staff member also noted, "Something that isn't surprising at all once it's said, but also something I didn't consider until my participation in the Network: the Earth's biosphere is the only one we know about, so we need to cherish it" (ISI survey). While not becoming an expert in ecological or Earth science content, one ISI respondent rated their personal gains as particularly strong around the community partnership-building, with three awareness or skill areas shifting from feeling under-prepared before the program (2 of 7) to well-prepared (6 of 7) after participation in Worldviews:

- Awareness of the work people are doing to effect change on this issue
- Awareness of who are key people/organizations in my community working to address this issue
- Using the dome for issue-focused discussions in my community

DMNS staff entered the project with high technological proficiency, and the ISI staff member who responded to the survey indicated that skills in this area generally started high and remained high. Only one area showed a jump from moderately prepared (5 of 7) to very well-prepared (7 of 7), which was preparing Earth datasets for Uniview. The staff person also noted that **there were also specific technical skill improvements**: "Learning to write Javascript and coding in CSS to develop browser control of Uniview" (ISI survey). The ISI staff reported gains in presentation (pedagogical) abilities through the program, specific to building skills to deliver presentations about Earth-focused content (preparedness increased from 4 to 6 out of 7). One staff person described this learning as "How stories that focus even just on the rest of the Universe can be brought back to the Earth. There seem always to be ways to connect the audience with topics closer (and dearer) to home" (ISI survey).

Institution

Extended outcomes (those extending months, even years, beyond the occurrence of a BCD event) associated with both shows included some piecemeal **reuse of digital assets and storyboard elements beyond the life of the Worldviews BCD events**. As one staff member described this reuse, "in some cases we were able to use the same material. In other cases, we have different material. It's always a question of the data" (ISI interview). In addition, staff members **continued to use Worldviews-style presentations and storytelling approaches for interpreting Earth science in the dome**. In the ISI survey, a respondent reported DMNS had <u>already done these extended actions at least once since their BCD event:</u>

- Use storytelling/narrative techniques from Worldviews (reported "started doing this regularly")
- Additional programming/community engagement about the ecological issue

> *"We do topical presentations. We're doing one on Africa in a couple weeks. We've done programs on energy. We've done programs on mountain ranges, programs on geohazards, programs on…geography of rivers. We've had a wide variety of topics that we've covered over the years, and they're done in the planetarium in an evening session. So they're in a format very similar to Worldviews Network events."* (ISI interview)

However, the staff noted that, due to other institutional factors and priorities in a very large institution, **the buy-in has been primarily among those working most closely with the planetarium team, and has not influenced an organization-wide shift**:

> *It has been a positive influence and experience on staff that work most directly with or are part of the planetarium. In many ways, these staff members (including myself) were already "bought" into the importance of the work that the Worldviews Network was doing. The BCD events were confirmation that the digital dome can be a powerful tool for educating the public beyond astronomical topics, and showed as well the power of live presentations. However the impact beyond this core team has been smaller.* (ISI questionnaire)

Finally, **ongoing relationships between staff and external advisors reflect another important outcome.** In the ISI survey, a respondent reported DMNS had <u>already done these extended actions at least once since their BCD event:</u>

- Been in contact with one of the Advisors/attendees from the BCD
- Worked with one of the Advisors/attendees from the BCD

The survey respondent also noted they intended to "Engage community partners/advisors to contribute to new projects," but had not yet done this. Importantly, it was noted that such partnerships require active maintenance, which limits the extent of such ongoing work: “The continuing collaboration, because we had that initial contact, there’s still possibilities, but it’s ongoing work to keep it up” (Leadership interview). More generally, there was a perception among members of the Leadership Team that involvement in the Worldviews Network “demonstrated in a profound way that Denver could be using their facilities for addressing the types of regional issues that so many people are involved in” (Leadership interview).

Case 2: RENCI

Site Overview

The Renaissance Computing Institute (RENCI) is a small ISI which focuses more on research and resource development (rather than informal learning specifically) with on-site audiences:

> *RENCI (Renaissance Computing Institute) develops and deploys advanced technologies to enable research discoveries and practical innovations. RENCI partners with researchers, policy makers, and technology leaders to engage and solve the challenging problems that affect North Carolina, our nation and the world. An institute of the University of North Carolina at Chapel Hill, RENCI was launched in 2004 as a collaborative effort involving the UNC Chapel Hill, Duke University and North Carolina State University.*[6]

As a result, hosting a live Worldviews BCD event that included an in-person dialogue was a novel effort for this ISI, which included the use of a portable dome, as there are no planetarium facilities on-site. RENCI did, however, have a history of deep participation with other organizations and projects surrounding sustainability and science outreach, particularly the Livable Communities Initiative, which focused on the intersecting concerns associated with sustainability and planning projects. From this, the RENCI staff reported coming in very well-prepared in presentation skills (generally and about Earth issues), as well as in knowledge of Earth-focused issues. They did not, however, have the technical skills associated with producing planetarium shows using Uniview.

According to an ISI staff member, "our whole project for Worldviews was working with local planners and a lot of the community on taking some of this information and really applying it on the ground to some key issues that we're dealing with here in the counties of western North Carolina" (ISI interview). RENCI's motivation for joining the Worldviews Network was deeply aligned with the high-level vision of the Leadership Team, particularly being motivated to join the project for the opportunity of "Collaborating with David McConville and Ned Gardiner" (ISI survey).

Worldviews Approach

In September 2011, RENCI hosted the second Worldviews Network BCD event, "Living Maps: From Cosmos to Community." This event focused on applications to key planning issues in western North Carolina, particularly those associated with energy, and was open to both "local planners and a lot of the community" (ISI interview). RENCI's experience with and investment in sharing science content, along with a wealth of technological expertise and local contacts, meant that ISI personnel needed relatively little support from the Leadership Team to create project outputs. In general, the support provided to RENCI was mostly in the form of conversation about locating and selecting community advisors and the story development process, as well as assisting with the production of the dome visualizations.

A concern for RENCI personnel, who knew the show content and local players well, was narrowing a broad complex of issues into stories that would work using dome resources and capture the interest and attention of the community. ISI personnel were also very committed to presenting the data in a way that would support dialogue and deeper exploration:

[6] Source: http://renci.org/about/

> *We were really wanting to say, 'Okay, yeah, be entertained by this, receive some valuable information, but now we want you to do something with that information.' So we actually took them out of the dome and into a room where we actually had them brainstorm with some of these other posters and media that we had sitting with it, to actually start and look at taking some action.* (ISI interview)

As a result, the event itself emerged from collaboration between the ISI staff and the Leadership Team, but production did not require the Leadership Team to fill in any major or unusual capacity gaps.

Technical barriers did emerge when the Leadership Team and RENCI attempted to participate in an *Octopus* simulcast presentation with other ISIs, which was not as successful as envisioned. This seemed to represent a point at which the Leadership Team decided to focus more energy on developing local offerings for partner ISIs' audiences, with less emphasis on creating public *Octopus* shows at remote locations. Leadership described RENCI's event as:

> *Where we kind of hit our boundary with the technical component. We realized we were trying to do too much, and the technology just wasn't supporting our ideas and our aspirations…we could just focus on delivering a really good local project – or a local event." (*Leadership interview)

This decision was also influenced by additional logistical considerations that the RENCI simulcast brought to light (e.g., the difference in time zones between sites, ISI operational needs, etc.). A result of the technical complications *and* the success of engaging in-person audiences at RENCI was that the Worldviews approach became more centered on-site experiences that directly concerned individual ISIs. As a member of the Leadership Team described it, "it's when we really began having to decide between is it more important to give the experience to the people locally and minimize complication….And at the time, I just thought the local show is everything, really." (Leadership interview)

Project Outputs

Living Maps: From Cosmos to Community (September 2011)

Full Description:
"What makes our communities livable and resilient? Through 3D visualization in the immersive GeoDome Theater, audiences explored the conditions that support life, from the outer edges of the solar system to their own communities in the Appalachian Mountains of Western North Carolina. Understanding these conditions can inform strategies for addressing interconnected challenges in this region.

[…] *Living Maps: From Cosmos to Community* highlighted concepts underlying the Livable Communities Initiative, a 3-year project funded by the HUD-DOT-EPA Partnership. We hosted three screenings and dialogues with audiences who represent an array of regional governmental, planning, NGO and academic institutions tasked to develop regional and local strategies for sustainable development, economic prosperity, and quality growth.

The "Living Maps" program explored three questions with audiences:

- How can we make transportation between where people live and work more sustainable and affordable?

- How do we balance land use demands among agriculture, development, recreation and environment?
- What global and regional issues will affect our communities over the next 20 years?"[7]

Event Type: Hybrid: fit the new show into an existing public program format at the institution, but added new components.

BCD Event Goal: "To get the audience to understand how big issues cross scales." (ISI Survey) Staff felt they achieved this goal "to a great extent."

Audience: Invited guests and public; both purposeful choices, since this ISI does not host a regular visitor base. This event was also simulcast.

Table 8. Demographics of survey respondents to RENCI BCD event

Audience demographic information (37 respondents)		
Visitor group description (n=35)		
On my own	25	71%
With friends or family	6	17%
With an organized group	4	11%
Number of children in group (n=30)		
None	30	100%
One	0	0%
Two or more	0	0%
Number of adults in group (n=30)		
One	16	53%
2 to 5	10	33%
6 to 10	0	0%
11 or more	4	13%
Age (n=33)		
18-29	2	6%
30-39	5	15%
40-49	10	30%
50-59	8	24%
60-69	6	18%
70-79	2	6%
80-89	0	0%

[7] Source: http://worldviews.net/living-maps/

Outcomes Achieved

Audience: Living Maps

There were 37 respondents to the questionnaire distributed after the "Living Maps" presentation. A summary of the audience's immediate reactions and self-reported learning from the presentation is below.

Nearly all respondents (32 of 34 who answered the question) reported learning something new from the show. The learning reported indicated learning was deeply focused on the themes of human use and relationships to natural resources.

- 62% reported learning something about human use of, management of, or influence from natural resources.
- 12% reported learning a general ecological fact or concept
- 9% reported learning about stewardship activities (things being done to address issues)

With the question asked a second way ("something you never realized"), respondents' responses were similar; responses mainly focused on human use of resources.

When selecting and ranking three items that could describe what they got out of their experience with the dome presentation, attendees of the event most often identified the following phrases as one of their top three takeaways (n=30):

- I felt a sense of how small the Earth is compared to the greater universe (50%)
    - This item was ranked as the #1 takeaway by 27% of the audience
- It made me think about the complex interrelations in Earth systems (40%)
- It helped me visualize certain concepts of time and scale (37%)

The majority of the audience also reported that the dome changed their understanding in some way (71%), with the following specific language used to describe how it was changed:

- 33% said it influenced perspective: talking about relationships, connections, a systems perspective, or the cosmic-global-local connections
- 27% said it allowed them to see: the benefit of visuals with the presentation
- 20% said they understood: referenced content, information, facts learned

What attendees liked most about "Living Maps" included technology, content, and pedagogical approaches (n=36):

- The visuals/images presented (tech) (31%)
- The organization and style of the storyline/presentation (19%)
- The content covered (content) (20%)

What attendees suggested could be improved (n=28):

- Content that could be added or clarified (36%)
- Suggestions to improve the speaker's presentation (36%)

ISI Professionals and External Advisors

RENCI staff did report substantial improvement of technical skills from the project, even if not becoming experts in every aspect of the Worldviews technology. RENCI staff reported skills improvement with both “GIS integration into Uniview” and “Breaking the total story into mini-

stories for repackaging and production" (ISI survey). They also rated that they increased from being very under-prepared (1 of 7) before the program to a neutral level of preparedness (4 of 7) at the end in these technical areas:

- Using the full technical capabilities of Uniview in the dome
- Creating visualizations for the dome
- Prepare Earth datasets for Uniview
- Using WMS and other layers in Uniview's Geoscope

Given the existing skills and knowledge of RENCI personnel in pedagogy and the content, there were no substantial gains reported from Worldviews. However, the ISI staff did report their institution has developed "even greater knowledge of how to get people involved in systems thinking and complex problem solving" (ISI survey). An ISI staff person also indicated that, since the BCD event, RENCI has already:

- Used storytelling/narrative techniques from Worldviews
- Worked with an advisor/attendee from BCD

Participation also presented **important opportunities for relationship-building and extending the reach of RENCI's programs**. An immediate outcome of the RENCI event was that ISI professionals reported event audiences of unprecedented sizes and interests. In their words, the event included "a whole new segment of our communities" and "got them to be thinking about the science themes that we wanted to so we could actually, then, have conversations off of that" (ISI interview). This event, in particular, highlighted the potential of the Worldviews Network model to use a production as a springboard for community dialogue and action. As one RENCI staff member wrote, the BCD demonstrated the "Importance of compelling storytelling to get across key messages and to get people to think a different way" (ISI survey). Furthermore, **staff perceived value in using what they saw as an "attractor technology" to facilitate better visualization and conversation of a complex issue**:

> *I really do think it was a much larger group of people willing to participate and this growing conversation of adaptation and resilient communities. You know, 'What are some of these things that are coming on the horizon? Why should I be thinking about devoting some near-term resources of time to something that might have some uncertainty?' But once I can see this picture, I can understand—'Oh yeah, now I'm understanding why I'm thinking about this and actually thinking about taking some action.' So I think it really did connect those dots for us quite well.* (ISI interview)

In addition, staff fostered **ongoing relationships as a result of project work, particularly in the form of additional work with the Worldviews Leadership Team on creating new visualizations** that were specially tailored for use at RENCI. According to their Worldviews collaborators, "we actually ended up doing custom visualization movies afterwards that they have since used regularly for their high-def visualization, as well as their portable dome. So it got a lot of play after the presentation" (Leadership interview).

Institution

At the institutional level, RENCI **demonstrated a commitment to reusing and repurposing Worldviews products over time following their event**. In addition to using custom visualizations in their educational spaces, RENCI staff also repurposed some segments of existing presentations for classroom use; some of the data visualizations were seen as leverage points for supporting the Livable Communities Initiative (an existing interagency effort to demonstrate the connectedness of

issues like development, energy use, etc.). Specifically, the intended purpose was "to create these stories so that they were not only delivered by a live person at a one-time event in a 3-D environment, but to also create that stories in that same entertaining format so that they could be displayed on a flat screen and accessed via a variety of platforms" (ISI interview).

Following the event, ISI personnel split a recording of RENCI's BCD event into chapters and made it available online as a set of video resources in order to "pull some of those into a classroom to help teachers teach some concepts, to use the whole thing to get new community members involved in this larger project we've got for the sustainable communities initiative here" (ISI interview). Ultimately, **RENCI's outreach focus, pre-project resources, and enthusiasm for the show topic meant that this early event demonstrated the potential for meaningful community extension of Worldviews efforts, both locally and at the network level.**

Case 3: California Academy of Sciences

Site Overview

California Academy of Sciences (CAS) is a large ISI with a full-dome planetarium, as well as a Worldviews partner which had a Co-PI on location, as well as the project manager. As such, this site had personnel who were experienced with both the Uniview system and the process of preparing immersive visual data. The institution's size and prestige as a research institution also meant that there was a potential pool of on-site content experts in Earth science. Given CAS's role on the project, the institution was strongly connected to the central grant partnership and was aligned to its goals for connecting the planetarium to broader science outreach. In fact, early conversations with potential community partners had in some cases already taken place before the project began:

> *We got talking about how we could bring in these indigenous voices through digital datasets, and in a live event. And we just started thinking about it…when we got the grant, it was really exciting because we thought here we have the Cal Academy as a venue, San Francisco Estuary Institute as the data supporters and partners, and the SFEI also has partners with government agencies and all kinds of conservation organizations that are working on restoring different habitats around California.* (Leadership interview)

As a result of strong capacity and early efforts toward building partnerships, CAS started its participation in the Worldviews Network extremely well-positioned to reach a range of audiences through live presentation of visual data.

Worldviews Approach

CAS hosted the third Worldviews Network BCD event in December 2011. This event, titled "Valley Oaks: An Ecological Journey Through Time," focused on Bay Area ecology, particularly as it related to the relationship between humans and tree species. This event was split into two presentations, one presented in the afternoon for invited guests and stakeholders, with some public attendance, and one presented in the evening as part of CAS's regular NightLife public programming. Given the ISI's pre-project resources, this event did not require any critical support from the Leadership Team beyond the typical production role. Both events included a post-presentation dialogue. In addition, successful collaborative efforts among existing local partners meant that this event was considered an important moment for understanding the potential deep involvement and contributions of community advisors.

A critical way that community advisors were involved in the "Valley Oaks" production was through heavy participation in developing the narrative, especially in ensuring that tribal voices were represented. Depending on their specific content interests, some advisors also helped in developing data sets and/or the storyboard itself. According to project leadership, this supported the project more broadly by identifying areas where advisors could authentically contribute to productions and their associated events:

> *We were able to kind of solidify a process of how to engage an advisory group…It worked out so well, and that the fact that we had such a diverse group of advisors that assisted in the narrative and developing the narrative, and forcing datasets, and reviewing it and giving us feedback. They were so responsive and so involved. We had about 12 of them. And that was really exciting.* (Leadership interview)

CAS also hosted the eleventh Worldviews Network event, "The Hidden Ocean," which was held as part of a NightLife event in September 2013. The topic of this event was selected to focus on a key area of research and conservation leadership by CAS, occurring in the Philippines. This presented a minor hurdle to the established process, because it meant this BCD event would require some additional content development to contextualize the global research as a locally relevant issue in the Bay Area. This eventually led the team to concentrate the event around coral health, since the issue could be connected coherently to a relevant ecological concern as well as ISI content priorities. Although the team was ultimately happy with the story they developed, the shift from the highly local Valley Oaks story to one that was geographically more distant meant that "It took a while to really land on that" (Leadership interview). The event also included a dialogue after the presentation for those who chose to remain; this was the first piloting of a formalized structure for the dialogue component.

Although ISI inputs remained strong, personnel transitions and other staff obligations created challenges during the process of developing "The Hidden Ocean." Specifically, CAS's local point person ended up being the same as the overall project manager for Worldviews; in the case of "The Hidden Ocean," the production process overlapped with the production of two additional BCD events (Perot's and a special event for the National Parks Service). Because of these circumstances, the event science content lead (and main presenter) took on a fair amount of independent work. As a member of the Leadership Team noted, he "did a phenomenal job with what he had to prepare. But I don't think he was expecting as much work as it was" (Leadership interview). However, because CAS was a core team site, the Worldviews project manager was physically there, and it was possible to do a comfortable amount of rehearsing prior to the event.

Comparison of the notes taken during dialogue portions of each event, as well as reflections from the Leadership Team, it seemed as though the "Hidden Ocean" dialogue had somewhat less audience engagement than the "Valley Oaks" dialogues. While there was general agreement that all the dialogue segments were somewhat successful, the Leadership Team noted that the post-presentation discussion at the "Hidden Ocean" event was more focused on Q&A with a few experts, rather than discussing or raising questions about the complexity of the issue. Similarly, the notes from the "Valley Oaks" NightLife audience dialogue compared with the "Valley Oaks" stakeholder dialogue indicate that the stakeholder audience engaged more deeply in issues and solutions, where the NightLife audience appeared to focus on Q&A and critique of the program. An important takeaway from both events was the extent to which audience composition, facilitation, and/or role of experts could affect audiences' comfort and ability to engage critically with the topics at hand.

