Increasing Internal Stakeholder Consensus about a University Science Center's Outreach Policies and Procedures

by

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ABTRACT

For decades the United States has tried to increase the number of students pursuing science, technology, engineering, and mathematics (STEM) education and careers. Educators and policy makers continue to seek strategies to increase the number of students in the STEM education pipeline. Public institutions of higher education are involved in this effort through education and public outreach (EPO) initiatives. Arizona State University opened its largest research facility, the new Interdisciplinary Science and Technology Building IV (ISTB4) in September, 2012. As the new home of the School of Earth & Space Exploration (SESE), ISTB4 was designed to serve the school's dedication to K-12 education and public outreach.

This dissertation presents a menu of ideas for revamping the EPO program for SESE. Utilizing the Delphi method, I was able to clarify which ideas would be most supported, and those that would not, by a variety of important SESE stakeholders. The study revealed that consensus exists in areas related to staffing and expansion of free programming, whereas less consensus exist in the areas of fee-based programs. The following most promising ideas for improving the SESE's EPO effort were identified and will be presented to SESE's incoming director in July, 2013: (a) hire a full-time director, theatre manager, and program coordinator; (b) establish a service-learning requirement obligating undergraduate SESE majors to serve as docent support for outreach programs; (c) obligate all EPO operations to advise, assist, and contribute to the development of curricula, activities, and exhibits; (d) perform a market and cost analysis of other informational education venues offering similar programming; (3) establish a schedule of fee-based planetarium and film offerings; and (f) create an ISTB4 centric, fee-based

package of programs specifically correlated to K12 education standards that can be delivered as a fieldtrip experience.

DEDICATION

In the course of this doctoral program I was struck with two back-to-back life threating medical emergency's requiring seven surgical procedures three of which were major. My dedication to this work would be the same without those challenges, however, especially in there light I dedicate this dissertation to my Lord, Jesus Christ; "I can do all things through Christ who strengthens me." (Philippian 4:13).

I would also like to dedicate this work to my family; my wife Tiffany and our two children, Laura Beth and Susan. Your continuous support, love and encouragement gave me the motivation and inspiration needed to succeed. And to my parents, Harry and Faith Fisher, for providing the moral foundation and work ethic that has served me well throughout my life.

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I would like to thank Dr. Caroline Turner for developing this doctoral program and for her faith in me. I would also like to acknowledge the rest of the faculty involved in this program from whom I have learned so much. To my cohort mates, your friendship and comradery were indispensable.

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CHAPTER 1

INTRODUCTION

Our nation has struggled for several decades to successfully increase the number of students pursuing science, technology, engineering and mathematics (STEM) education and careers. As a result, many economists and national leaders are concerned that the United States is losing its position of global economic dominance and as a result has experienced a weakening in our national security. At the behest of domestic industry, the U.S. government has for many years increased the number of H1B visas to allow highly qualified foreign nationals to fill the STEM job vacancies in some of the best paying and most sensitive jobs in the country. In 1992 for instance, the U.S. government issued 48,600 such visas; however, by 2002, 163,600 had issued been issued (National Foundation for American Policy, 2010). Educators, administrators, and policy makers continue to create strategies and educational experiences to increase the number of American students in the STEM education pipeline. Most public colleges and universities are involved in this effort through various education and public outreach (EPO) initiatives. This dissertation presents an action research plan that utilized the Delphi research method to help establish a new education and public outreach operation for the School of Earth & Space Exploration (SESE) at Arizona State University (ASU).

Local Setting

The School of Earth & Space Exploration was founded in the summer of 2006 by merging the geological sciences and the area of physics focusing on astronomy, astrophysics, and cosmology. This new experiment in earth and space sciences was designed to create “a unique academic environment in which scientific discovery

motivates the exploration of today, technological innovation enables the discoveries of tomorrow, and transdisciplinary learning prepares future generations of explorers" (SESE, 2008).

Since SESE's founding an array of previously established and new education and outreach programs have been offered at Arizona State University. All of these programs operate independently and are largely tied to specific departments (e.g., Center for Meteorite Studies) or specific grant funded research programs (e.g., Mars Space Flight, Lunar Reconnaissance Operation Center, and Project EarthScope). Others have been stand-alone operations like the Dietz Geological Museum and the planetarium. Funding, staffing, and operational resources derive from sources as diverse as the operations themselves.