Project Outputs

Valley Oaks: An Ecological Journey (December 2011)

Full Description:

Valley Oaks: An Ecological Journey Through Time took audiences inside the Morrison Planetarium on an immersive tour from the canopy to the cosmos, exploring the history and ecology of one of California's most iconic and threatened tree species, the Valley Oak. Academy scientists, indigenous partners, and historical ecologists from the San Francisco Estuary Institute revealed how Valley Oaks and humans are intertwined in a relationship of disturbance and adaptation, with implications for the health and well-being of Bay Area communities. There were two screenings and dialogues that hosted over 520 people representing a diverse array of participants ranging from policy

makers, local tribes, NGOs, educators, and scientists working to help re-establish the Valley Oak in Northern California as well as public audiences during the Academy's NightLife after-hours event.[8]

Audience: Primarily invited guests, with some public (daytime); mostly public (evening)[9]

Daytime audience demographic information (122 respondents)			**Evening audience demographic information (113 respondents)**		
Visitor group description (n=112)			**Visitor group description (n=101)**		
On my own	27	24%	On my own	11	11%
With friends or family	64	57%	With friends or family	85	84%
With an organized group	21	19%	With an organized group	5	5%
Number of children in group (n=109)			**Visitor group description (n=98)**		
None	102	94%	None	95	97%
One	5	5%	One	1	1%
Two or more	2	2%	Two or more	2	2%
Number of adults in group (n=103)			**Number of adults in group (n=95)**		
One	24	23%	One	10	11%
2 to 5	62	60%	2 to 5	73	77%
6 to 10	17	17%	6 to 10	10	11%
11 or more	0	0%	11 or more	2	2%
Age (n=111)			**Age (n=96)**		
18-29	11	10%	18-29	36	38%
30-39	30	27%	30-39	29	30%
40-49	24	22%	40-49	16	17%
50-59	22	20%	50-59	9	9%
60-69	18	16%	60-69	6	6%
70-79	3	3%	70-79	0	0%
80-89	3	3%	80-89	0	0%

[8] Source: http://worldviews.net/valley-oaks/

[9] Here, CAS sought to create events for both audiences: "none of these groups had really gotten together around the story of the oak, per se, so it was an exciting discovery…to say, well, let's do this… we immediately filled the dome with just private partnerships. So we thought, well, we can't just do private partnerships in a public museum; we should also do something to bring the public in" (Leadership interview).

The Hidden Ocean (September 2013)

Full Description:

"Though we live on a blue planet, the ocean is vast and largely unexplored. As scientists have begun to map its vast underwater worlds, they have discovered many ways in which the ocean makes life on Earth possible. Not only does the ocean regulate climate worldwide, but human well-being and the global economy are intimately connected to the health of ocean ecosystems. Come join us in the California Academy of Sciences' Morrison Planetarium on September 5, 2013 at 6:30pm for an immersive journey from deep space to the deep blue sea, visualizing previously invisible relationships that are shifting perspectives on the extraordinary conditions of our home planet.

The live presentation will be guided by Bart Shepherd, Director of the Steinhart Aquarium, and David McConville, Creative Director of the Worldviews Network. Admission is free to anyone attending the Academy's NightLife event.

After the presentation, enter into a dialogue with scientists and entrepreneurs about the ways in which human activities are affecting the ocean. We'll explore the numerous case studies of how combining scientific research and entrepreneurial approaches are creating new opportunities to increase both human and ocean well-being."[10]

Audience: Mostly public (evening event)

Audience demographic information (87 respondents)		
Age (n=66)		
18-29	31	47%
30-39	22	33%
40-49	8	12%
50-59	4	6%
60-69	0	0%
70-79	1	2%
80-89	0	0%
Attendance to dome presentations (n=73)		
5+ times per year	4	5%
2-4 times per year	14	19%
About once a year	11	15%
Less often than once a year	19	26%
Today was my first show	22	30%
I work here	3	4%
Special training or expertise about topic (n=66)		
Yes	15	23%
No	51	77%

[10] Source: http://worldviews.net/hidden_ocean/

Outcomes Achieved

Audience: Valley Oaks

There were a total of 122 respondents to the questionnaire distributed after the "Valley Oaks" presentation during the day (to stakeholders), and 113 respondents to the evening presentation (general public). A summary of the audience's immediate reactions and self-reported learning from each of the showings is below.

Nearly all respondents (around 90% in each group) reported learning something new from the show. The learning reported (of those who wrote an answer; 103 daytime, 69 evening) indicated a split of learning related to Earth ecology facts and concepts, as well as strong learning about human use and relationships to natural resources.

Daytime/Stakeholders

- 27% reported learning about ecological changes over time, often referencing human influence.
- 19% reported learning about stewardship activities (things being done to address issues).

Evening/Public

- 33% reported learning a general ecological fact or concept.
- 19% reported learning about ecological changes over time, often referencing human influence.
- 10% reported learning about a connection between Earth and the universe (such as the idea of planetary boundaries and Earth's uniqueness in the universe)

With the question asked a second way ("something you never realized"), respondents' responses were similar; both sets of responses mainly focused on the idea of ecological change over time and implied human effects.

When selecting and ranking three items that could describe what they got out of their experience with the dome presentation, attendees of "Valley Oaks" most often identified the following phrases as one of their top three takeaways:

Daytime/Stakeholders (n=85)

- It helped me visualize certain concepts of time and scale (35%).
    - This item was ranked as the #1 takeaway by 13% of the audience.
- I felt a sense of how small the Earth is compared to the greater universe (33%).
- It made me think about the complex interrelations in Earth systems (32%).
    - This item was ranked as the #1 takeaway by 13% of the audience.

Evening/Public (n=56)

- I felt a sense of how small the Earth is compared to the greater universe (39%).
    - This item was ranked as the #1 takeaway by 22% of the audience.
- It helped me visualize certain concepts of time and scale (38%).
- It made me think about the complex interrelations in Earth systems (27%).

The majority of the audiences also reported that the dome changed their understanding in some way (83% daytime; 75% evening), with the following specific language used to describe how it was changed:

- It influenced perspective: talking about relationships, connections, a systems perspective, or the cosmic-global-local connections (38% daytime; 29% evening)
- It allowed them to see the benefit of visuals with the presentation (27% daytime; 34% evening).

What attendees liked most about "Valley Oaks" included technology and content:

- The visuals/images presented (tech) (21% day; 60% evening)
- The content covered (content) (12% day; 23% evening)

What attendees suggested could be improved:

- Content that could be added or clarified (33% day; 26% evening)
- Technical glitches (25% day; 35% evening)

Audience: The Hidden Ocean

There were 87 respondents to the questionnaire distributed after the "The Hidden Ocean" presentation. A summary of the audience's immediate reactions and self-reported learning from the presentation is below.

Nearly all respondents (83 out of 86 who answered the question) reported learning something new from the show. The learning reported (from 74 people) indicated learning mostly about ecological concepts, but learning particularly in areas of scale and change that highlight the systems focus of the presentation.

- 23% reported learning a general ecological fact or concept.
- 20% reported learning about human use of or relationship to natural resources, and the influence of resources on humans.
- 19% reported learning about the importance of an issue.

When selecting and ranking three items that could describe what they got out of their experience with the dome presentation, attendees of this BCD most often identified the following phrases as <u>one of their top three takeaways</u> (n=33):

- It made me think about the complex interrelations in Earth systems (48%).
- I felt a need to take better care of Earth (39%).
    - This item was ranked as the #1 takeaway by 27% of the audience.
- I felt a sense of the sacred in regards to Earth (30%).

In response to the added retro-pre/post question to self-report the extent to which they felt their knowledge had been affected by the event, reflecting on how knowledgeable they felt they were before and after the presentation. A paired samples t-test revealed gains of more than 1 point for three of the four statements (out of a 5-point scale), and that gains were statistically significant (Table 9). While post-knowledge levels were moderately high (4.12) on the topics presented, the concepts of groups working on the problem or opportunities to get involved rose only to neutral levels after the presentation.

Table 9. Attendees' ratings of knowledge before and after the CAS Hidden Ocean.

Statement	N	Before Mean	After Mean	Mean Change
The ecological issue(s) addressed in the presentation***	83	3.01	4.12	1.108
The complex nature of the issue(s) presented***	82	2.93	4.12	1.195
The individuals or groups in my community working on this issue ***	81	2.1	3.46	1.358
Opportunities for me to get involved to work on this issue ***	78	2.15	2.82	0.667

*** Statistically Significant at the .001 level

A majority of the audience also reported that the dome changed their understanding in some way (69%), with the following specific language used to describe how it was changed:

- 37% said it influenced perspective: talking about relationships, connections, a systems perspective, or the cosmic-global-local connections
- 28% said it made them feel immersed.

In terms of the affective response, attendees rated their attitudes to the program, as shown in Table 10, as generally positive. Respondents mainly felt the issue was relevant and that they enjoyed the presentation. They were less likely, however, to get involved in work happening on this issue, giving it an overall mean of 3.5 on a 5 point scale.

Table 10. Average ratings of agreement about attitude items for CAS Hidden Ocean.

	N	Mean	Std. Dev.
The ecological issue presented was relevant to my community.	79	4.29	1.076
I enjoyed today's program.	79	4.16	1.006
I felt inspired by the presentation.	78	3.99	1.051
I intend to find out more about this topic.	77	3.92	0.970
I intend to get involved in work happening on this issue.	78	3.50	1.214

When describing the feelings inspired by the presentation, the most common categories of descriptions of feelings used were (n=87):

- Concern (22%)
- Informed (11%)
- Responsible (9%)

What attendees liked most about this presentation included technology, content, and pedagogical approaches (n=76):

- The visuals/images presented (tech) (37%)
- The presenters (pedagogy) (25%)
- The data used/shown (content) (22%)

What attendees suggested could be improved (n=62):

- The visuals/images presented (47%)
- Technical glitches (21%)

ISI Professionals and External Advisors

An immediate outcome associated with the "Valley Oaks" event was **institutional collaboration among ISI professionals, local organizations, and tribal communities**. In particular, the team as a whole took pains to ensure that "the tribal voices were also deeply embedded in the narrative in the story, so it wasn't just us creating a story, it was these advisors and having the indigenous community involved" (Leadership interview). **Project personnel perceived that the "Valley Oaks" event generated community energy toward re-oaking, but realistically pointed out that the partner organizations would need more scientific data and structural support to act**. Nonetheless, they felt that bringing together indigenous partners, SFEI, and their respective collaborators "blew the whole paradigm out of the water" (Leadership interview). Personnel also reported that some of the collaborations formed through the "Valley Oaks" event are ongoing*:*

> *The organizations are very much continuing on with their work, and a lot of them met up again for the first time at that event. And then continued to develop those relationships. And I also know that we had more indigenous communities in representation of the tribal groups that are in the area that had never come to the Academy before.* (Leadership interview)

In terms of its effect in the local community, project leadership considered the event "a catalyst. It was like a point within the longer continuation of what it takes to bring Valley Oaks and other oak species back into the landscape. So I think that was a big success" (Leadership interview). Ultimately, the collaborations for this event also seemed to **represent ISI staff's efforts toward being more inclusive in their programming**:

> *It was amazing actually having that in Cal Academy, you know, in terms of the boundaries between kind of Western indigenous knowledge and traditional ecological knowledge sort of fused with satellite data. I mean I felt that was a really important effort with regards to demonstrating how those things can be synthesized and support one another (Leadership interview).*

Participation in both events also resulted in technological, content, and pedagogical learning among project personnel throughout the production process. For example, a member of the Leadership Team reported that by working on the "Ocean" event, "I actually learned a whole lot just in terms of the science… and all the ways in which the oceans were interacting to create different zones. I felt that it helped to clarify the way some of that is communicated and why that's important to communicate to general audiences" (Leadership interview). The one ISI staff member who responded to the survey reported learning about the power of certain visualizations using the dome, such as the "'Black Marble'- the Earth at night showing the impacts of commercial fishing" through his participation in "Ocean"; this staffer also reported improved pedagogical skills in "use of the full-dome and Earth visualization software as a presentation tool" and in "crafting a storyline to meet the audience (Nightlife- informal, non-scientific) and accompany the visuals" (ISI survey). While this respondent showed little change in content or pedagogical knowledge (both of which started fairly high) and little change in technical skills (which started very low, and was not a focus of this person's involvement), **there was substantial gains in self-reported learning about the power of the dome**:

- Using the full technical capabilities of Uniview in the dome (increase from 1 to 7 out of 7)
- Using the dome for issue-focused discussions in my community (from 1 to 6 out of 7)

In addition, ISI personnel reported **using technology skills acquired through both events, as well as adopting the Worldviews approach more generally**:

> *We've actually been doing what we call our version of Earth Update, which is very similar to like a Worldviews event. Like we use a similar storyboard and kind of do cosmic, global, local….So we have a routine down together for how we work. And I think being able to kind of take what I've learned from participating in Worldviews and having, like, being on site physically for the production, and knowing the technical side of the house here in house, was extremely beneficial for the process*. (ISI interview)

Institution

Institutional outcomes for CAS included **cross-departmental collaboration**, particularly in developing the "Oceans" event. Although that presentation had fewer local partnerships with external advisors, the topic's relevance to the ISI's own content specialties meant that it provided an opportunity to bring CAS's planetarium and aquarium together. As one member of the team put it, "It seemed like another way of just sort of dissolving the boundaries between these kind of fragmented areas of inquiry that are actually deeply interrelated. You know, like corals are not separate from the universe, but they are usually discussed like it's a totally different discipline" (Leadership interview). Similarly, the "Oceans" presentation resulted in particularly notable **institutional recognition of this strategy, including involvement and participation by CAS leadership in the audience dialogue session.** This event also led to contact from an external conservation organization, which had a representative in the audience, and was interest in a future partnership with the ISI. **Follow-up with ISI personnel suggested greater institutional buy-in to the approach and vision of the Worldviews model**, particularly related to "the internal recognition after the event" (ISI interview). This was specifically observed as coming from those in positions of authority:

> *Like from higher-ups and executives in the Academy that were really excited about what was presented, how it was presented, and the effects that it had on people. They found it to be really powerful. And the dialogue after, they really enjoyed being able to bring the kind of intangible sort of planetarium experience with the tangible. And having some specimens there on site. And the dialogue afterwards, and kind of continuing the conversation afterwards…And we had one of our board members in there.* (ISI interview)

Still, this was also true for ISI personnel who were directly involved in production. According to one staff member, "I have a much better appreciation and understanding of the dome as a storytelling tool. I will encourage my institution to do more programming in the dome that is not astronomy related content" (ISI survey).

Another extended outcome, potentially related to increased skills and buy-in at CAS, was **the reuse of Worldviews products from both events**. For example, a staff member said of the "Oceans" presentation, "I love the topic that we chose…I feel like it was something that could really connect with the museum. And we've talked about kind of doing it again in the future and showing it to all of our staff. So I think that there's an opportunity to really integrate that into programming here at the Academy" (ISI interview). More generally, participation in a production with strong advisory support and one that leveraged internal expertise meant that the CAS events together illustrated the power of systematically engaging advisors both to advance the ISI itself and the Worldviews Network collective.

Case 4: Minnesota

Site Overview

The Minnesota Regional Planetarium Network (Minnesota), which includes the Bell Museum of Natural History at the University of Minnesota and the Minnesota Planetarium Society, encompasses "a mix of fixed and portable GeoDome systems running Uniview, sharing costs and program development" for the purpose of regional outreach.[11] Minnesota's involvement in Worldviews was deeply connected to the central grant partnership, and its team's wealth of both Uniview technical expertise and presentation experience meant that ISI staff were initially envisioned as trainers for other partner ISIs. Although this element of Minnesota's participation was not realized in the final grant implementation, due to changes in the nature of PD, local personnel perceived Worldviews as an opportunity to leverage technologies to bring Native communities together and voice localized concerns to a broader audience.

A member of the ISI team reported that Worldviews was an opportunity "To improve our ability to tell Earth stories. To use our dome and dome network to work with local researchers and community of issues to help build better understanding of critical environmental issue" (ISI survey). In particular, ISI personnel reported being drawn to the project's efforts to discuss "the nine boundaries and the boundary conditions, the tipping points to the planet's viability" in a dome visualization format (ISI interview). Furthermore, ISI personnel felt that Worldviews would be a strong fit for their preferred modes of live interpretation and that their work could benefit from the resources associated with a larger group of partners:

> *I'm very proud of the fact that we, more than anybody in the community, were using the tools for teaching and using them interactively….we really felt there's something to what we were doing that was having not just intrigue and interest, but just having—there was stickiness to the learning when it happened in this interactive way versus just media. And so, we were eager to be part of something like Worldviews because we were just a small team and we don't have the budget nor the wherewithal to create the type of resources that have come out of Worldviews.* (ISI interview)

With proficiency in both dome technology and the content knowledge for their BCD narrative (across different members of the team), as well as very close alignment with project outcomes, Minnesota only required critical support from the Leadership Team in the form of logistical assistance. Especially central to the Minnesota's pre-project resources were existing deep relationships with the target audiences within Native communities, as well as broader familiarity with interactive facilitation and cultural competencies related to producing content with and for Native audiences.

Another important part of site context for Minnesota was the unique institutional structure, as a local partnership of institutions and players, rather than a single ISI. Additionally, there were institutional changes over the course of the grant that established the Minnesota Regional Planetarium Network, in a slightly different organizational structure than at the start of the grant. This context, as well as the goals of the site meant that the Minnesota team had to be open and adaptive to change, adjusting to make the most of circumstances. As one ISI representative stated:

> *Because we didn't have the overarching structure of a large institution, and the turnstile and ticket receipts and everything else we had to worry about, we had a lot of*

[11] Source: http://geodome.info/client/minnesota-planetarium-society/

freedom and flexibility to really test ideas, too, and how people learn and so on. So it was a good – for us, it was a really good marriage. There was a lot of growing pains for us, which was driven more than anything else by mergers and things of that sort, but, fortunately, we didn't really have to miss a beat in the overall delivery of service or plans that we had as part of our role in the Worldviews. Things did shift from the original plan, as most grants — we thought it would work out if we did things this way, but we found out it would work better if we did them this way, some of that did happen, but we still participated fully and gained quite a bit from our role. (ISI interview)

Worldviews Approach

In March 2012, Minnesota hosted the fourth Worldviews event, "Where Condor Meets Eagle." Held in conjunction with the Augsburg Native American Film Series, this BCD event brought together invited guests from indigenous communities in Minnesota and Bolivia at the Bell Museum of Natural History. The event was focused on cultural knowledge in relation to contemporary issues related to sustainability, and it particularly emphasized a dialogue component.

Aside from assistance with preparing the data visualizations, the local team took the lead on most aspects of production development, while the Leadership Team remained heavily involved through ongoing communication and at the event itself. Their combined efforts answered both logistical challenges (e.g., the necessity for multiple layers of live language translation) and the complexity of framing the event with visual data. According to a member of the Leadership Team:

it was really another exploration of how [data visualization] is used in the environments to facilitate cross-cultural dialogue work with indigenous knowledge…And I felt that one was quite a success from the perspective that I had an opportunity to do the steering on the indigenous film festival. And then we did a pretty extensive post-dialogue kind of about a lot of how they are dealing with or the observations they are making about climate change and how it's sort of shifting traditional stories that are used…a mnemonic device that understands certain cycles and patterns within their environment. (Leadership interview)

Further, the general process of production for the Minnesota team demonstrated a greater amount of adaptability and flexibility of process than was evident in many other Worldviews Network production processes. The qualities and unique skill-set of the ISI point-people in Minnesota seemed to contribute to this increased flexibility of process. As noted, ISI staff leads had been originally tagged as advisors/trainers to the overall project. In that vein, personnel within the Minnesota ISI team took on roles of both ISI representative and community advisor simultaneously, having entered the project from positions of expertise and longtime and trust in working with local indigenous groups. Specifically, this internal role as community advisor was critical to ensuring full and equitable participation among the groups the team wished to engage efficiently and effectively, given the extensive time needed to build relationships and trust between partners:

all birds and fish and plants and buffalo and eagles, it's all relatives to us. We're all, you know, life forms in one large family. So, with that kind of context, we really wanted those elders' perspectives, and it took a couple of years of, you know, kind of building the bridges and the integrity and the relationships. (ISI/advisor interview)

With a team of people at the local ISI (rather than just one point-person) who had the full spectrum of needed expertise for the project (technical, pedagogical, and content), as well as a demonstrated shared vision with the Leadership Team, the leads did not strongly assert the general Worldviews production process at the Minnesota site. The process was allowed to be flexible, letting the expertise and cultural knowledge of the ISI staff team to guide a process that worked well in this site. One member of the Leadership Team described the process as being, "Worldviews, as a production group, working with directors of their own systems and their own ways of working. So it was like [ISI staff member] just working away on his own visuals and working with [ISI advisor], and we just sort of touched in to make sure that it could work for all of us" (Leadership interview).

Minnesota also organized the seventh Worldviews event, "Dakota Star Stories," in February 2013. Attendance at this event was limited to residents and guests of the Upper Sioux Community, which hosted the event, and the presentation and dialogue focused on the connections between Native cosmologies and key environmental issues identified by community members. Although the local ISI team was again mainly self-sufficient and allowed to develop the BCD event with their own process, this event presented logistical challenges that needed Leadership Team support to help resolve. A particular concern was sourcing and delivering a portable dome for the event, which personnel in Denver were able to facilitate. As Worldviews Leadership described the event itself, "we were using a lot of the same visuals as your previous event, but something more focused on the concerns of that particular tribal community. For the most part, it was kind of [the Minnesota Team] doing something really independent of the rest of the team, and we were able to provide financial support" (Leadership interview).

As ISI personnel explained, "the technical support was mostly in the preparation of some of the elements that we had and some of the GIS layers, things like that. And that was great" (ISI/advisor interview). Worldviews also offered a few opportunities for viewing simulcast presentations from other ISIs:

> *We, probably because we cut our teeth so early on all of these things…we were pretty independent in terms of our own BCDs, but we also made it a point of trying to participate in all of the others….any time we could, actually — we would have range from myself watching it sometimes with some of the other guys to audiences from some of our small planetaria. And so they enjoyed that opportunity to bring in a voice on a critical issue, even though it may not be specific to our community, you can generalize those things, like the 'Water Story' or something*. (ISI/advisor interview)

Similarly, Leadership reported that for "Where Condor Meets Eagle," "we did do an *Octopus* session – a very successful one, actually, I think, in the end. We got to listen in at least to the dome component…if not the full event" (Leadership interview).

Although the workflow leading up to each production at Minnesota looked somewhat different than at other sites, all project personnel described a highly collaborative process with strongly coordinated objectives. For example, an ISI representative reported that "The whole team is very willing to support in whatever it takes. We communicate often through e-mail and live and phone conferencing, and, you know, it's a wonderful team…There are some common partners, some goals in the process. So, I think we've all learned from each other" (ISI/advisor interview). Given the orientation of both Minnesota events, this extended to important issues related to representation and non-Western ways of knowing:

> *[The Leadership Team is] always willing to take suggestions and feedback from us. We know that we're coming in maybe looking at this differently than they have*

traditionally looked at this kind of data and information, and that it's important for us to be able to include cultural components, cultural teachings about these things. And they're willing to – you know, they're willing to hear them to figure out how to try to include them – and try to include our communities as well. (ISI/advisor interview)

Across audiences, events, and project roles, a key element of Minnesota's participation in Worldviews was building existing relationships and skills. Interestingly, although a relationship with the University of Minnesota also existed, this site's team chose to not focus their story or programming on University faculty's research/expertise, instead focusing on the ISI/advisors' work with Native communities. This was a decision both to focus the story and form of outreach, as well as to obviate the logistical barriers that emerged when trying to engage faculty in a lengthy process of BCD narrative development (e.g., scheduling difficulties, departmental siloes, etc.).

Project Outputs

Where Condor Meets Eagle (March 2012)

Full Description:
"*Where Condor Meets Eagle* brought together an invited delegation of indigenous educators and community leaders from Minnesota and Bolivia in an afternoon of visual storytelling and cultural exchange in the Bell Museum's Exploradome.

Part of the Augsburg Native American Film Series, the afternoon consisted of ceremony and dialogue about issues of community health, environment, cultural traditions, and cosmologies that unite the First Peoples of the Americas. The result of an agreement between the Bolivian Ministry of Decolonization and the Phillips Indian Educators in Minnesota, the program utilized the power of immersive, interactive visualization technology to explore astronomical, cultural, and Earth based imagery guided by participants and Worldviews facilitators Jim Rock and Joel Halvorson. Taking place in All Nations Church in downtown Minneapolis, the program was dedicated to providing educational, multicultural, and cultural empowerment for Native people through an Indigenous film, art, and cultural exchange."[12]

Event Type: Hybrid: fit the new show into existing public program format at our institution, but added new program components

BCD Event Goals: "To build multicultural (multi-lingual) awareness and understanding of issues that impact indigenous communities in the Americas"; staff reported achieving that goal "somewhat" (ISI survey).

Audience: Community leaders, Minnesota tribal communities, indigenous delegation from Bolivia, local public (event also partially simulcast)

[12] Source: http://worldviews.net/condor-meets-eagle/

Dakota Star Stories (February 2013)

Full Description:

Because this was a private event, it was not advertised on the Worldviews Network website. One of the presenters described the general premise and orientation of this event as follows:

> *there was interest in getting our community's perception of what's been changing. And then also because of our star knowledge. We directly originate from star groups, very culturally significant to us. We say, "We come from the stars, into the stars we return. We come from the Earth, to the Earth we return." There are sites on the Earth that mirror like a map constellation sites in the stars.* (ISI/advisor interview).

Event Type: Hybrid: fit the new show into existing public program format at our institution, but added new program components

BCD Event Goals: "To build multicultural and intergenerational awareness and understanding of environmental issues that impact tribal communities in MN and elsewhere." Staff reported achieving that goal "somewhat" (ISI survey).

Audience: Residents and guests of Upper Sioux Community

Outcomes Achieved

Audience: Dakota Star Stories

For the "Where Condor Meets Eagle" BCD event, the multilingual and intercultural format and audience meant that the audience questionnaire that the project team had been using at other sites would have been an inappropriate evaluation tool for this event and audience. Given this (and the lack of a project evaluator at the time), direct audience data were not collected for this event.

For "Dakota Star Stories," similar concerns about the appropriateness of the standard, interim audience questionnaire being used by the project were present; so the ISI and advisors in Minnesota developed their own questionnaire specifically for that event. The questions were administered before and after the dome presentation, in a written form. While most of the items were geared to the ISI's internal program and outreach activities, a few areas yielded insights about Worldviews-related outcomes. A summary of responses to these items on the post-presentation instrument is included below. Twenty-three audience members responded.

When asked to describe the ways in which the presentation was helpful or informative, half of respondents (n=10) mentioned or alluded to cultural relevance of seeing astronomy and topics presented in a relevant cultural context:

> *Just really cool to see and perceive the Universe and the vastness of Indigenous knowledge*
>
> *I loved all the stories particularly the ones about the sky matching the Earth*
>
> *Links between cultures*
>
> *Informed me about how long our people were here for.*
>
> *It was motivating because it was Dakota, not Greek.*

One additional respondent reported that it was “Really neat to see both the planets & the stars,” another wrote “I want to learn more,” and the remaining three respondents all provided general positive comments.

All respondents (n=14) gave positive, affective answers to the question: “What were your thoughts or feelings about being surrounded and immersed by the visual experience?” Most of the responses were brief answers such as "amazing" or "awesome." Three of these, however, further connected their positive feelings to what or how they learned in the dome:

> *Lots of information. Could be used for an immersive experience in learning about stars or the planet’s geography.*
>
> *Easier to relate to.*
>
> *I realized that where we are is our center of the universe and our only point of view. The areas we haven’t seen is what we have yet to learn.*

After the event, when asked to select areas where they saw a "growing personal interest in continuing discussion" as a result of the event, respondents (n=13) answered as below.

- All of these: 9 of 13 respondents
- Dakota and other indiginous cultural cosmovision: 6 of 13
- Climate change / relationship with Maka Ina / Earth Mother: 4 of 13
- Community health and well-being (traditional medicine): 4 of 13
- Education: 3 of 13
- Other: 2 of 13

When asked to select areas for which they would be willing to get involved in local and regional discussions and project work, respondents (n=12) answered as follows:

- Environmental justice issues especially pertaining to your indigenous community... (energy, sacred site and wetland restoration/preservation, toxicity, etc.): 8 of 12 respondents
- Indigenous youth involvement, education and language in traditions: 6 of 12 respondents
- Food security and sovereignty; Food availability & diversity; Affordability and quality: 4 of 12 respondents
- Citizen Science: 3 of 12 respondents
- Ceremony: 1 of 12 respondents

When asked to suggest improvements to the program (n=5 responded), requests for more time were mentioned twice; “more focus,” “more comfortable mats,” and “specifically Dakota stories needed” were each mentioned once.

ISI Professionals and External Advisors

An immediate outcome for both events was **collaboration across institutions and communities**. For the local team, **this took the form of positive feedback and continued relationships with audience members**. After “Where Condor Meets Eagle,” for instance, advisors reported further contact with the visiting delegation about an ongoing collaboration related to Bolivia’s *vivir bien* initiative:

> *Well, we actually were invited to return [to Bolivia]. …They haven’t had a good relationship with our government because we keep trying to take their stuff. And so, it was historic for us to be part of that. And at the end of that, then we created this*

beautiful document on, you know, what we believe is living well and, you know, how well we're – what we're needing from each other to participate in an effort to continue that work so that everybody lives well. (ISI/advisor interview)

Similarly, an important result of "Dakota Star Stories" was supportive feedback from the Upper Sioux Community audience:

I would say the most valuable outcome was that we received a positive thumbs up from those elders and other leaders in the indigenous community. Oftentimes technology can be intrusive, and, you know, certainly not a good bridge. But in this case, Worldviews provided the human and the technology opportunities for bridging our communities and respecting that knowledge. And it allows us to talk about important issues. (ISI/advisor interview)

Despite an already high level of expertise across skill areas, the ISI representative who completed the survey indicated slight skill improvement in almost every area. One area where skills for this individual were reported to go from neutral (4) to well prepared (6) was the **technical skills** "Creating visualizations for the dome. Specifically, this staffer reported an increased **"**ability to create HTML 5 based web pages for more efficient control of Uniview modules and time series animations," (ISI survey). **Improvement of storytelling/narrative techniques** also emerged as a notable outcome for Minnesota ISI staff. Including understanding of "How critically important the storytelling and storyteller are to the process of engagement and understanding" (ISI survey). Staff also reported learning new presentation techniques from watching live broadcasts of other ISIs' shows, such as "The addition of first person experiential elements to help personalize and familiarize a story…I thoroughly enjoyed [a presenter from another ISI's] personal sidebar stories. These stories helped to give issues a human context" (ISI survey).

A more extended outcome reported by ISI personnel and advisors was having **applied a similar approach (i.e., using data visualization to connect local concerns with broader environmental issues) at other events after participating in Worldviews**. For example, one ISI representative cited:

The opportunity to use this methodology to engage our community partners…and to do more of this hybrid storytelling, which is a mixture of kind of Western science and indigenous ways of knowing and using that to incorporate the essence of who they are and the integrity of what they want to become as communities and some of the environmental issues they're dealing with, and so on….all those pieces, we were able to incorporate – use this sensibility and this means of delivering visualization in a story-telling format that has some additional support and structure to it and documentation to it. (ISI/advisor interview)

Another ISI staff member reported using a similar approach in a professional gathering that included stakeholders who represented different levels of planning and policy; in that case, data visualization across scales acted as "a spatial way to connect the dots, we could look at the larger issue, we could look at the local impact, and we could put everything into one common frame" (ISI interview). Finally, staff members reported working together to put on presentations that followed a BCD structure between and after their Worldviews events.

Institution

For the Minnesota network more generally, an extended outcome of participation in Worldviews was both **reuse and repurposing of project assets**. Those who worked directly with the project reported that the products from Minnesota and other Worldviews sites have served as a kind of repository for show resources and for extension at other sites:

> *the archive of that and then also the scripts…and the narrative scripts that go with it just help to create your own thing based on those assets. So that has been huge for us because we've also taken all the — many of the various BCD assets, and we've had some of our community members of our ten-member network who have participated as remote sites, but we've also taken it upon ourselves to train them in on using them. You know, or this module might work really well for middle school kids, or whatever. So it's become, in some ways, like a library source of resources for our little community of ten.* (ISI interview)

At the same time, staff also reported that **access to project assets had also allowed their colleagues to explore ways to repurpose visual data:**

> *the legacy of Worldviews has been really huge because while we may not replay a carbon copy of a BCD from some of the other communities, we have repurposed many of those — and continue to repurpose many of them for all number of programs. You know, a good example in a couple of weeks, the Bell Museum, that's the Natural History Museum, is opening an autobahn exhibit. And so my colleague over there, who has been part of Worldviews, she's basically putting together an interactive Planetarium program using stuff from the American Museum of Natural History BCD, to go with the opening of this autobahn exhibit. Now, completely different application than the BCD, but wouldn't be able to do it in the ways she's designing it without it. You know, to be able to lay over the migration path and to talk about some of the natural migration patterns, and so on.* (ISI interview)

An ISI representative also reported that "without the WvN we would not have been able fully develop or deliver the wealth of content and data we now have available and have integrated into our programming" (ISI questionnaire). More specifically, Worldviews "has reinforced the value and impact of doing live programming over 'canned' and it has empowered us to pursue more research based live programs. Knowing there is a community of practitioners also pursuing these goals also helps to build the local case for further development" (ISI questionnaire). Finally, **ongoing relationships between staff and external advisors reflect another important outcome.** In the ISI survey, a respondent reported Minnesota had already done these extended actions at least once since their BCD event:

- Additional programming/community engagement about the ecological issue from our BCD event
- Been in contact with one of the Advisors/attendees from the BCD
- Worked with one of the Advisors/attendees from the BCD

They also reported they are planning to engage community partners/advisors to contribute to new projects. ISI representatives reported **stronger relationships between Minnesota, its community advisors, and, by extension, tribal community partners,** which they connected to participation in Worldviews:

> *we have this kind of ongoing program we've done many times with one of the Worldviews [advisors]…but we didn't have the wherewithal to do the extension we did*

with the two BCDs, and sort of allowed us to focus and to introduce this concept to some of the other community leaders and some of the elders from a couple of the tribal communities in Minnesota, as well as the partnerships that they had with a community in Bolivia, when they had this ongoing dialogue between indigenous communities in North America and South America. (ISI interview)

Case 5: University of Michigan Museum of Natural History

Site Overview

As an ISI attached to a large academic institution, the University of Michigan Museum of Natural History (formerly known as the Exhibit Museum of Natural History, referred to here as Michigan), focuses on serving a combination of public audiences, school audiences, and the University community. The museum has a full-dome planetarium. Although the museum and the planetarium do not have a large dedicated staff, its institutional connection to the University of Michigan made its experiences with the Worldviews production process show some qualities similar to those of the large ISIs.

As the institution made a move toward greater emphasis on its University audience, Michigan needed to find a way in its programming to both support faculty requests and remain accessible and compelling for school and public audiences. Previous contact with DMNS about potential applications of planetarium technology led to Michigan's involvement in the Worldviews Network; according to an ISI representative, Worldviews seemed "like an avenue to some new resources and new people and new experiences" (ISI interview), pursuing institutional goals of "Development of new skills and tools; new presentation content for our audiences" (ISI survey). Despite the relatively small staff at Michigan, they began with strengths and assets of a full-dome planetarium facility, technological experience with creating visualizations (around astronomy), and experience presenting and developing presentations (around astronomy).

Worldviews Approach

In October 2012, Michigan hosted "The Lake Effect: Creating a Resilient Future," which was the fifth Worldviews BCD event. The event, which included a Science Café-style dialogue segment after the dome presentation, focused on the relationship between fresh water systems and climate change. Michigan's connection to the University meant that faculty and researchers were both key community advisors and a primary audience for the event. However, it emerged that ISI staff efforts were supported by the Leadership Team through technological troubleshooting and content development.

Michigan's on-site personnel came to the project with a broad story idea in mind, and because of this, the Leadership Team and local contributors began the process by emphasizing a need to narrow the scope and develop content details during the scripting and storyboarding process. Major project support from Leadership Team members, beyond data visualization, included "the process of looking for advisors, for thinking and brainstorming towards story ideas, for narrowing down the story, for going out and looking for datasets" (Leadership interview). In general, the Leadership Team's role was described as very hands-on, largely due to the need to give heavy support to both Earth science content development and technological troubleshooting.

Both ISI staff and the Leadership Team reported a heavier workload than initially anticipated in the process of producing the Michigan BCD event, which seems to have stemmed from several contributing factors. One of these was the change of Worldviews' project manager, which meant the Leadership Team was experiencing a transitional moment during Michigan's production timeline. Although the collective efforts resulted in a successful production, the loss of the project manager combined with a very small ISI staff meant that individuals within the Leadership Team and at the ISI took on more responsibilities than they did for other events, and certainly felt the pressure of

this workload at the time. In addition, the academic calendar meant that coordinating schedules with local advisors/faculty was very difficult, particularly when content experts had to travel for their research: "we had a lot of drop-outs, which is not unusual in the university community. Especially the time of year we were trying to do this [summer production for a fall BCD event]" (ISI interview). Community advisors who participated were mostly University faculty/researchers, and they supported the production by sharing information with ISI staff, in some cases providing data sets, giving facility tours, or referring staff to other experts.

For the Leadership Team, the Michigan production was an opportunity to better articulate how and why storyboarding could be implemented across institutions. As with DMNS, the ISI staff at Michigan had extensive experience with both delivering live presentation and developing planetarium shows. As a result, the Leadership Team discovered the need to more fully discuss and articulate the unique value of the Worldviews approach, along with collaborative norms for and benefits of working with advisors, rather than using the ISI's tried-and-true, go-it-alone approach. As one member of the Leadership Team put it, "it was exciting for us…[to] walk ourselves through…what can we offer these institutions that aren't used to reaching out to collaborators, and how do you do that in an authentic and timely way?" (Leadership interview). For the ISI staff, this meant having to adapt to a very different approach to presentation development, including the focus on a new type of content (ecology, rather than astronomy) and engaging community advisors for data and to create a new story. While this was a substantial learning curve, which took support and encouragement from the Leadership Team, in the end the ISI staff showed great success at seeking and finding datasets, content, and visualizations to create this new type of presentation.

Combined with the technological support work the Leadership Team consistently contributed across sites, the specific needs at this ISI "would also help me think about, well, if I had to train people on how to do those, this is what I have to do" (Leadership interview). Finally, members of the Leadership Team reported that remote simulcast with Michigan "went flawlessly" and they felt that the overarching goal of improving ecological literacy among those who attended the Michigan event "was precisely what we were able to do" (Leadership interview).

Project Outputs

The Lake Effect: Creating a Resilient Future (October 2012)

Full Description:

"For *The Lake Effect: Creating a Resilient Future*, the University of Michigan's Museum of Natural History Planetarium linked with numerous other domes across the country to present a live program about the Great Lakes Watershed. Participants interactively explored climate-related issues relevant to one of the largest fresh water systems on the planet using 3D scientific visualizations and 2-D historic imagery from numerous sources, including NOAA, NASA, and JPL. This program has now become part of the planetarium's public and school program offerings.