In 2008, construction began on the largest research facility in the history of Arizona State University: Interdisciplinary Science and Technology Building IV (ISTB4). As the new home of SESE, ISTB4 has been "designed in an entirely novel way that reflects the school's dedication to K-12 education and public outreach. The first and second floors of this 290,000 sq. ft. building will be largely devoted to the integration of cutting-edge research in earth and space sciences with public education. The goal of this design is to engage visitors in the process of "doing science" (SESE, 2008), specifically, doing science through exploration. To accomplish this goal of engagement, the facility includes a state-of-the-art 236 seat lecture hall and theater (Marston Exploration Theater), which is equipped with a high-definition video projection (Sony 4K) and SkySkan Corporation's new "Definiti" planetarium system. There are several exhibit gallery spaces that compose the Gallery of Scientific Exploration from which visitors can peer

into clean rooms, high-bay labs, and wet-labs. Additionally, a one-of-a-kind highly mediated classroom will be available for programming.

Position of the Researcher

The primary function of this researcher's job description is to collaborate with the director of the School of Earth & Space Exploration and others within the SESE community to (a) articulate a long-term operations plan for centralized K-12 and public outreach programs for the School of Earth & Space Exploration; (b) develop and implement a funding strategy for carrying out that plan; and (c) establish the exhibition and educational spaces necessary for these programs in ISTB4.

In an effort to accomplish these duties and responsibilities, I developed a plan to engage an exhibit design firm to facilitate an exhibit deign charrette. A design charrette is a facilitated and guided face-to-face brainstorming activity conducted with a group of expert stakeholders. This process employs an iterative, quasi-nominal group technique where opinions are offered, ideas consolidated, and opinions are merged to percolate the salient points, and then recirculated among the group for further consideration.

Preliminary Intervention

I gathered critical information from a two-day facilitated design charrette on December 12 -13, 2011. The design firm presented an exhibit conceptual design plan on December 30, 2011 that included numerous drawings with narrative descriptions of the exhibits to be used in the ISTB4 education and public outreach exhibit galleries. The exhibit design charrette notes where then emailed to the charrette participants, and the exhibit conceptual design plan was posted to a website for them to review. This exercise forced the group to address the following questions: Why are we doing this? Who is it for

(audience/constituency)? What are the global message and the sub-messages (big-main, primary, secondary and tertiary)? By evaluating the brainstorming results through discussion, group-thinking, and consensus-building the participants distilled the following principle messaging structure:

- Main Message. SESE is a unique group of people passionate about exploring Earth and the universe and sharing that knowledge.
- Primary Messages. (a) Science is the process of exploring, theorizing, and experimenting (the nature of doing science); (b) Science has led us to new understandings about the universe as explorers probe the unknown (the great truths); (c) Scientists and engineers at SESE are doing amazing things *right here, right now*!

The new outreach space in ISTB4 provides a unique, state-of-the-art venue in which to tell SECE's many remarkable stories. Historically, SESE education and public outreach programs included the following:

- Lunar Reconnaissance Orbiter Camera (LROC) Science Operations Center (SOC) tour
- Mars Space Flight Facility tour
- Mars Student Imaging Project (MSIP)
- Mars Exploration Student Data Teams (MESDT)
- Mars Educator Workshop
- STARLAB Portable Planetarium Loan Program
- Astrobiology Virtual Fieldtrips

- EarthScope Teacher Workshop
- NASA Triad teacher professional development workshop
- Center for Meteorite Studies exhibits and vault tours
- Center for Meteorite Studies classroom loaner kit
- Dietz Geological Museum
- Planetarium Shows
- Space Photography Lab tour and packets.

These educational programs have operated as stand-alone programs, and to set-up a fieldtrip teachers had to contact individual program representatives to arrange for their classes to participate in these disparate and incongruous operations. These fieldtrips are then casually coordinated between the programs to accomplish "hand-off" of the tour groups from one tour to the next.

My hope is that the exhibit design charrette and exhibit design plan has accomplished its intent of reinforcing the over-arching mission of the outreach program, which is explaining scientific exploration and telling the SESE story. Furthermore, it was hoped that the process would serve as a catalyst for motivating the many disparate and distinct education and public outreach groups to begin visualizing not only how they may use the new ISTB4 space and assets for their own programs but also how the various programs can begin to operate in a more integrated and seamless way from the visitor perspective. With future education and public outreach programs largely being delivered from the single new facility, all the stakeholders need to starting thinking about how to address overlapping interests through collaboration and centralization in areas such as marketing, reservations and sales, staffing, and budgeting.

Theoretical Framework

Classical organizational theorist like Weber, Taylor, and Fayol, thought that there was "one best way" to organize. However, most organizational theorist today believe there is no single best way. Rather, it is important for there to be a good fit between an organization's structure, size, technology and the environment. This perspective is known as "contingency theory" and informs my theoretical framework for this action research plan (Borgatti, 2001). According to Walter Johnson (2011), "the key concept behind contingency theory is adjustment. The internal structure of the firm is 'contingent' on the pressure put on it by outside market forces (p. 2)." In a similar way, SESE's outreach operations will need to adjust to operate in a new environment with different resources and a diverse group of stakeholders sharing common facilities.