The event was followed up with a Science Cafe about climate change and the Great Lakes region with scientists from NOAA's Great Lakes Environmental Research Laboratory and the University of Michigan's Great Lakes Integrated Sciences & Assessments Center."[13]

Event Type: Entirely new program/event for the Worldviews show.

[13] Source: http://worldviews.net/the-lake-effect/

BCD Event Goals: "Let faculty and staff know of the tools we have available for presentation" (ISI survey) ISI staff reported goals were achieved "to a great extent"

Audience: Invited guests and public

Table 11. Demographics of survey respondents to Michigan Event

Audience demographic information (9 respondents)		
Sex (n=9)		
Male	2	22%
Female	7	78%
Age (n=7)		
18-29	1	14%
30-39	0	0%
40-49	1	14%
50-59	3	43%
60-69	1	14%
70-79	1	14%
80-89	0	0%

Outcomes Achieved

Audience: The Lake Effect

There were a total of 9 respondents to the questionnaire distributed after the "The Lake Effect" presentation. A summary of the audience's immediate reactions and self-reported learning from each of the showings is below.

All respondents (8 of 8 answering the question) reported learning something new from the show. The learning reported primarily focused on learning about ecological change over time, including implied or stated effects of human actions.

- 6 of 8 respondents reported learning about ecological changes over time, including referencing human influence
- 2 of 8 respondents reported learning about ecological information related to large geographic scales and breadth

With the question asked a second way ("something you never realized"), respondents' responses were similarly split between topics of ecological change over time and ecological facts about large geographic scales.

When selecting and ranking three items that could describe what they got out of their experience with the dome presentation, attendees of this BCD event often identified the following phrases as one of their top three takeaways:

- I felt a need to take better care of Earth (6 of 7 selected).
    - This item was ranked as the #1 takeaway by 3 of 7 respondents.

- It made me think about the complex interrelations in Earth systems (4 of 7 selected).
- I learned or was reminded that the Earth is always changing and evolving (3 of 7 selected).

About half of this group reported that the dome changed their understanding in some way (4 indicated yes to change, 4 indicated no). The following specific language used to describe how it was changed:

- It influenced perspective: talking about relationships, connections, a systems perspective, or the cosmic-global-local connections (2 respondents).
- It allowed them to see the benefit of visuals with the presentation (2 respondents).

What attendees liked most about "The Lake Effect" included technology and content:

- The visuals/images presented (tech) (4 of 7 respondents)
- The content covered (content) (2 of 7 respondents)

What attendees suggested could be improved:

- Presenters / style (3 of 7 respondents)
- Content that could be added or clarified (2 of 7 respondents)

ISI Professionals and External Advisors

Among the staff-level outcomes for Michigan, **a particularly important achievement was improved institutional collaboration**; although scheduling challenges precluded heavy involvement from advisors during production, an ISI representative reported that "they're still around. And I'd like to reconnect with them on discussion that we had had earlier in this planning process" (ISI interview). Further, both ISI staff and the Worldviews Leadership Team reported that, throughout the process of developing the event, Michigan personnel had gathered information and data sets from advisors that were critical to the success of the event (e.g., seeking out content information about seasonal agricultural practices, etc.), and **the event served as a tangible example of how Michigan's planetarium could be used to tell stories related to Earth science**.

Another important outcome area was in skills development. Within this area, learning tended to concern technology, "through new skill sets, access to new data, how to manage data" (ISI interview). According to an ISI staff member, this included "learning how to do things like what became the media containers essentially, which I use now a lot. I've designed several more programs that are kind of like this…using the same kind of a format, formula that the BCD used. I maintained that as a structure to build other things in" (ISI interview). ISI staff responding to the survey indicated growth in preparedness in three technological areas:

- Using the full capabilities of Uniview in the dome (from 4 to 6 out of 7)
- Preparing Earth datasets for Uniview (from 3 to 6)
- Using WMS and other layers in Uniview's Geoscope (from 3 to 6)

Specific staff-reported examples of technological learning included "the use of data sets, converted for use in Uniview" and "pulling images from Google Earth, use of the Tileset Tool, and general understanding of KML/KMZ files, and where they go in Uniview" (ISI survey).

ISI staff also indicated in the survey that there were substantial **gains in awareness of the issues and community resources addressing the issues dealt with in "The Lake Effect**." ISI staff reported going from being slightly low or neutral in awareness to moderate awareness:

- Awareness of the work people are doing to effect change on this issue (from 3 to 6 out of 7)
- Awareness of who are the key people/organizations in my community working to address this issue (from 4 to 6)
- Using the dome for issue-focused discussions in my community (from 3 to 5)

ISI personnel also reported that **the Michigan event resulted in their adopting a similar approach for some of their live programming**:

> *We wouldn't have done this at all without the Worldviews project. And so that's what really was the catalyst -- more than that. It's what started it. And was the catalyst to get it done. And will be the model in the outline that we're going to use to redo it and to do other topics down the road. Because that's the style of presentation -- we do lots and lot and lots of live shows. But this was a style that we hadn't precisely done before that I generally liked. It was a non-astronomy approach which I liked. In fact I have -- I'm working on two others right now that are going to be just live discussions using Uniview. That's using a whole bunch of stuff from the BCD as well. So that approach will continue on and will impact our future programming.* (ISI interview)

Institution

More generally, participation in Worldviews seemed to result in **greater institutional buy-in for exploring the possibilities of dome technology**. An ISI representative emphasized that "it really was a tool to accomplish two things. One was to give us all those new toys to play with, but also as an avenue to try and expose the university faculty to the technology that actually exists, that can be used and it doesn't really matter what you teach" (ISI interview). **The exposure of technology resources to the University of community, especially potential collaborators among faculty, was also reported to have resulted in partnerships with both the planetarium and the ISI** more generally:

> *We had to find new ways to work with faculty and to demonstrate their research. And we do a lot of that now. I have at the moment I have six. One is complete, six faculty research based projects in the dome. So we have begun that process now. The museum has many more in other areas that don't involve the dome…in the dome they include gravity, dark matter, dark energy, mathematics, dance, music…. it's not the astronomy department alone for example saying 'Hey, let's do this. It's other departments who have NSF Grants…the better impact projects, those aspects of grants now required by NSF and they don't know how to interact with the public, but we do. So we're becoming quite a hub. Almost to the point of being overwhelmed by U of M faculty looking for that public connection.* (ISI interview)

Although ISI staff felt it was "Too early to tell" what the long-term institutional effects of working with Worldviews would be, they reported that Michigan had already begun to produce "More non-astronomy content, live presentations and Full-dome movies" (ISI survey). ISI staff reported in the survey that since participation in Worldviews, they had <u>already done the following:</u>

- Given at least one other dome presentation about Earth-focused content
- Worked with one of the Advisors/attendees from our BCD

They reported they were currently planning to…

- Do additional programming/community engagement about the ecological issue(s) from our BCD
- Be in contact with an Advisor/attendee of our BCD
- Engage community partners/advisors to contribute to new projects

Members of the Worldviews Leadership Team observed institutional buy-in, too, noting that invited guests included "a lot of other people from the university, including the administrators. But this is an opportunity to show other people on campus what the dome could do because they previously didn't know anything about what was happening in the planetarium. And so this was, based on that, just to be more visible" (Leadership interview). In addition, "it demonstrated how the planetarium could be relevant for a lot more than just astronomy lessons" (Leadership interview).

Michigan staff also reported **continued use of digital assets, particularly through repurposing visualizations and storyboards.** In some cases, this meant refocusing for different audiences and adding more visual elements:

> *I'm in my secondary model here in my office. I'm staring at a new outline for this program. We're redesigning it to meet our needs more specifically outside the grant for area schools and public. And we're really tearing it apart and reorganizing it -- we think it will work better for us here in our particular situation. And it has dozens of images and video.* (ISI interview)

In the new iterations of the presentation, different versions were created to be more specific:

> *We're just narrowing it a little bit…so that we could focus more on things that might show up in school curriculum, for example. And then the public version of this would be more about the fact that when you have a boat and you go into a lake…your boat gets water in it. You should dump that water out before you go to the next lake. Just simple things like that.* (ISI interview)

Finally, Michigan's event and ongoing contact with external collaborators has also **resulted in possibilities for extension beyond the immediate area and even beyond the dome format**:

> *I got an e-mail from the one of the watershed groups up in northern Michigan about five hours north of me who wants to know more about the Worldviews project that we did. But since they don't have access to Uniview, I will probably be converting that somehow into a PowerPoint. All the visualizations to go up there and present the project to them. And so that word is getting around.* (ISI interview)

In the broader project context, the Michigan BCD was an event that extended the reach of the ISI, better articulated the process of event development, and inspired local partners to push the boundaries of new ways to use both planetarium resources and Worldviews data sets.

Case 6: American Museum of Natural History

Site Overview

The American Museum of Natural History (AMNH) is a large ISI which interprets a broad range of science content, and its Hayden Planetarium is a renowned educational resource for both the museum and the field. In addition, AMNH's prominence as an institution of research with many scientists of all disciplines working on-site meant that it had the potential presence of a lot of internal content experts. Although it did not have a co-PI on-site, AMNH's role as a technological leader and the major developer of Uniview technology meant that it was well-positioned to participate by hosting a live, data-driven presentation in its dome. Because an ISI staffer was a key author of the Uniview software, technological expertise at this site was particularly high; support needs were more related to the content and logistics surrounding the BCD event itself.

Worldviews Approach

AMNH hosted the sixth Worldviews event, "Earth, Migrations, and the Human Effect," in December 2012. The event focused on changes to ecosystems and migrations in the context of seasonal and climate cycles and was presented to a primarily public audience. The strong technological expertise meant that the dome presentation could also be broadcast live to participating Worldviews partners, and this was considered a strong effort by the team: "I got to see that [BCD event] at Cal Academy. It was great…what we saw in California was incredible. I think it was a great success with *Octopus*" (Leadership interview).

In the early stages, the major supports provided by the Leadership Team were related to content development. An ISI staff member had the idea to focus the BCD event presentation on migration patterns over time. Ornithology researchers from another department of AMNH were identified as potential content resources to flesh out this story and were engaged. The Leadership Team was aware that content support was critical at AMNH because the point-person was an astronomy, not ecology, expert, noting they held "a hope that we would have cooperation with…the researchers because [ISI staff] wanted to do a story on migrations, and there were several – a couple of ornithologists that were available who were researchers there."

The Leadership Team, experienced in creating storyboards for BCD events by this point, recognized that the story of migration needed to be larger than one type of animal and would require other scientific expertise: "The ornithology was an important part of migration story… [But the show] couldn't just focus on bird migrations. It had to have a larger context. So in other words, it also helped to pick out what that was" (Leadership interview). Unfortunately, the schedules of the research advisors became a barrier to implementation of the vision. Advisors from within AMNH were involved in early conversations about story development, and then were obligated to travel for fieldwork as the production process continued. At this time, the Leadership Team stepped in and took a very strong role in content development, as it was a major gap at the ISI with the departure of the community advisors. Leadership Team members with content expertise really took the lead of identifying other migration stories that could be interwoven, locating datasets, identifying additional local advisors outside of AMNH, and creating the overall narrative to present the content. Ultimately, a member of the Leadership Team delivered the live presentation of the global and local ecological content in the show, with the ISI staff person delivering the cosmic portion.

Another area where the Leadership Team contributed a great deal of support was in preparing the visual data that would work for the space. This dovetailed with content development; a key element of this process was locating and assembling data packages that would support the storyboard. For one member of the Leadership Team, "it was really tech…a lot of the weight of that project was the kind of Uniview time data that we needed to pull off" (Leadership interview). Although AMNH had advanced technological expertise, the technical specifications of the dome in the Hayden Planetarium differed from those of other spaces—for example, Leadership team members noted that the projectors were darker than other spaces, and as a result, "You really couldn't tell what you were seeing on their dome. So we ended up changing colors and just changing things– well, some of them we went back and recreated from scratch" (Leadership interview).

Further, the Leadership Team and the ISI site point-person sought to experiment with new advancements, such as showing animated time-series data on the dome (something they had not yet achieved). As the AMNH site presented challenges, the Leadership Team took it as an opportunity to develop their own professional learning, overcome challenges, and put on a presentation that "pushed the Uniview to the limits and past it" (Leadership interview). This, combined with a strong story and supporting content, along with assistance from the Leadership Team, meant that those involved felt the production at AMNH resulted in "a really mind-blowing show with the visuals stated ever so subtly" (Leadership interview).

Project Outputs

Earth, Migrations, and the Human Effect (December 2012)

Full Description:

"Life on Earth depends on the energy of the Sun and the cycles of seasons and climate. Plant, animal and human communities respond to these cycles in ways both familiar and fascinating. Rapid global changes are influencing these enduring patterns of life, threatening biodiversity and human wellbeing. Drawing on a range of data, the American Museum of Natural History's Director of Astrovisualization, Carter Emmart, and NOAA's Dr. Ned Gardiner, will lead you through an immersive visualization of these cycles, how life responds in grand migrations, and human influences – past, present and future. Together, we will journey from our place in the vast cosmos to imagine the future of our local ecosystems.

We invite you to the Hayden Planetarium to experience these patterns of Earth and life, and to explore our common future as part of an interconnected Earth system. This production is based on scientific data from the National Oceanic and Atmospheric Administration, the National Aeronautical and Space Administration, the U.S. Fish and Wildlife Service, the North Atlantic Landscape Conservation Cooperative, and collaborating scientists."[14]

Audience: Primarily public, along with invited guests. This event was also simulcast.

[14] Source: http://worldviews.net/earth-migrations-and-the-human-effect/

Table 12. Demographics of survey respondents to AMNH Event

Audience demographic information (50 respondents)		
Visitor group description (n=44)		
On my own	7	16%
With friends or family	36	82%
With an organized group	1	2%
Number of children in group (n=42)		
None	39	93%
One	3	7%
Two or more	0	0%
Number of adults in group (n=42)		
One	9	21%
2 to 5	24	57%
6 to 10	5	12%
11 or more	4	10%
Age (n=42)		
18-29	6	14%
30-39	11	26%
40-49	5	12%
50-59	5	12%
60-69	7	17%
70-79	4	10%
80-89	4	10%

Outcomes Achieved

Audience: Earth, Migrations, and the Human Effect

There were 50 respondents to the questionnaire distributed after the "Earth, Migrations, and the Human Effect" presentation. A summary of the audience's immediate reactions and self-reported learning from the presentation is below.

Nearly all respondents (45 of 46 who answered the question) reported learning something new from the show. The learning reported (from 37 people) indicated learning was focused on ecological facts and information specific to the show, with some particular emphasis on themes of change over time and vastness/scale of some concepts (such as migrations).

- 32% reported learning a general ecological fact or concept
- 22% reported learning about ecological change over time, often implying or stating human influence
- 11% reported learning about large scales of ecological information (vastness of migrations, for instance)

With the question asked a second way ("something you never realized"), respondents' responses were in the same three categories.

When selecting and ranking three items that could describe what they got out of their experience with the dome presentation, attendees of the event most often identified the following phrases as one of their top three takeaways (n=34):

- It made me think about the complex interrelations in Earth systems (65%).
    - This item was ranked as the #1 takeaway by 24% of the audience.
- It helped me visualize certain concepts of time and scale (44%).
- I learned or was reminded that the Earth is always changing and evolving (32%).

The majority of the audience also reported that the dome changed their understanding in some way (85%), with the following specific language used to describe how it was changed:

- 35% said it influenced perspective: talking about relationships, connections, a systems perspective, or the cosmic-global-local connections.
- 35% said it allowed them to see the benefit of visuals with the presentation.
- 24% said they understood referenced content, information, facts learned.

What attendees liked most about this BCD event included technology, content, and pedagogical approaches (n=40):

- The presenters (pedagogy) (30%)
- The visuals/images presented (tech) (28%)
- The content covered (content) (15%)

What attendees suggested could be improved (n=29):

- Content that could be added or clarified (28%)
- Suggestions to improve the speaker's presentation (24%)

ISI Professionals and External Advisors

Among ISI staff, **an immediate outcome was content learning about the social-ecological issues** in the BCD presentation. As was noted in interviews with the Leadership Team, the site point-person had extensive expertise in astronomy and the technical knowledge and skills of the Uniview system. but coming into the project, the ISI staff had only basic content knowledge about the ecological topics. The team hoped that the engagement with community science advisors would fill the gap in creating the program, essentially that they "could drive the story" (Leadership interview). By the time of the BCD event, a Leadership Team member recalled the ISI staff, "commented to the others on the team that he had learned a lot of things that he didn't know about the ecology of the animals in the migration story. It struck me that someone who's a great expert in one area of science, like astronomy, might only know pretty general or basic information about another domain of science, like animal migrations" (Leadership interview).

AMNH was one site where the community advisors (2) responded to the survey, providing some insights on their perspectives on their gains from the experience. The data showed that **advisors walked away from the project with high respect for the potential of the dome/visualizations for presenting Earth science stories and working with AMNH as a partner**.

Both advisors responded that their personal learning had to do with the challenges and successes of representing data in the immersive environment and from the global perspective. They reported one new idea learned was "How difficult it is to represent events on a global scale" and "That the effects of climate change and patterns of migration can be seen from space and effectively communicated to the public via immersive visualization" (Advisor survey). In terms of their perspectives on outcomes, Advisors both focused on the power of the immersive environment and the cosmic perspective for telling stories about Earth's ecological issues:

> *[The most valuable outcome was] the perspective gained from looking at phenomena on the Earth from the sky* (Advisor survey)
>
> *The most valuable outcome was the demonstration of the potential for using immersive visualization as part of a broader approach to communicate about the importance of landscape conservation to address conservation challenges including climate change.* (Advisor survey)

Both advisors responding also reported strong agreement about the power of the dome for visualizations and the ISI as a community resource – both agreed (6 or 7 out of 7) to all six statements below:

- I really enjoyed working with the staff from AMNH on this project.
- AMNH is an important resource in this community.
- AMNH can help this community understand ecological issues.
- I would like to collaborate with AMNH on another project in the future.
- The dome should be used more often for stories not about astronomy/space.
- The dome is a powerful tool for presenting ideas and information.
- I really enjoyed the process of developing our BCD event.

The advisors' responses to the survey also indicate that **continued work and relationships between AMNH and the advisors were possible, but had generally not yet taken place**. One advisor reported actually planning to be in contact with an attendee from the BCD event. This advisor also reported an intention (but no plan) to 1) be in further contact with AMNH, 2) to work with AMNH on another project in the next six months, and 3) to do additional programming/community engagement that directly grew out of involvement with Worldviews. The project did not seem to affect desire to work with other informal science education efforts; the advisor who had not worked with informal education previously indicated no intention to do this. The second advisor generally indicated they already engaged with AMNH prior to Worldviews (so there could be no change).

Institution

For the ISI more generally, **an area of immediate outcome achievement was cross-departmental collaboration**. Consistent with the experiences of other large ISIs involved in the project, AMNH's event marked an important opportunity that brought together staff from subject areas that were previously very separated in the institution. Although operational challenges were encountered, such as the timing of fieldwork research for natural scientists, the connections were made and the advisors had positive feelings about the experience. From this, Leadership Team members felt they also saw the Worldviews BCD event as a first step toward a higher-level extended outcome for the ISI: institutional change that was inherent in agreeing to tell Earth stories in the planetarium. As the Leadership Team described this change,

> *It was cultural – getting AMNH to use their dome to focus on ecological issues was really significant. I mean because, historically, AMNH has been like the place where attention is focused on space within the planetarium, you know, going back decades. And based on [my experience, there is] a gap between all the Earth science stuff they do…and the planetarium. And so I would argue that the biggest success was actually integrating those more thoroughly for the first time.* (Leadership interview)

For Worldviews itself, AMNH's production was a useful opportunity to explore strategies for filling unanticipated gaps in capacity and to push the boundaries of what was technologically possible.

Case 7: Journey Museum

Site Overview

The Journey Museum (Journey) is a small ISI which focuses on "the heritage of the cultures of the Black Hills region and the knowledge of its natural environment."[15] While the institution's pre-project resources did not include a large planetarium space, the institution selected a narrative for its BCD event with which it had deep familiarity as a local issue. In fact, this content was the driver for the institution joining the Network: the stated institutional goals were that "Originally we wanted to develop a program for an exhibit and improve our use of Uniview" (ISI survey). This gave Journey a strong starting position to apply the Worldviews approach to presentation.

Journey did have a portable dome, but its small size would not accommodate the audience size of interest for the BCD event, so a large flat-screen solution was used to present the event instead. The institution did not have researchers on-staff, but it identified a content area about which the museum had already produced a collaborative exhibit with local partners. Because of this, an archive of source materials was available to the ISI. These sources, paired with related content knowledge and key contacts, meant that a great deal of the content information required to develop the BCD was already quickly available.

Worldviews Approach

In March 2013, Journey hosted "Resilient Landscapes: The History and Future of Black Hills Floods," the eighth Worldviews event. The presentation focused on the 1972 Black Hills Flood, as well as issues of flooding more generally across time.

One major unique element of Journey's approach was the decision to use a large flat-screen rather than the ISI's portable dome. As noted, the reason was the need to accommodate a larger audience at one time. This change, however, made a substantial impact on the nature of the support the Leadership Team had to provide in terms of technological expertise. Although the flat screen presentation venue had specific data needs, production of Journey's data visualizations was reported to be streamlined in that it did not require the same kind of testing and development that would be necessary to ensure accurate projection in a dome. According to a member of the Leadership Team, "in some ways it was easier because we do most of our work on just – laptops or workstations…So knowing that they only have a flat screen to work with…working at our end would work reasonable at their end, as far as color or lighting or brightness issues" (Leadership interview).

The story development process was described as extremely collaborative, as both ISI staff and the Leadership Team contributed a great deal. Specifically, ISI staff members shared local content information and were able to readily identify people who could serve as advisors, drawing upon sources and partners from their previous work. As a member of the Leadership Team put it,

> *[The ISI staff] were active participants in the meetings, connecting us with contacts they had from the governmental and NGO side. They brought their knowledge to table and really participated with the Worldviews team, versus kind of one side having to be a bigger driver than the other side.* (Leadership interview)

[15] Source: http://journeymuseum.org/about/mission/

ISI staff members' previous collaboration with community partners meant that the team was able to build on existing story ideas. Rather than start from scratch, the Journey BCD event extended their prior narrative to include flooding data over time (e.g., Paleo era floods). In doing so, the team was rapidly able to focus on the areas that they felt would be most relevant for the local community: "we didn't have to spend time brainstorming, or, you know, thinking about and trying to pinpoint a story down. [The ISI representative] had such a good idea that we were basically trying to fit his vision of what he wanted to present to the audience" (Leadership interview).

Meanwhile, the Leadership Team helped provide contacts to additional partners and external advisors to further expand the data and story, as well as assisting to package the data visualizations for presentation. The Leadership Team also attributed the ease of work with community advisors to the local importance of the flood. Because most of the storyboard's structure was already in place, support from community advisors generally meant contributing knowledge about the 1972 flood's local impact or contributing weather data that could be part of the visualizations:

> *…the 40th anniversary was in 2012, and what that meant was they had all these resources…a lot of ideas already of…what they could do. What we helped them with was reaching out to new partners and external advisors. And so [an ISI staff member] was able to find people at NOAA and folks from the National Weather Service. So he really did a stellar job of just going out there into the community and finding – you know, maybe these were people that he was already aware of, but he really pulled in people who said…point us to all these resources that were available about the flood. So we were able to get maps, flood plain maps, precipitation maps, later data, just all these really great visuals, and they were – we were able to do that because of these external partners that they had found.* (Leadership interview)

In this case, a major takeaway was the extent to which local support and content knowledge supported the process; the ISI staff's familiarity with their story and with their community meant that the Leadership Team was more able to focus on technological needs (which were relatively light, given the use of flat screen, rather than dome) and contextualizing the local with global and cosmic contexts.

Project Outputs

Resilient Landscapes: The History and Future of Black Hills Floods (March 2013)

Full Description:

"Resilient Landscapes uses scientific data to visualize the 1972 Black Hills flood, paleo 'mega' flooding, and more recent flooding from extreme weather. It builds on the Journey Museum's programming on the 1972 flood and recent US Geological Survey research. Although focused on the floods from extreme weather events, it also provides a big picture perspective on water. Audiences will be 'flown' from the surface of Earth to see how water originated in the solar system and learn about the habitable zone that allows liquid water (and therefore life) to exist on Earth. The presentation then explores how the water cycle on Earth contributes to the unique conditions and history of flooding in the Black Hills area. It highlights floodway community planning and preparations as well as the importance of heeding warnings from the National Weather Service and Pennington County Emergency Management. The 45 minute presentation will be followed by a public forum with a panel of experts from the US Geological Survey, National Weather Service, SD

School of Mines and Technology, Pennington County/Rapid City Emergency Management and the City of Rapid City."[16]

Event Format: Hybrid: fit the new show into an existing public program format, but added new program components

BCD Event Goal: "Our goal was to develop a program for an exhibit and improve our knowledge of the use of Uniview" (ISI survey). Reported accomplishing this goal "somewhat."

Audience: Mostly public audience, given the memory of the flood and stake in the relevant issues among community members

Table 13. Demographics of survey respondents to Journey Event

Audience demographic information (51 respondents)		
Visitor group description (n=39)		
On my own	13	33%
With friends or family	26	67%
With an organized group	0	0%
Number of children in group (n=28)		
None	27	96%
One	0	0%
Two or more	1	4%
Number of adults in group (n=27)		
One	6	22%
2 to 5	21	78%
6 to 10	0	0%
11 or more	0	0%
Age (n=36)		
18-29	0	0%
30-39	0	0%
40-49	2	6%
50-59	7	19%
60-69	13	36%
70-79	13	36%
80-89	1	3%

[16] Source: http://worldviews.net/resilient_landscapes/

Outcomes Achieved

Audience: Resilient Landscapes

There were 51 respondents to the questionnaire distributed after the "Resilient Landscapes" presentation. A summary of the audience's immediate reactions and self-reported learning from the presentation is below.

A majority of respondents (40 of 46 who answered the question) reported learning something new from the show. The learning reported (from 29 people) indicated learning was focused on two aspects of ecology – change over time and vastness/scale of some concepts.

- 24% reported learning about ecological change over time, often implying or stating human influence.
- 14% reported learning about large scales of ecological information (vastness of migrations, for instance).
- 14% reported learning about the importance of the issues or an aspect of the Earth.

With the question asked a second way ("something you never realized"), respondents' responses were focused on issues of scale, primarily.

When selecting and ranking three items that could describe what they got out of their experience with the dome presentation, attendees of the event most often identified the following phrases as one of their top three takeaways (n=23):

- The Dome helped me visualize specific events (43%).
    - This item was ranked as the #1 takeaway by 30% of the audience.
- I felt a sense of how small the Earth is compared to the greater universe (39%).
- It helped me visualize certain concepts of time and scale (35%).
- I learned or was reminded that the Earth is always changing and evolving (35%).

The majority of the audience also reported that the dome changed their understanding in some way (86%), with the following specific language used to describe how it was changed – words about "perspective" were generally not as common in this group:

- 43% said it allowed them to see the benefit of visuals with the presentation.
- 29% said they understood referenced content, information, facts learned.
- 14% said it influenced perspective: talking about relationships, connections, a systems perspective, or the cosmic-global-local connections.

What attendees liked most about this BCD event included technology, content, and pedagogical approaches (n=39):

- The presenters (pedagogy) (33%)
- The visuals/images presented (tech) (33%)
- The content covered (content) (10%)

What attendees suggested could be improved (n=17):

- Visuals could be improved (2 people)
- Discomfort with the facility (2 people)
- Time (make it longer or it's too long) (2 people)

ISI Professionals and External Advisors

Since the ISI staff for this production had deep incoming knowledge of the ecological topic and strong community ties, they did not report outcomes associated with learning in either of these areas. However, members of **the Leadership Team observed strong community support, as well as evidence of organizational partnerships**, at the event itself: "this flooding that happened back in '72, this flood that looms very large in their collective memory. And from the perspective of being on the ground, we're just packed; they extremely happy, the mayor was there, all of these folks in the community came" (Leadership interview). In addition, "it prompted a really good dialogue that all happened. They had all these emergency responders and different people from different organizations" (Leadership interview).

The ISI staff reported substantial gains in skill development, in technological, pedagogical, and content knowledge due to participation. The ISI staff-person who responded to the survey reported the greatest gains in technological knowledge, shifting from unprepared to moderately prepared from the project:

- Using the full technical capabilities of Uniview in the dome (from 1 to 5, of 7)
- Creating visualizations for the dome (from 1 to 5)
- Preparing Earth datasets for Uniview (from 1 to 5)
- Using WMS and other layers in Uniview's Geoscope (from 3 to 6)

The ISI staff person reported that they "learned how to use Google Earth within a Uniview program. I also received web links for better geoscope imagery" (ISI survey). In addition, staff commented that participation in Worldviews "was a good way to start utilizing the idea of using the octopus to connect to other Uniview users" (ISI survey). In pedagogical and content knowledge, the staff person indicated growth from a feeling of neutral preparedness to being well prepared, including noting that "the whole process of a detailed storyboard" was new learning (ISI survey):

- Delivering a live presentation to an audience (from 4 to 6, of 7)
- Delivering a presentation about Earth science content (from 4 to 6)
- Understanding of ecology in general (from 3 to 5)
- Understanding of local/regional ecological issues from my BCD event (from 4 to 6)

Based on their conversations both during and after the event, the Leadership Team also perceived **possibilities for leveraging technology to discuss Earth science** and, perhaps, greater traction for the possibility of continuing to experiment with the Worldviews presentation structure:

> *it's just sort of a traumatic personal thing for most people, but I think it was – they really liked being able to consider it from a geological perspective, from like a long-term perspective, and that's a lot of what they try to address from the exhibits and the museums. So I think that it was just – we went in…and we helped to catalyze it.*
> (Leadership interview)

Institution

For Journey, participation in Worldviews seemed to suggest the possibility for broader institutional change. The event itself appeared to **build interest in future partnerships, particularly among upper leadership.** According to project personnel, "both the board chair of the museum and the executive director, you know, they were just really looking for ways to continue this kind of work for community engagement. So we were very, very excited" (Leadership interview). Interest in the program also extended beyond the local community to the broader network of professionals

involved in immersive data visualization: “actually one of the board members that funded the whole Uniview system was there and just very, very engaged and interested” (Leadership interview).

However, in September 2013, the team at Journey reported they had not yet engaged in major follow-up initiatives as a result of the BCD event. The staff representative indicated there was not an intention to do any actions related to engaging or continuing to work with community science advisors after the event (ISI survey). They reported there were intentions, but no plans, to do the following:

- Give another dome presentation about Earth-focused content
- Use storytelling/narrative techniques from Worldviews

Between this event and the time of the evaluation, the institution underwent a number of large-scale leadership and staffing changes, which limited the continuity of outcomes directly resulting from the Worldviews Network event. However, Leadership Team reports indicate that the institution is still demonstrating ongoing interest in taking new approaches to representing science content and using the dome to tell stories and interpret science, as the ISI staff indicated in the survey. Leadership Team reported Journey is **collaborating with an ISI professional from one of the other Worldviews Network sites to prepare new staff to use these technologies and techniques.** For the Worldviews project itself, the Journey collaboration was an opportunity to explore working with data for different presentation formats, as well as an important illustration of how content with a strong local connection could be reimagined using a cosmic-global-local approach.

Case 8: Perot Museum of Nature and Science

Site Overview

The Perot Museum of Nature and Science (Perot) is a medium-sized ISI which focuses on delivering interactive visitor experiences related to science, math and technology.[17] Its participation in Worldviews was connected to an individual ISI staff member's previous contact with the Leadership Team and interest in the Worldviews approach, which she carried with her to Perot. This was articulated as: "the goals of the group [Worldviews Network] would be well supported within my institution (as well as an incredible professional development opportunity for me and for the program I manage)" (ISI survey).

The institution had the technological asset of a portable dome, as well as the ISI staff's experience in creating and delivering educational programs and working with the portable planetarium technology. The content, however, was not an area of expertise, and the institution's size meant that those community advisors would have to be found outside of the institution.

Worldviews Approach

Perot's event, "The Search for Water: Replenishing Watersheds in the Texas Drought," took place in September 2013 and was the tenth Worldviews event overall. The event focused on the Texas water supply in relation to ecological concerns at global and local scales. This topic was selected specifically for its local relevance, important to the ISI staff as part of their mission to serve their community:

> *that topic is so relevant in our daily lives, I mean we're currently on water restrictions for like irrigation for lawns that you get to water like once a week. We see that all the time in North Texas area, so we wanted to really speak to something that already exists as a problem that people are aware of and then give a little bit of hope to it as well. Because there are ways that we combat severe drought and make life a little bit easier on ourselves.* (ISI interview)

The most critical supports from the Leadership Team came in the form of supporting event logistics and technological troubleshooting, mainly due to limited resources on-site. For example, an ISI representative pointed out that "I am the only full-time person for our planetarium, [this project] demanded a lot of my time and had it not been during the summer when we have a lull in school groups I probably would not have been able to do as much as I did" (ISI interview). In addition, because two other Worldviews events took place in September 2013, Leadership Team personnel had a particularly heavy workload leading up to this BCD. Because there was no member of the Leadership Team on-site, many production specifications had to be handled long-distance. As a member of the Leadership Team described the process, "they definitely had all of our commitment and involvement," but "…I think we could've done even more if we'd had somebody on site. And just the timing with the other three presentations [made it difficult]" (Leadership interview). Despite the logistical challenges of, ISI staff commented that members of the Leadership Team "were very organized and helped keep us on track" and described the overall production workflow, which had been very much systematized by this site's work, as "very…streamlined in the entire process" (ISI interview).

[17] Source: http://www.perotmuseum.org/about-the-perot/the-mission.html

The idea for the event also was unique in who it identified as its public audience. Rather than a general public audience or even stakeholders in the environmental issue, Perot focused on local teachers, including the BCD event in a larger professional development day for teachers. Placed between other sessions about particular activities and demonstrations to do with students to teach about issues of water, runoff, and local aquatic systems, the BCD event was presented to give an overview of the content (and present it as an outreach option that could be taken to classrooms by the museum). This idea occurred during one of the weekly production meetings held between the Leadership Team and the ISI staff:

> *a lot of people on the Perot side were—really, are—heavily involved in [professional development for teachers] in the museum. And they were like, "Well, why don't we do it like this? And we can utilize our work that we've done in the future?" So yeah, that was the really unique thing about that particular one. And I think it was a big success.* (Leadership interview)

Despite the logistical challenges that the BCD presented, ISI staff were described as "extremely committed and very easy to work with. And it was exciting to do a teacher professional development event. So that was really unique to that particular BCD" (Leadership interview).

For their part, the ISI staff played an important role in maintaining momentum on-site and working with community advisors. According to Leadership, "the people at Perot were really excited and committed to doing this….even though they were an external partner site….they were just so enthusiastic. It almost felt like they should have been part of the core group…there was a lot of internal support, from what I could tell, for the project" (Leadership interview).

While at many ISI sites, the Leadership Team played a strong role in identifying or pushing sites to identify community advisors, Perot took on this challenge themselves and were highly successful. The Leadership Team commended ISI staff for taking the lead in "bringing in external advisors who, you know, were also excited and committed… and giving [Perot staff] feedback and helping them with their story" (Leadership interview). For the ISI staff, their ownership of this collaborative process resulted in some learning about the process and goals for identifying a good community advisor:

> *I think that having seen the process once I know a little bit more of how to identify advisors and what types of people that we might want to request information of. Some of the advisors are fantastic but if it's so descriptive and there's…no scientific data there, then it does make it difficult to use Uniview as a tool of scientific visualization. I think in the future when we seek out advisors, we're going to want a mix of both the descriptive people who know a lot about the subject and the story of it in our area as well as the scientists who have the data that we want to visualize to enhance the story.* (ISI interview)

As with other events, key areas of focus in event production work were focusing the storyline and preparing the visual data itself. Still, Perot's work took on a slightly different tone than other productions, not least because it was perceived as a specific kind of priority: "There was a lot of data visualization for this one so we had to kind of stay on top of it. I think the really interesting thing about it was that they really need these [data visualization] layers. I mean, the museum has been opened for a year. There are all these issues with water in Texas" (Leadership interview). Following the event and the process of developing it, Perot's BCD stood out as an effort that was particularly focused from conception on not only an immediate need, but also a future use.

Project Outputs

The Search for Water: Replenishing Watersheds in the Texas Drought (September 2013)

Full Description:

"Texas has a long history with drought. Appreciating their causes, and how to better prepare for them, requires understanding complex interactions between the natural world and human activities. *The Search for Water: Replenishing Watersheds in the Texas Drought* immerses participants in a journey from outer space to Dallas to explore how the availability of water in Texas is impacted by the behavior of global weather patterns and local ecosystems. It highlights the value of design and planning for the long-term health of our communities, and how simple steps can help to ensure the wellbeing of current and future generations.

The *Search for Water* presentation will take place in the Perot Museum's 'Portable Universe' planetarium. Extension activities will be in the pre- and post- guide for educators."[18]

Event Type: Created an entirely new program/event for the Worldviews show. Note: "We created the public event to meet the requirements of the BCD, but intend to use the product in schools, for public programming, and for Environmental Science programming. However, I believe that we have come to see a new type of event can occur in the BCD." (ISI survey)

BCD Event Goal: "To create an educational model where the spatial, visual, and storytelling experience of the dome was coupled with inquiry-based hands-on exploration;" "create a new program that we can continue to use in the future. We also wanted to venture into ecological content;" and "professional development for high school teachers." (ISI survey) Reported achieved those goals to a great extent/somewhat.

Audience: Pre-registered high school classroom teachers (professional development workshop); three teachers registered and attended [although the museum intended to keep using the show for outreach programs]

Table 14. Demographics of survey respondents to Perot Event

Audience demographic information (3 respondents)		
Age (n=3)		
30-39	2	67%
50-59	1	33%
Attendance to dome presentations (n=3)		
Today was my first show	3	100%
Special training or expertise about topic (n=3)		
No	3	100%

Dialogue: There was no dialogue directly tied to the BCD event portion, presented essentially as a show; the demonstrations of curricular materials (before and after) were shared with more interaction between and among museum educators and attendees about using the resources.

[18] Source: http://worldviews.net/search_for_water/

Outcomes Achieved

Audience: The Search for Water

All three attendees responded to the questionnaire distributed after the "The Search for Water" presentation within the teacher PD session. A summary of the audience's immediate reactions and self-reported learning from the presentation is below.

All three reported learning something new from the show. The learning reported was as follows:

- Groups working to address the issue and/or things that could be done to address the issue (2 of 3)
- The importance of the issue (1 of 3)
- A positive impression of the dome format of presentation (1 of 3)

When selecting and ranking three items that could describe what they got out of their experience with the dome presentation, attendees of this BCD identified the following phrases as one of their top three takeaways (n=3):

- I became interested in where the information on the Dome comes from. (3 of 3)
- It made me think about the complex interrelations in Earth systems (2 of 3)

In response to the added retro-pre/post question to self-report the extent to which they felt their knowledge had been affected by the event, reflecting on how knowledgeable they felt they were before and after the presentation. Before the event, teachers rated themselves a mid-range (2, 3, or 4, out of 5) of knowledge about the four issues (below); after the event, they rated themselves at a (4 or 5), indicating a sense of growth of some areas of knowledge:

- The ecological issue(s) addressed in the presentation (2 of 3 said they knew "5 - a great deal" after the BCD event)
- The individuals or groups in my community working on this issue (2 of 3 said they knew "5 - a great deal" after the BCD event)
- The complex nature of the issue(s) presented (1 of 3 said they knew "5 - a great deal" after the BCD event)
- Opportunities for me to get involved to work on this issue (1 of 3 said they knew "5 - a great deal" after the BCD event)

All three reported that the dome changed their understanding in some way, with each using different language used to describe how it was changed:

- 1 teacher reported it influenced perspective: talking about relationships, connections, a systems perspective, or the cosmic-global-local connections.
- 1 teacher reported it made her feel immersed.
- 1 teacher reported the content she learned.

In terms of the affective response, all three teachers agreed strongly with the attitudinal statements (rating them a 4 or 5 out of 5).

- The ecological issue presented was relevant to my community.
- I enjoyed today's program.
- I intend to find out more about this topic.
- I felt inspired by the presentation.
- I intend to get involved in work happening on this issue.

When describing the feelings inspired by the presentation, all three talked about feeling motivated to action from the presentation.

What attendees liked most about this the visuals/images presented, the presenter, the dome format itself, and the discussion. What attendees suggested could be improved were logistical issues.

ISI Professionals and External Advisors

Among project personnel, **institutional collaboration was to be a major immediate outcome**, and the ISI's production team was described as "really engaged" and "thinking about [the production process] a lot" (Leadership interview). In addition to ISI staff members' lessons learned about engaging advisors (described above), a member of the Leadership Team observed the potential for the local team of ISI staff and advisors to continue working together: "I got the sense that it cohered a lot of the conversation around how to talk about water and wetlands, and all of, was just part of the excitement because…they brought in some of the scientists whose data we were visualizing, and they were really excited to come and do more of that" (Leadership interview). As in other aspects of the BCD, staff connected collaboration to the potential for longer-term outcomes: "I enjoyed the networking process within our community. I believe this particular project will act as a spring board for many yet to come" (ISI survey).

ISI staff also reported developing their individual skills around storyboarding and narrative development. For example, "the process of learning to storyboard as they have has been very helpful," not least because it included "examples of their other projects and how they were developed" (ISI interview). A staff member specifically connected this to learning to balance breadth and depth in preparing a storyboard:

> *I felt a little bit lost when we initially started our story draft. We had all this information, and that's probably a normal thing, we had all this information, we had trouble narrowing it down to get a story that makes sense all the way through, has a great flow all the way through…Previously when I have done products, I had productions with just a storyboard and a script and it was a little less detailed, but the amount of detail that was in the Worldviews Network storyboard I think is very worthy and ends up helping you out in the end. It's good.* (ISI interview)

Most of the team members involved were already familiar with pedagogical methods through work in education. From this context, **two of the three staff reported gaining new skills in live presentation through working on the project** – both delivering live presentations and delivering them about Earth topics. More specifically, a staff member wrote, "I enjoy the flow of the story from cosmic to global to regional. It gives the viewer a sense of the time and space making up a complete picture. To me, this appeals to the learner's different ways of 'Knowing' the information--despite the visual format" (ISI survey). Another staff member commented on the "flexibility of being able to interact with visitors in the dome. The presentation has a timeline and sequence but it is flexible. I like how the learning develops in this type of storytelling" (ISI survey).

Another area of learning for ISI staff was science content outside their own disciplines. Two of the three staff people reported personal gains in understanding of ecology generally and of local/regional issues that the BCD focused on (ISI survey). For example, a staff member reported learning "about the relation the municipal and governmental involvement in distributing water, monitoring water use, and encouraging responsible water management in North Texas" (ISI survey). Another team member reported that "I think members of the institution are more aware of

what are the natural and anthropogenic causes of drought and our direct connection to those processes (both how we affect drought and its severity and how drought affects us)" (ISI survey). Further, the areas that all three staff people reported gains were around increased awareness of the work and people addressing the issue of drought and how to use the dome for issue-focused discussions (ISI survey).

ISI staff also connected their experiences with production to having **improved their skills at using the technology through the one-on-one support** provided through Worldviews, commenting that "It's very user friendly, but to use it very well there really needs to be some intensive training, and this did help cover that for us and for myself" (ISI interview). In the survey, two of the three reported gains in these skills, with one staffer reporting great gains in technological skills. In at least one case, such training resulted in staff becoming "more comfortable with how to make my own full show profile in Uniview--specifically in customizing the layersets and custom events" (ISI survey). Moreover, comments like "I hope to adopt some of it in my work" suggest that staff perceive their own outcome achievement, not just the products of the event, as being applicable in the future (ISI interview). More generally, staff reported that "it was just a fantastic process and I learned so much…the professional development has just been phenomenal" (ISI interview).

In some cases, team members came away with a broader view of how to use the dome and its technology. As one ISI staffer commented, "The emotional connection that comes from inside the dome cannot be replicated in a few words" (ISI questionnaire). According to another ISI representative, the process of using the dome also helped facilitate both internal and external partnerships:

> *WVN has helped introduce my non-planetarium colleagues to the world of scientific (and artistic) visualization that can exist inside a dome aside from a 'star talk'. They were excited to collaborate on the project and seemed to enjoy stepping out of our normal roles as 'Earth scientist, manager, curriculum' to a comprehensive, integrated-subject approach. Additionally, we have found that we will not need to look far to find local individuals who are passionate advocates for a healthy and sustainable community.* (ISI questionnaire)

A final area of achievement for this event was continued relationships with the target audience, in this case, classroom teachers. According to a member of the Leadership Team,

> *I even had a lot of follow-ups with the teachers afterwards that this is something that is gonna live on and continue to influence the way that issues of water and wetland and all these things are communicated within – not only within Perot, but within schools. And they have already sent me more resources for the webpage, and I think they want to continue to lean on that in classes. So unlike a lot of the other productions, where it's kind of one-off; we go in, we do our thing, this seems to kind of, you know, open up a portal to possibilities of using the planetarium, as well as in class tools addressing the issues.* (Leadership interview)

Institution

For Perot itself, participation in Worldviews seems to have resulted in **plans to repurpose products for extended use**, and the Worldviews Leadership Team observed that "they were just extremely appreciative that now they have these layers that can also be viewed in Google Earth and a lot of the conversations we had were…about how a follow-up could occur" (Leadership interview). Staff members' own examples of repurposing products also included bringing data visualizations to new audiences:

> *We're going to take the program and we're turning it into a school show because it meets several of the state requirements that are for older kids in our science curriculum. And not only that but I'm able to demonstrate what our planetarium can do to staff members who don't necessarily know and it can only be seen like a traditional star show with a few constellations up on the screen and they won't have seen this. So we're gonna…present this particular program to staff in a lunch and learn couple of sessions so I'm very excited about that.* (ISI interview)

> *Several of us have already begun an email dialogue about how to further refine our presentation for school groups. I would like to see it a little further away from a traditional 'narrator' and to more of a visualization lab experience inside the dome. With the portable planetariums, a polished, single-narrator show does not seem to work with all groups; the guests are in such an intimate space that active participation seems a natural fit for the presentation style. We are currently working on an astronomy program to bring active decision making to older elementary and middle school kids--creating a more inquiry based approach while still incorporating theater and story-telling techniques.* (ISI questionnaire)

As one of the last ISIs to do an event, there was not enough time lapse when data were collected for them to have yet taken any actions. However, the ISI staff reported intentions or plans to do the following:

- Give another dome presentation about Earth-focused content
- Be in contact with advisors/attendees from our BCD
- Work with one of the advisors/attendees from the BCD
- Engage community partners/advisors to contribute to new projects
- Do additional programming/community engagement about the ecological issue from the BCD
- Use storytelling/narrative techniques from Worldviews

Notably, **plans to include a Worldviews approach in Perot's staff professional development also suggest greater institutional buy-in, particularly for the idea of telling Earth stories in a facility normal used for astronomy** only. Although this event did not receive the same public turnout as other BCDs, its focus on higher intensity skill-building for both staff and teachers meant that Perot's participation in Worldviews resulted in unprecedented extension and new possibilities for use of legacy products.

Discussion: Cross-Network Findings of Outcomes and Strategy

This section of the report looks across all of the cases described individually above to look for what can be said about the big picture of the Worldviews Network as a whole. This occurred in two ways. At one level, the analysis compiles the cases to understand what trends can be said about overall, aggregated trends in the eight sites. At another level, the analysis looks for unique attributes of variation between sites, seeking to identify what other relationships in the cases may explain those differences.

Audience Outcomes

In total, survey responses were collected from 627 attendees at 10 events across seven of the eight sites. The Minnesota program data is not included in this reporting, as they used a different approach to collect data with audiences, given the cultural differences of their presentations.

Table 15. Worldviews Network BCD event Dates, Locations, and Survey Respondents

Date	Location/Event	Number of Respondents	Percentage of Total Respondents
5/24/2011	DMNS: Global Water Story	66	11%
9/29/2011	RENCI: Living Maps	37	6%
12/8/2011	CAS: Valley Oaks (Day/Stakeholders)	122	19%
12/8/2011	CAS: Valley Oaks (Night/Public)	113	18%
3/17/2012	Minnesota: two events	--	--
10/3/2012	Michigan: Lake Effect	9	1%
12/18/2012	AMNH: Migrations	50	8%
3/26/2013	Journey: Resilient Landscapes	51	8%
6/4/2013	DMNS: Fire & Beetles	89	14%
9/5/2013	CAS: Hidden Ocean	87	14%
9/14/2013	Perot: Search for Water	3	<1%
	Total	**627**	**100%**

Summary:
Looking across audiences as a whole, the following outcomes were reported by attendees:

- An overwhelming majority (93%) of respondents reported they learned something new at the presentation.
    - The majority of those reported learning about key ecological knowledge, either general facts, changes occurring over time, or the expansive scale of ecological systems
    - Other learning related to human interactions with natural systems
- When selecting their top three takeaways of the effect of the presentation, respondents tended to feel the presentations helped them:
    - Think about the complex interrelations in Earth systems (41%)

        - This was selected as the #1 takeaway by 15% of the total sample.
    - Visualize certain concepts of time and scale (35%)
    - Learn or be reminded how the Earth is always changing and evolving (28%)
    - Feel a sense of how small the Earth is compared to the greater universe (27%)
- Looking at just the items respondents ranked as their #1 takeaway from a Worldviews BCD event:
    - 15% selected "Think about complex interrelations in Earth systems."
    - 13% selected "I felt a need to take better care of the Earth;" people who selected this item felt it very strongly.
- More than three-fourths of respondents (79%) reported the dome changed the way they understand the material in some way.
    - They primarily sited the medium as giving "perspective" or providing a visually-focused experience ("seeing" things).
- For the last four events, visitors reported how the show made them feel, and results showed reactions were split between hope, concern, and feeling informed. Individuals responded very differently in what they connected with – some reacted to positive messages of hope for change, others to more negative feelings of concern and being overwhelmed, and others to a neutral sense of having learned more about an issue.

These outcomes are discussed in more depth below, including if and how results varied between events, indicating possible differences due to approach taken at specific ISI sites.

Learning Content

An overwhelming majority of the respondents (93%) of those responding to the question indicated they learned something new from the presentation. **Among those who elaborated, responses showed strong achievement of goals for audience learning about ecological issues and the interactions between humans and ecological systems** (Table 16)**.**

- **About half of respondents across events reported learning something new about Earth ecology –** general ecological facts (22%), ecological changes that have occurred (18%), and about the expansive scale of some ecological topics (10%).
- **16% reported learning about various aspects of human resource use or management**; these responses highlighted understanding of the interplay between natural and human systems at various levels.
- **10% reported learning about active steps that can be taken and groups working to address the issues presented.**

Table 16. Respondents' coded comments, including brief code descriptions, about what was learned from the presentation (n=489)

Knowledge Gains	Percentage of Respondents
General Ecological Facts	22%
Ecological Changes & Change Over Time Often, but not always, implies/states human causes	18%
Human Resource Use Includes management of resources and influence on human civilization	16%
What People Can Do/Stewardship Approaches or groups to address ecological problems	10%
Ecological Facts focused on Scale/Expanse Focus on the global or expansive scale of information	10%
Specific Data or Collection Methods	6%
Cosmic-Earth Ecological Connections Relationship of Earth's ecology to space / uniqueness of Earth's habitability	5%
Importance of Resource Mentioning the importance of the issue without other context	5%
Positive Comment about the Format/Dome	4%
Facts about Space Generally Not contextualized with Earth	3%
Positive-Affective Response Emotional response without other context	2%
Other	5%

Comparing individual events, there were only a few substantial deviations from the overall patterns (see Table 17). Those that were noteworthy were:

- In responses from Denver: Water Story and RENCI, participants more heavily focused on Human Use/Relationship to Natural Resources. These reactions aligned with the thematic topic of those events, which heavily emphasized the relationship between natural resources and human use of land.
- In responses from Denver: Pine Beetles, participants focused primarily on issues of Ecological Scale/Vastness. These reactions aligned with the focus on topics of expansive fires globally and the local issues.
- CAS: Valley Oaks (both audiences) were similar in that both audiences primarily reported learning ecological content. However, the tertiary learning reported among the daytime, community stakeholder audience included learning about *What People Can Do* to address the issue more frequently, whereas the casual visitors to the NightLife event described their learning more in terms of the Cosmic-Earth connections.

Table 17. Respondents' most-identified perceptions of knowledge gained from the presentation, by event site (n=489)

Location/Event	Most Mentioned	2nd Most	3rd Most
Overall	**General Ecology**	**Ecological Change**	**Human Use**
DMNS: Water Story	Human Use	General Ecology	Steward
RENCI: Living Maps	Human Use (62%)	General Ecology	Steward
CAS: Valley Oaks (day)	Ecological Change	General Ecology	Steward
CAS: Valley Oaks (night)	General Ecology	Ecological Change	Cosmic Earth
Michigan: Lake Effect	Ecological Change	Ecological Scale	General Ecology / Other
AMNH: Migrations	General Ecology	Ecological Change	Ecological Scale
Journey: Landscapes	Ecological Change	Ecological Scale	Importance
DMNS: Pine Beetle	Ecological Scale	Ecological Change	General Ecology
CAS: Oceans	General Ecology	Human Use	Importance
Perot: Water	Steward	Importance	Format - Positive

For the final three events that were held, an additional question was added to the questionnaire allowing attendees to self-report the extent to which they felt their knowledge had been affected by the Worldviews event. Specifically, attendees reported on how knowledgeable they felt they were before and after the presentation on two five-point Likert-type scales. A paired samples t-test was used to analyze participants' responses to five knowledge items. This analysis revealed statistically significant gains in average ratings of knowledge, increases which were greater than one point for three of the four statements. The fourth statement also showed a statistically significant gain (Table 18).

Table 18. Respondents' reported change in knowledge to retro-pre/post item regarding final three events

Statement	N	Before Mean	After Mean	Mean Change
The ecological issue(s) addressed in the presentation***	173	3.05	4.11	1.058
The complex nature of the issue(s) presented***	171	2.91	4.09	1.181
The individuals or groups in my community working on this issue ***	170	2.11	3.46	1.359
Opportunities for me to get involved to work on this issue ***	165	2.11	2.98	.867

*** Statistically Significant at the .001 level

Immersive Experience: Pedagogy & Technology

As noted, more than three-quarters of the respondents reported that they felt seeing the presentation in the dome influenced their understanding of the materials presented in some way. Evaluators coded responses to an open-ended prompt about this perceived influence according to the types of words people used in their descriptions (Table 19):

- **34% of respondents used language indicating the dome "gave them perspective;"** referencing perspective, relationships, connections, or a systems-perspective. Additionally, responses coded to this category include those who mentioned a cosmic-global-local connection.
- **28% of respondents used language that implied the dome was "helping them see;"** referencing the benefit or ease of the visual presentation or seeing things, often as opposed to simply hearing a talk.

In general, there was very little difference in trends by event to these responses.

Table 19. Respondents' coded descriptions of how dome experience changed their understanding (n=468)

Category	Percentage of Respondents
Perspective (relationships, connections, cosmic-global-local)	34%
See (benefit of visual presentation)	28%
Understanding (Enhanced learning of new information, content)	17%
Immersion (References to 3D, being surrounded)	12%
Feelings (An emotional or affective response)	10%
It made it seem real (Content became real, "came to life")	3%
Other comments not related to dome presentation	7%

Attendees were also asked to select and rank prescribed statements about what they most got out of their experience with the dome presentation (via a question previously used in a survey of visitors to the Science On a Sphere® (SOS) Network survey. Overall, respondents identified the following phrases most often within their top three takeaways:

- It made me think about the complex interrelations in Earth systems. (36%)
- It helped me visualize certain concepts of time and scale. (32%)
- I learned or was reminded that the Earth is always changing and evolving. (25%)
- I felt a sense of how small the Earth is compared to the greater universe. (25%)

The selection of these statements **indicate the success of the Worldviews Network events at connecting visitors cognitively and affectively with Earth systems-thinking, concepts of time and scale, ideas of change and dynamism, and the perspective of Earth in the universe**.

Because a similar question was used, these results can be compared to the results of SOS Network visitors (Goldman, et al., 2010). **Audiences from Worldviews events showed some marked differences from SOS shows (see Table 20). Looking at the three most commonly selected statements, only one was the same in the two samples: visualizing concepts of time and scale.** Worldviews attendees associated slightly more strongly with ideas of Earth systems, change over time, and the smallness of Earth; whereas SOS viewers associated more strongly with visualizing specific events and the realism of the information.

When comparing how frequently each item was ranked as the #1 takeaway, the results were very different. **Worldviews attendees most indicated that their #1 takeaway were:**

- **It made me think about the complex interrelations in Earth systems. (15%)**
- **I felt a need to take better care of Earth. (13%)**

While SOS visitors tended to say their #1 takeaways were:

- I appreciated how realistic the information appeared when on the dome/sphere. (17%)
- I was amazed at the beauty of what was shown on the sphere/dome. (11%)

Table 20. Percentage of respondents selecting each of the 14 statements as one of their three top takeaways from the show from both the Worldviews Network and SOS Network studies.

	Worldviews (n=453)	SOS[19] (n=691)
It made me think about the complex interrelations in Earth systems.	36%	23%
It helped me to visualize certain concepts of time and scale.	32%	25%
I learned or was reminded that the Earth is always changing and evolving.	25%	23%
I felt a sense of how small Earth is compared to the greater universe	25%	13%
I felt a need to take better care of Earth.	21%	17%
The dome/sphere helped me understand global processes.	20%	21%
The dome/sphere helped me better understand geography of Earth or other planetary objects.	19%	16%
The dome/sphere helped me visualize specific events.	17%	31%
I appreciated how realistic the information appeared when on the dome/sphere.	16%	36%
I felt a sense of the vastness of Earth.	14%	18%
I felt a sense of the sacred in regards to Earth.	13%	7%
I became interested in where the information on the dome/sphere comes from.	11%	7%
I was amazed at the beauty of what was shown on the dome/sphere.	11%	22%
I was thinking about how this planet is my home.	10%	6%

Looking at the top three rankings by site, Earth Systems was found in the top three at 8 of the 9 sites, and Time and Scale was found in the top three at 7 of the 9 sites. Some slight differences by individual event included:

- A feeling of "smallness in the universe" was selected most often at both RENCI and CAS: Valley Oaks (evening) events; Valley Oaks (day) and Journey events had this concept selected 2nd most frequently. This suggests the cosmic-to-global perspective was highly affecting for these three productions; including one (Journey) which was not screened in a dome/planetarium.
- The Journey event attendees uniquely selected "visualizing specific events" most frequently, which aligns with that event's presentation of a specific, and highly meaningful, community ecological event.

[19] Data as reported in Goldman, et al., 2010 (p.29).

- Michigan and CAS: Oceans events both showed high connection with feelings of needing to "care for the Earth", indicating that those two events may have provided a strong impetus for feeling responsibility (or audiences inclined to care).

Table 21. Respondents' selections of their top three takeaway messages from the Worldviews Network BCD event (n=453)

Location/Event	Selected Most	Selected 2nd Most	Selected 3rd Most
Overall	**Earth's Systems (41%)**	**Time & Scale (35%)**	**Change (28%)**
DMNS: Water Story	Earth's Geography (35%)	Earth's Systems (35%)	(tie) Time & Scale Global Processes (27%)
RENCI: Living Maps	Smallness in Univ. (50%)	Earth's Systems (40%)	Time & Scale (37%)
CAS: Valley Oaks (day)	Time & Scale (35%)	Smallness in Univ. (33%)	Earth's Systems (32%)
CAS: Valley Oaks (night)	Smallness in Univ. (39%)	Time & Scale (38%)	Earth's Systems (27%)
Michigan: Lake Effect	Care for Earth (86%)	Earth's Systems (57%)	Change (43%)
AMNH: Migrations	Earth's Systems (65%)	Time & Scale (44%)	Change (32%)
Journey: Landscapes	Visualize Events (43%)	Smallness in Univ. (39%)	(tie) Change Time & Scale (35%)
DMNS: Pine Beetle	Earth's Systems (50%)	Change (48%)	Time & Scale (46%)
CAS: Oceans	Earth's Systems (48%)	Care for Earth (39%)	Sacred (30%)
Perot: Water	Source of Information (100%)	Earth's Systems (67)	

Attitude and Affective Outcomes

For the last three events, respondents were asked to respond to a set of items about their affective response to the program and their commitment to continued action, using a five-point Likert-type agreement scale. Attendees strongly enjoyed the program and believed the ecological issue presented was relevant to their community (with mean scores greater than 4.47 on a 5-point scale). Additionally, they felt inspired about the program and intend to find out more about the topic (with mean scores greater than 4.13). Respondents were less likely, however, to get involved in work happening on this issue, illustrated by a mean score of 3.7 on a 5-point scale; this suggests that, as a whole, the events were more successful at inspiring and engaging attendees cognitively than encouraging participants to take specific actions beyond the program.

Table 22. Respondents' level of agreement with these statements of the event

Statement	N	Mean	Std. Dev.
The ecological issue presented was relevant to my community.	170	4.56	.883
I enjoyed today's program.	167	4.47	.870
I felt inspired by the presentation.	167	4.16	.946
I intend to find out more about this topic.	167	4.13	.886
I intend to get involved in work happening on this issue.	168	3.70	1.097

Most of the participants (83% or 513 individuals) who completed questionnaires described one or more things they liked most about the event; while 60% (368 individuals) described one or more things they thought could be improved about the event. Overall, respondents appeared to appreciate technological and pedagogical aspects of the program. Specifically, respondents were most likely to mention the visuals and images presented (35%) followed by the speakers at the events (19%).

Table 23. Respondents' coded comments about what they liked best about the event, in broad categories aligned with TPACK framework (n=513)

Category	Percentage of Respondents
Technology	43%
Pedagogy	42%
Content	21%

Table 24. Respondents' coded comments about what they liked best, in sub-categories (with major category noted) (n=513)

Category	Category Description	Percentage of Respondents
TECHNOLOGY: Visuals	The visuals, images presented	35%
PEDAGOGY: Presenters	The presenters	19%
CONTENT	The information presented	16%
PEDAGOGY: Connections	Connections from universe to Earth, global to local	11%
TECHNOLOGY: Dome	The dome specifically mentioned	8%
PEDAGOGY: Storyline, Style	Organization/style of the storyline, presentation	6%
CONTENT: Data	Use of data in the presentation	5%
PEDAGOGY: Time scale	Connections made from past to present to future	5%
PEDAGOGY: Discussion	Panel discussion portion of the presentation	5%
Affective	Had an affective or emotional response	4%
Audience	The people gathered for the event	4%
Everything	Everything / General	3%
Native peoples	References to inclusion of native peoples	2%
Other	Other	4%

Comparing what people liked, the reactions were generally consistent across the events with the overall trends. The only unique variations were:

- RENCI attendees noted the style of the storyline about the event
- Denver: Beetles attendees noted specific data sources second most frequently

In terms of improvements, only 60% of respondents provided any answer to this question. Among those who did provide a suggestion, **attendees reported concerns with content that could have been added or clarified (27%), followed by suggestions to improve the visual images (21%) or address technical glitches (20%)** that occurred during the presentation. These comments tended to be highly specific to the individual show, rather than global comments about the Worldviews approach. They do suggest the importance of advance planning and preparation around the content, the preparation of the visuals, and solving as many technical problems as possible in advance to meet some audience members' expectations.

There were slightly more variations by site in these results. While suggestions for content remained the top place at most events, there was more variation in other categories. For instance:

- Attendees at RENCI, Denver: Water Story, and AMNH were more likely to suggest improvements in the speaker's presentation than other sites.
- Journey attendees focused more on elements of discomfort and critiqued the length of the event
- Attendees at the CAS: Valley Oaks (day) event shared more logistical suggestions.

Table 25. Coded suggestions to improve the presentation, by event site

	Top 3 Suggestion Codes		
Event Site (Number of Respondents)	**1**	**2**	**3**
Overall	**Content**	**Visuals**	**Technology**
DMNS: Water Story (35)	Content	Presentation	Time
RENCI: Maps(28)	Content	Presentation	Visualization
CAS: Valley Oaks (day) (73)	Content	Technology	Logistics
CAS: Valley Oaks (night) (54)	Technology	Content	Visualization
Michigan: Lake Effect (7)	Presentation	Content	Time
AMNH: Migrations (29)	Content	Presentation	Visualization
Journey: Landscapes (17)	Visualization, Discomfort, Time (tie)		
DMNS: Beetles (60)	Content	Technology	Visualization
CAS: Oceans (62)	Visualization	Technology	Content
Perot: Water (3)	Logistics		

At the final four events, respondents were asked to report how the presentation made them feel. The descriptors were coded into categories of similar types of feeling-words (i.e., “concerned,” “troubled,” “overwhelmed,” “sad,” and “worried” all refer to a similar type of feeling and are grouped into a single code to represent the frequency of that idea). Table 25 presents the results of this analysis, showing that the three most common feelings expressed at these events were concern and hope, followed by feeling informed. This highlights the variation in response from attendees to Worldviews events -- with some people attaching to the hopeful message, while others feeling concerned and overwhelmed by the situations presented

Figure 3 presents a word cloud of the *actual words* people wrote down in their responses, giving a visual sense of the words that were used. It should be noted that this visualization represents actual words written on the paper; it does not represent accurately into which the groups of synonyms/concepts those words fell (see Table 26).

Table 26. Respondents' coded descriptors of feelings after the presentation; individual words coded into groups of similar ideas

Feeling	Percentage of Respondents
Concern	20%
Hope	20%
Informed	16%
Other - Positive	8%
Small	7%
Interested	6%
Awe	6%
Responsible	6%
Inspired	4%
Other - Negative	4%
Connected	4%
Motivated	4%
Other - Misc	3%

Figure 3. Word cloud of descriptors of feelings written on questionnaires in the final three events; larger words indicate that specific word was used more often.

ISI Partner Outcomes

Collaboration: External and Internal

As a result of participating in the Worldviews Network project, ISI representatives reported a number of individual and institutional outcomes that they observed. **The most common ISI outcome, mentioned by five of the eight ISI sites, was engaging and developing new collaborations with outside institutions or partners,** (DMNS, CAS, Minnesota, Michigan, and Perot). These collaborations included those with external scientists who helped review stories, with community groups who helped create stories or events, and/or with the members of the Leadership Team, who brought their and their institutions' expertise to the relationship.

In addition to this, **two of the eight sites (CAS and AMNH) indicated that internal, cross-departmental collaboration was a significant outcome from participation** in Worldviews. This related to engaging planetarium programmers with science researchers on staff to contribute to BCD events. For another site (DMNS) cross-departmental collaboration was also a critical element of staff members' work; however, it was less attributable to Worldviews participation directly because such collaboration was already an established part of the ISI's practice. As is discussed in depth below, this outcome aligned with large ISIs where such cross-departmental work was less common and was a barrier to be overcome by the project.

One site, RENCI, which was unique, as it is not a traditional ISI venue, reported **an institutional outcome of successfully reaching and connecting to a new audience.**

Individual Learning: Technical and Content Knowledge

Individual ISI representatives expressed gains in skills and knowledge through engagement in Worldviews BCD events. When asked to rate their level of preparedness before and after their participation in Worldviews (1- Very Under-prepared to 7- Very Well-prepared), **ISI staff members representing seven ISIs (n=9) reported significant gains across all technological, pedagogical, and content knowledge and skills areas following the production of their BCDs** (Table 26). Although this item was administered as a retrospective measure for both the pre- and post- ratings and reflects staff members' own perceptions of gains, the positive difference in respondents' paired ratings suggest that **ISI personnel saw the Worldviews production process as having supported their individual professional development across all areas.** While all areas showed improvement, the greatest gains were in the technological knowledge/skills, where increases went from unprepared to moderately prepared overall; other large gains were seen in the community-focused knowledge areas. The areas of content and pedagogy were where ISI staff entered with the highest levels of preparedness before the project; but even in these areas, slight gains were shown.

In describing the learning that was important to them personally, the technical skills remained at the forefront. **At four of the eight sites (Michigan, CAS, Journey, and Perot), individuals reported gaining technical skills** in using the Uniview platform and other aspects of the data visualization for the dome, as described in the individual cases. **At three of the sites (DMNS, AMNH, and Perot) individuals (experts in areas of astronomy) reported gaining knowledge about the scientific content and ecological themes that were part of their productions**.

Table 27. Mean self-reported knowledge and skills (pre and post); results of comparison of paired retro-pre/post ratings*

Skill or knowledge area	**PRE**	**POST**	**Sig.**
	Median	Median	p-value
TECH: Using the full technical capabilities of Uniview in the dome	3	6	.018
TECH: Creating visualizations for the dome	1	5	.027
TECH: Preparing Earth datasets for Uniview	1	5	.011
TECH: Using WMS and other layers in Uniview's Geoscope	3	6	.016
PED: Delivering a live presentation to an audience	6	7	.034
PED: Delivering a presentation about Earth science content	4	6	.016
CONTENT: Understanding of ecology in general	4	6	.039
CONTENT: Understanding of local or regional ecological issues that were the focus of my BCD event	5	6	.014
COMMUNITY: Awareness of the work people are doing to effect change on this issue	4	6	.011
COMMUNITY: Awareness of who are key people/organizations in my community working to address this issue	5	6	.041
COMMUNITY: Using the dome for issue-focused discussions in my community	2	6	.007

**Wilcoxon Signed Rank test for significance (non-parametric; n=9)*

In terms of their attitudes about the effectiveness and principles of the project, on the whole, the ISI representatives ended the project feeling positively and in agreement about the project's goals. Nearly each respondent strongly agreed about the use of the dome for telling Earth-focused stories, its overall potential, and their desire to use it in this way (Table 27). There was also quite strong sentiment that the community advisors were an important resource and that the overall process was enjoyable. There was more mixed reaction regarding the degree to which the community advisors contributed to the BCD event, however, with five ISI staff strongly agreeing, and four feeling more neutrally about the level of their contribution. This seems to align with the wide range that was seen in the level of involvement by advisors in the creation of each show; some had deep engagement, while others had more minimal input from outside content experts.

Table 28. ISI staff ratings of agreement/disagreement with attitude items about participation in Worldviews Network.

	Agree (7 or 6)	Neutral (3-5)	Disagree (1 or 2)
The dome should be used more often for stories not about astronomy	9	0	0
The dome is a powerful tool for presenting ideas and information.	8	1	0
I would like to do more public programming in our dome about ecological topics	8	1	0
The Advisors we worked with are important resources for my institution	7	2	0
I really enjoyed the process of developing our BCD	6	3	0
The Advisors in our community contributed greatly to our BCD event	5	4	0

Longer-Term Outcomes at ISIs

This evaluation allowed us to capture evidence of the extended impact of the project, revisiting several of the sites in the 6 months to 2 years following their Worldviews Network productions. These outcomes show a suite of long-lasting outcomes, with **seven of the eight sites reporting at least one area of impact on the institution that has persisted since their engagement in Worldviews**.

Institutional Buy-In

The most commonly reported long-term outcome has been evidence of increasing and continued institutional buy-in to the ideas and vision behind the Worldviews Network, particularly using the dome to communicate about Earth-focused stories and scientific data. Four of the eight sites reported continued and growing institutional buy-in (CAS, Michigan, Journey, and Perot). This included increased interest among leadership (directors, board members, etc.) in the opportunities presented by a Worldviews BCD event (such as the CAS "Hidden Ocean" event or the Journey "Resilient Landscapes" event), or continued approach of staff with interest in new opportunities, such as an increased number of faculty interested in working with the planetarium at Michigan.

It's worth noting that two sites that did not report this outcome were either without a central institution (Minnesota) or a small, non-planetarium organization that was already a proponent of communicating about science in non-traditional ways (RENCI). The buy-in seemed to pre-exist the project among the small team of those working on the project. DMNS reported there was continued work in the Worldviews model within the institution and strong buy-in among planetarium team members, but noted that broad buy-in or change at an institutional level had not occurred. AMNH was the only ISI site that did not report this ongoing buy-in at some level, partially due to difficulty obtaining follow-up data from this site. However, DMNS and AMNH both represent very large ISIs with large staffs and departmental structures, where influencing institutional-level change may be a far bigger undertaking than at a smaller institution.

Reuse and Repurposing of Products or Approach

As is discussed in more depth below, the products created through Worldviews were a major focus and center of time, energy, and effort across ISI sites and the Leadership Team for each one of the 11 productions created. It is valuable to see that **five of the sites (RENCI, Michigan, Perot, DMNS, and Minnesota) articulated specific ways that they have already reused or repurposed the visualizations, datasets, or storylines** that were created through the Worldviews process, some within six months of the original production. So far, this has included using the materials for:

- Internal professional development opportunities (Perot)
- Adapting or testing with classrooms, teachers, or students (Michigan, RENCI, Perot, Minnesota)
- Adapting for new audiences or members of the public (Michigan, Minnesota, DMNS)

Two sites (CAS and Minnesota) reported having applied or extended the overall approach of the Worldviews Network by using data visualizations to tell globally important stories. Journey has also expressed intention to continue the approach and style of events/interpretation, but change at the institution has limited what they have achieved thus far. Table 28 presents a synthesis of results from the ISI survey, showing the distribution of what the group of institutions had already achieved, planned to do, has no intention of pursuing, or that they were already doing prior to Worldviews involvement (with all but AMNH reporting). **The most common follow-through has been working with an advisor/attendee from a BCD event** (4 have done this at least once since their event). **Next is using the narrative techniques of Worldviews**, with one ISI incorporating it as regular practice and one has done it already; four others reported they used this technique prior to the project. Two ISIs reported they have conducted additional programming on their BCD topic and have been in contact with an advisor/attendee. No ISIs had yet engaged community partners in a new project, but four reported they planned or intended to do so. Finally, **there was no reported impact on increase in live presentations among these ISIs** because all (except for RENCI) already engaged in this practice prior to Worldviews.

The Leadership Team has continued to apply this approach to other projects and communication opportunities outside of the formal bounds of the Worldviews Network ISI programs here, as well. From presentations for diverse groups, including the Aspen Ideas Festival and the National Park Service, they've shown commitment to furthering this approach as a relevant strategy for a variety of audiences.

Table 29. Frequency distribution of reports from ISI survey of whether their institution has taken outcome-related actions since the completion of their BCD event. Green highlights are the most-selected response. (n=7 institutions)[20]

	Done regularly	Have done since	Plan to do	Intend (no plan)	No intention	(n/a) Did this Prior
Use storytelling/narrative techniques from Worldviews	1	1	--	1	--	4
Work with an advisor/attendee from BCD	--	4	1	--	1	1
Additional programming/community engagement about our BCD ecological issue	--	2	2	1	1	1
Be in contact with an advisor/attendee from BCD	--	2	2	1	1	1
Give another dome presentation about Earth-focused content	--	1	1	1	--	4
Engage community partners/advisors for new projects	--	--	3	1	1	2
Increase number of live presentations that we give	--	--	--	--	1	6

Ongoing Relationships

Four of the sites (DMNS, Minnesota, RENCI, CAS) reported maintaining or building new relationships outside of their home institution as a result of the project. This was a major goal articulated by the project team, but difficult to manifest at every site. Even when this relationship-building did occur, maintaining connections in a meaningful way beyond the parameters of the BCD event required additional effort and capacity. One ISI representative reported, "The problem we have had is keeping the whole team (creation, production and delivery) intact during the economic downturn. It has been much harder to be able to get the synergy to occur" (ISI survey). For these sites, however, the representatives reported continued work with either science/community advisors or with technical advisors.

Within the Worldviews Network of eight institutions, occasional discussion via an email listserv has shown evidence of sharing relevant information, data sources, visualization sources, audience insights, and technical troubleshooting. This email list has been the most ongoing form of communication among the Network since its initial kick-off; other instances, such as a Google Hangout conference to describe the AMNH visuals/script, have been used more infrequently. In general, however, building a strong sense of connection across the individual ISIs has not been highly successful at this stage. The ISI staff who responded to the survey tended to be neutral about whether they felt connected to others in the Network (67% gave it a 4 or 5 out of 7). **While ISI staff may not feel strongly connected as a whole group, other evidence points some instances of ongoing one-on-one relationships between individual project site representatives that are successful**. An example is the relationship between Minnesota and Journey representatives for ongoing work to help rebuild expertise among new staff members to

[20] Three staffers responded for Perot. Where there was not unanimity in responses, the point selected by 2 of 3 was used for reporting here. All other ISIs had only one staff person respond to the survey.

continue the foundation of the Worldviews Network approach, as well as RENCI's continued work with members of the Leadership Team.

Table 30. ISI staff ratings of agreement/disagreement with attitude item about the Network.

	Agree (7 or 6)	Neutral (3-5)	Disagree (1 or 2)
I felt connected to the other institutions in the network	2	6	1

Relationships between Site & Strategy

There was not one "ideal model" of what a Worldviews Network site, program, or development process looked like. The process, the products, and the extended outcomes were very different for each site within the Network. However, each site felt that it had been somewhat or very successful when judged against its own goals and vision for the program. The nature of the Worldviews Network model allowed for a high degree of flexibility in goal-setting by an ISI, to identify the story, audience, and event-type that was feasible and desired for the institution. Only the visual product and development (storyboarding) process for that visual product were more strictly defined and directed by the Leadership Team. Within that structure of flexibility, some relationships could be found between site characteristics and ultimate strategies used or outcomes achieved, which inform the transferability of this model more broadly.

Barriers & Contextual Factors

The underlying concept of Worldviews was ambitious and innovative, creating a new model to be tested; in that context, the sites that were engaged in the first year were on a steep learning curve. The first DMNS event experimented with what a production process might look like. Looking back on this production aided in the realization of the need for and the creation of a more systematized production process to use going forward. The first CAS event was the first to experiment deeply with the role of a number of community and scientific advisors in the story process. This created some examples of how a site could approach co-developing a production with community stakeholders. The RENCI event was the first to experiment with the idea of using remote technologies to simulcast presentations at multiple sites, uncovering significant difficulties and limitations to this idea. Across these productions from the first year of the grant, major lessons were learned by the Leadership Team and models for production planning were created that would guide and shape the process going forward. **These examples highlight that more than a year of experimentation was necessary to develop tools, approaches, and operationalize the idea of Worldviews Network into an overall process.**

Institution-types also created influencing contexts; sites seemed to group into two categories, large ISIs or universities and small ISIs. Within the large sites (AMNH, CAS, DMNS, and Michigan), institutional-level challenges reflected the tendency for large organizations to have staff siloed in departments and responsibilities in a way that can make cross-department collaboration more difficult. While not always insurmountable, these institutional barriers often made the process of engaging researchers in the production process difficult, particularly on a first attempt. Those sites that made a second attempt sometimes found an easier path, with some groundwork and common understanding built over time. For these sites, the headway made was a significant outcome they identified from the project (described above). One of these sites, Michigan, represents a hybrid; the ISI and planetarium are a very small staff, but

their engagement as part of the larger university system (and the goal to serve that larger audience) impacted their experience in this area, making them align with the larger ISIs.

In contrast, small ISIs (Journey, Minnesota, Perot, and RENCI), the sites tended to face a more substantial lack of resources or tools available to make their vision a reality. While these were not insurmountable, given successful productions at each, accommodations had to be made. All four of these sites, for instance, had access to a portable dome, which limited capacity. In the case of Minnesota, there were challenges to transport a dome to the audience they sought to serve; for Journey, they ultimately had to use a non-dome projection system in order to accommodate the audience they identified; and at Perot the attendance was small, as they created and marketed a new type of program for the institution. RENCI benefitted from two Co-PIs working closely with them, on-site, on their production, but noted in their ISI survey that financial challenges over time made it difficult to keep the team and momentum together.

Across all sites, except for Journey, there were challenges reported in the process of technically adapting the scientific datasets to the dome. Journey was the exception because they presented on a large flat-screen, which greatly eased the process of getting data into the production (as it could be tested and visualized on any computer screen). **With the immersive dome at the heart of the concept of Worldviews, this technical process (and the corresponding technical skill-set) required a major direction of energy, time, and effort** from the Leadership Team members with this expertise, perhaps beyond what was envisioned in early plans. It highlights a cost-benefit tradeoff; for the benefit of the immersive dome experience, the creation of the visuals requires a high investment of expertise and time to create a custom production.

Motivation to Join the Network

The inspiration for this project was concerns related to "Coupled Human-Natural System Boundary Conditions ," as evidenced by the model visualizing the Worldviews Network project concepts. Examining how the site representatives described their motivations and connection to the project goals highlighted how different sites operated at different levels in thinking about their connection to this concept. **Those operating with this goal at their center were the sites who were affiliated with representatives that formed** (CAS, DMNS, and RENCI) or were advisors to (Minnesota) the original Network concept. **Other sites approached the project with willingness to experiment with the idea of bringing Earth issues into the planetarium, but with other guiding motivations specific to their institution.** These sites operated at a different level of buy-in to the concept, approaching the project with interest, but placing staff professional development and/or the creation of new visual resources for their institution to use for other purposes (Perot, Michigan, AMNH, Journey).

Product-Driven Process: Variation in Events and Experience

A Product-Driven Process

Because of the visibility and substantial challenges (technically, scientifically, pedagogically) that became evident in creating Worldviews Network productions, a common pattern across nearly all of the cases was that the creation of this end-product (a dome presentation and event by a certain date) was the center of focus and attention. Decisions were made in a way to get to that product, typically in whatever way was most expedient. Leadership moved in to fill gaps and pick up slack

where it was needed so that the productions were completed as planned; with few exceptions, events had direct involvement from someone on the Leadership Team who came to the site to assist with the BCD event.

Variation in Audience: Public vs. Stakeholder

Two general strategies emerged in how sites defined and invited audiences to their events. One strategy, taken by CAS: Valley Oaks (day), RENCI, and Minnesota, was to focus energy on "curating" their audience -- strategically inviting an audience that was primarily comprised of community stakeholders with a potential connection to the issue or solutions. While these events were sometimes welcoming of other members of the public, they were targeted for an audience with higher incoming knowledge and an interest in engaging in dialogue around the issue. These were also sites were dialogue played a significant role in the event. One variation was Perot, where they were focused on a specific stakeholder audience (teachers), but the presentation was one element within a suite of teaching resources demonstrated.

Other events were prepared for a more general audience. While a list of some experts and stakeholders were specifically invited to the event at nearly every site, these events were primarily attended by general public, primarily regular attendees of evening planetarium or museum events (DMNS: Water Story and Beetles, AMNH, CAS: Valley Oaks (night), CAS: Oceans, Michigan, Journey), promoted through existing channels or mailing lists to audiences of those venues.

This second, more common condition, resulted in audiences that were often mixed in their composition of experts and non-experts in the content and issues being presented. Looking at the data from attendees of the first seven events, formative data was collected about what made a presentation easy or hard to understand. Within the overall data from all events, 14% of the audience members reported that it was easy to understand the presentation because they were already an expert or trained about the topic; and about 8% of people who reported it was difficult to understand indicated it was because they were unfamiliar and non-experts, and felt the presentation was "over my head." Looking closely at the events with a large proportion of public attendees, some of these events (including CAS: Valley Oaks (night), AMNH, and Journey) showed that 35% or more of the audience members who reported they had difficulty understanding believed the content to be complex and/or blamed themselves for not knowing enough about it. At these same events, a substantial portion of respondents reported that learning was easy because they were already familiar with the content. While it was not the case at all events with mixed audiences, **the contrast of two different invited groups (experts and general public) highlights a potential challenge of presenting one event to widely varying levels of audience expertise.**

The Challenge and Lessons of Facilitating Dialogue

In addition to the narrated presentations in Worldviews Network productions (i.e., one-way presentation with accompanying visuals), the Leadership Team identified an aspirational extension to incorporate active audience dialogue in the BCD model. As has been shown, this occurred at some sites; those sites were primarily the most-invested (i.e., co-PI) institutions (CAS, DMNS, RENCI, Minnesota). These dialogue sessions were led or supported by Leadership Team members (none of the dialogues occurred with only ISI representatives), and one was facilitated by a hired consultant who was piloting a more formalized process (CAS: Oceans).

In observations conducted of the dialogues at DMNS: Beetles, CAS: Oceans, and analysis of notes taken of group discussion at CAS: Valley Oaks, it becomes evident that it was sometimes difficult, even with skilled facilitators, to transition the group from a Q&A session with the experts to a session of true dialogue, where attendees were as active in feeding the conversation as the experts. Of those sessions observed, the CAS: Valley Oaks (day), which consisted of only community stakeholders, was the most successful at achieving true, solution-oriented dialogue (of those observed; Minnesota dialogues were absent from this dataset and it is likely that a different approach of dialogue was used with the unique formats of these presentations). At the CAS: Oceans event, attendees tended to have some connection to the content or project, but there were several instances where those with deepest knowledge of the research presented took the floor for extended portions of the session, indicating that there was not a shared understanding of the purpose of dialogue amongst all in the room. In looking at these notes, as well as data supplied from interviews with ISIs and Leadership, there seem to be three factors that are necessary or highly supportive of creating a successful environment for community dialogue, following a Worldviews presentation:

1. **Enough "expert" attendees in the room to sustain dialogue**, rather than falling into the more comfortable (for non-experts) Q&A format;
2. **An experienced facilitator**, with the skills to initiate, set ground rules, and support open group dialogue in this format;
3. **Comfort by the facilitator in the framework** and purpose of the dialogue toward solution-building around social-ecological systems.

Factors Influencing Outcomes

The Effect of Incoming Resources & Strengthening Gaps in Expertise

The incoming resources, strengths, and assets of an ISI partner affected their implementation strategy and approach. Each site worked from a set of institutional constraints and opportunities at the outset of their project, and each site built on competency strengths and needed project support to compensate for competency weaknesses. Each site worked with what they had and their own motivations (which were often not solely, or at all, articulated in terms of human-caused environmental change) to create a program that met a suite of needs and circumstances.

Because this project was largely driven and implemented by the efforts of just one or two individuals at an ISI site, the competencies of that individual person were a lynchpin to what occurred at the site**.** Within the TPACK framework, it is evident that different individuals entered with different strengths and competency levels in each of the three areas (technological, pedagogical, and natural science content), and the process had to adapt to fill in for or build in areas of weakness, and to take best advantage of a site's strengths.

Through the process of working with the Worldviews Network, ISI professionals did gain new skills and knowledge in the areas where they entered with deficits. For example, someone with low levels of experience with the full-dome technology would gain substantial skills at understanding and working with the platforms of their ISI's dome. Someone with experience in astronomy, but not ecology, gained new understanding of ecological issues covered in their domes. This came through one-on-one mentorship and "spot-training" on whatever was needed to get the site to the end product of the dome show. While the ISI staff acknowledged the gains, they were also understood to be "on the job" training experiences.

However, this process of gaining skills through practice was not sufficient to create an expert (or feel like an expert). In many areas, gaps were filled by Leadership Team when the learning curve was too steep for individual ISI staff. For example, while an astronomy expert reported gaining knowledge about the social-ecological issues in their communities, this expert still felt uncomfortable taking the lead to deliver the ecological portions of the Worldviews show. Additionally, the experience of Journey highlights the challenges with any skill-building program: "If key people leave the institution, then all of this training will have been for naught" (ISI survey). When staff change occurs, the skills and know-how for this type of programming could be at risk if it is not shared or institutionalized in a greater fashion. In Journey's case, the institutional commitments have led to re-building of skills among new staff, but in a different case, the project could become a one-off.

Defining and Building Pedagogical Skills

Pedagogical skills may be an area for particular emphasis in future work or development of Network members. It seemed the greatest pedagogical skill built through Worldviews was the ability to present in the dome about Earth science content. All of the sites reported prior experience doing live delivery of programming, and so general presentation skills were only marginally improved. With this presentation experience in this sector of ISI professionals, it is important to note that there is a wide range of communication expertise. While live presentation skills are a valuable foundation, they are not identical to the different types of audience engagement that were considered and tested within the Worldviews Network project**.**

One area of pedagogical skill used in all Network events was live presentation of the dome show, which included both cosmic and ecological content. The presentation technique included the development and preparation of a storyline and, to some degree, script (or at least very detailed outline) to be read/presented live to an audience. ISI professionals at future sites would need to have skills to create and deliver this type of presentation. Within Network sites, where there was great comfort presenting live astronomy-focused shows, some programs still used support by science experts (locally or from the Leadership Team) to deliver these components during the live show. Even a member of an ISI noted the challenge of developing strong communication skills for a live dome presentation:

> *it is a challenge; doing them well is a huge challenge and it's tough to break the mold if you're not familiar with teaching in the dome interactively and doing that type of service, you kind of default to what you know and that's talking at a PowerPoint and that does not play well at a dome-cast, either."* (ISI interview)

From Big Idea to Practical First Steps

In looking at the data from the eight sites and eleven productions, it becomes clear that the Worldviews Network project became about operationalizing the practical reality of a big idea. The project began with a big vision and big idea about harnessing the power of immersive visualizations and dome technology to bring local ecological stories into context locally, globally, and cosmically. It built from this strategy to envision collaborations between science experts and ISI partners in creating stories and delivering events, and to push toward follow-up community dialogues that took the presentations beyond the data and toward solution-oriented discussions. These were big ideas.

In practice, the Network attempted to operationalize these visions at different levels, and the members of the Network quickly learned to identify what was a feasible first step or second step at each site, based on their level of readiness. The Network model was not cookie-cutter. Over the course of this process, Network members and Leadership were able to "let go" of rigid ideals or frameworks, and the team adapted to what was available, of interest, and realistic at a particular site. This took time, and in instances some tension and negotiation between an individual ISI and members of the Leadership Team in their coaching roles occurred. At both DMNS and Michigan, for instance, very experienced planetarium staff with their own processes for developing shows had to negotiate with the Leadership Team to adapt to a new process that came from the Leadership Team's experience with this model.

The result of this was that each site produced an event that was manageable for that site. Meaning:

- Only Leadership-affiliated sites (and Minnesota, led by a project advisor) attempted dialogues;
- Only sites with prior goals or contacts focused on community leaders as a primary audience;
- Leadership filled in with narration when sites weren't ready/able;
- Leadership filled in with story-creation or technology when sites weren't able.

While acknowledging contextual challenges, the project also strove to push forward, make advances, and go beyond the bare minimum of what could be done. In a step-wise manner, there was a concerted effort by Leadership to push ever closer to the Big Idea and break limitations wherever possible. For example:

- Technical advisor (Yu) pushing the limits of what data visualizations translated to Uniview/domes could do; such as creating a way to show time-series data for the first time (AMNH);
- Pedagogical advisors (Connolly and McConville) encouraging, leading, and experimenting with audience dialogues wherever there was the will or interest;
- Content advisors (Gardiner and Hamilton) going beyond familiar data sources to identify and gather the scientists, data sets, and research findings that could best tell the stories that were identified by ISIs as important.
- Constantly engaging in new opportunities and venues to share the stories and model with others that might find value in the messages, such as Aspen Ideas Festival, National Park Service, etc.

Conclusions and Recommendations

In sum, the Worldviews Network project was successful at achieving a number of its intended outcomes with its professional and public audiences. The eight case sites in the Network showed that in general, ISI staff developed a great number of technical skills, new aspects of pedagogical skills, and/or content understanding about social-ecological issues, particularly in those areas that were not their personal realms of expertise. Each ISI also engaged in the process put forth by the Leadership Team to develop their BCD event, even when it presented substantial workload and unfamiliar ways of working, with each site producing and holding an event of its own design. Each project engaged community advisors in the process at some level, which was critical to the development of the narratives, but the depth of the involvement of community advisors varied widely based on the circumstances at each site.

Public audiences (including varying mixes of general public and invited stakeholders in the topic) responded very positively to the events they attended. Responses to event surveys indicated that nearly all audience members reported learning something new, with that learning reported primarily as being about ecological information or facts, with some emphasis on understanding concepts of time, scale, and broad geographic perspective. Interestingly, audiences' reports of their main thematic takeaways from the Worldviews Network shows aligned deeply with the goals of the productions (complexity of Earth systems; concepts of time and scale; continual change; and perspective on the Earth in the universe). These results, however, were substantially different than results from a 2010 survey of audiences to Science On a Sphere® (Goldman, et al., 2010), where the realism of the information and a focus on specific events were the themes with which audiences most connected. The dome environment and/or the use of extensive, carefully designed visualizations were received very well by audiences who appreciated seeing the information (rather than just hearing it) and the presentations that providing perspective on the data.

Perhaps most importantly to the project's longer-term impact, since the end of the individual productions, nearly all of the sites reported tangible ways that they have sought to extend their work within Worldviews in some capacity. Those extended impacts ranged from the most material (continuing to use/adapt the digital assets created) to practice-based (using the narrative approach generally) to institutionally pushing on the paradigm of what a planetarium can present and do for its community. Several individual relationships within the Network, as well as a number of relationships with community advisors, have either continued via some contact between ISIs and their new partners or that ISIs report a desire to re-engage with those experts.

As the first iteration and cohort of the Worldviews Network project completes, focus has shifted to a goal of sharing resources that have been developed by the Leadership Team and the ISI sites. This focus includes efforts underway to provide a publicly available repository of digital assets and training/guidelines for existing and new Worldviews sites that might seek to advance the vision of the Worldviews model for public engagement. As this effort seeks to expand the number and diversity of sites using this framework, in a second phase where there is less direct support from project Leadership, the findings from this evaluation highlight several overarching recommendations for future network sites to consider.

Recommendations for Future Network Sites

- **The TPACK (Technological-Pedagogical-Content Knowledge) framework is a useful organizing device for understanding and supporting new Worldviews Network sites**. Because this project tends to be driven and implemented by the efforts of just one or two individuals at an ISI site, the competencies of that individual person were a lynchpin to what occurs at the site and what strategies are used**.** Within the TPACK framework, it is evident that different individuals entered with different strengths and competency levels in each of the areas (technological, pedagogical, and natural science content), and that the areas that were not strengths were those that needed the most outside support.

- **Looking forward, new sites should be encouraged to engage in a self-assessment of their individual competencies along this framework, as well as to identify institutional priorities and assets that should be leveraged.** In the program years, the Leadership Team informally made these assessments of sites and adjusted their approach to suit needs and provide as-needed support and encouragement. As the Network must become more self-sufficient, it would be valuable to facilitate the process for new sites to engage in this process for themselves and use what they learn to shape their self-guided professional development.

- **Investment in carefully planning a BCD Event – including intended audience, social-ecological content, and technical troubleshooting – will likely enhance audience experience.** Identifying your intended audience (community stakeholders or general public?) and then aligning the content and story to meet audiences where they are was a key challenge faced by Worldviews sites. Similarly, audiences tended to identify room for improvement related to the specifics of the show – what content was included (or not), the way the visualizations were presented (quality, timing, understandability), and technological glitches. These lessons may apply to other educational storytelling and visualizations.

- **For future sites, pedagogical skills related to creating and facilitating true dialogue with an audience would need to be an area of development and training**, if an increase in the use of the post-presentation dialogue is desired. Facilitation of dialogue with public and stakeholders uses a specialized skill-set, which is often not a core focus of the work of many types of ISI professionals, even museum or planetarium educators.

- **A worthwhile question for entering partners is the ways in which the Worldviews Network approach could be adapted to non-dome settings.** In order to achieve a broader audience reach, two current Network sites have already pushed on the need to apply the techniques to flat-screen environments, whether in their BCD Event (Journey) or in post-project extensions of resources (Michigan). The Network may want to advise future sites on trade-offs of the two platforms (e.g., it is technically easier to produce for flat-screen, but it involves the loss of immersion experiences) and any critical decision-points to consider.

- **Patience is a virtue for advocates of this approach who hope to affect institutional-level strategy.** At most sites in the Network, there were one or two staff advocates, who invested a lot of their own time and passion to engage in this experiment and seek to bring others at their ISI onboard through the experience. For many sites, buy-in did not happen overnight, and it took persistence and showing evidence of success. In those cases where institutional-level interest has mounted, there was generally some strategic alignment of the program with a larger institutional goal (such as the program's ability to promote internal research achievements or provide a unique, marketable product for educational outreach).

Considering the lessons learned through the first iteration and establishment of the Worldviews Network, a major concluding initiative among project personnel is supporting the growth of the Worldviews Network and ongoing implementation of its approach and vision in concrete ways. Over the final year of the project, the Leadership Team has worked to develop online resources for prospective ISI partners on the project website (www.worldviews.net). Team-produced materials so far include presentation packages from Worldviews BCD Events so far; discrete data layers for download and use; suggestions for extension and community outreach; and a suite of video tutorials for developing and producing a BCD-inspired event. To help new sites operationalize the findings and recommendations from this evaluation, the evaluation team has created additional resources available that visualize the steps of the Worldviews Network production process, self-assessment tools using the TPACK framework, and video and graphical presentations of starting strategies that new sites can use to leverage their unique strengths and institutional priorities to create their own BCD event.

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Appendices

Appendix A: Logic Model documents

Appendix B: Instruments

**See accompanying PDF for Appendices*