The School of Earth & Space Exploration is populated with a large number of highly intelligent academicians and researchers who represent a broad range of experience and expertise. Many of these stakeholders have specific, diverse (and perhaps topically narrow), and valuable opinions about our outreach programs. Many of these stakeholders feel isolated from the process and believe they have no way to contribute to how outreach is conducted at SESE. Following the theoretical framework of contingency theory, I sought to tap into those professors' deep pool of knowledge, experience, and expertise to identify best practices. The process I employed was designed to cross-pollinate information between and among disparate units and give stakeholders a voice in fashioning a consensus-informed plan for future outreach operations, something I hoped would increase buy-in and satisfaction among the participants.

Purpose of This Study

As a continuation of the process initiated by the charrette and exhibit design activity, I conducted an action-research intervention to establish an enhanced education and public outreach operation in the new building through a process of (a) soliciting expert stakeholder opinions and (b) developing consensus and/or merging opinions about the new operation. I employed an iterative Delphi process to bring together the knowledge and opinions of a diverse multi-stakeholder, multi-disciplinary group of experts to define and describe the most effective self-sustaining SESE education and public outreach operation for the new ISTB4 building. Following the three-round Delphi process exercise, I evaluated this intervention by documenting the degree of consensus or convergence of perspectives achieved, measuring the degree of agreement and also by interviewing a targeted subset of participants in the Delphi process about their satisfaction with the exercise.

Summary

The School of Earth & Space Exploration's current EPO programs are dispersed and very loosely coupled. For the visitor or school teacher coordinating a fieldtrip one is forced to interact with each of the disparate programs separately. Moving SESE into the new ISTB4 building with space and asset dedicated to the outreach mission provides an opportunity for the school to redefine the outreach enterprise as cohesive and user-friendly with increased efficacy.

CHAPTER 2

LITERATURE REVIEW

Introduction

The purpose of the review of scholarly literature in an action research dissertation is not to discover what the next research question should be but rather to inform and strengthen the action research intervention. Therefore, this study employed a targeted literature review focused on several pertinent articles that specifically inform action research, the Delphi research design and data analysis and organizational theory including higher education culture.

Action Research

Stringer (2007) describes action research as a process that is meant to be utilized within a particular community of practice and works from an assumption that all people affected by or having an effect on an issue should be involved in the processes. Action research documents and evaluates an action or cycle of actions that members of a practice have taken, are taking, or wish to take, to address a particular problem or situation (Anderson& Herr, 2005). This research approach has been described as a participatory, experiential, and reflective mode of research in which all individuals involved in the study are contributing actors in the research endeavor (Berg, 2004).

Action research has been concisely explained as a form of self-reflective Problem-solving that enables practitioners to better understand and solve acute problems in social settings (McKernan, 1988). It has also been described as systematic inquiry that is collective, collaborative, self-reflective, and conducted by the participants of the inquiry. The goals of action research projects are the articulation of a rationale or

philosophy of practice that enhances the understanding of a practice in order to improve it (Jung & McCutcheon, 1990).

By collecting data associated with a specified problem and then feeding it back to the organization, researchers identify the need for change and the direction that the change might take (Watkins, 1991). Action research consists of a team of practitioners, and possibly theorists, who cycle through a spiral of steps including planning, action, and evaluating the result of an action, continually monitoring the activity of each step in order to adjust as needed (Kemmis & McTaggart, 1988). The cyclical nature of action research portends the need for action plans to be flexible and responsive to the environment and to allow changes in plans for action as people learn from their experiences (Dickens & Watkins, 1999).

Herr and Anderson (2005, p. 5) insist that action research demands some form of intervention that constitutes a spiral of action cycles in which the research undertakes the following four steps of "action":

1. Develop a plan of action to improve what is already happening;
2. Act to implement that plan;
3. Observe the effects of the action in the context in which it occurs;
4. Reflect on these effects as a basis for further planning, subsequent action, and on through a succession of cycles.

The cyclical and pragmatic nature typical of action research is also a common characteristic of the Delphi method, making the two methodologies compatible and well suited for my study that involved gathering feedback and facilitating a convergence of opinion among a wide array of stakeholders with varying views.

The Delphi Technique

There are hundreds of scholarly articles in the literature written about or related to the Delphi study, technique, or method. However, the purpose of the review of scholarly literature in an action research dissertation is not to discover what a good research question is but rather to inform and strengthen the action research intervention. Therefore, this study employed a targeted literature review focused on four articles that specifically inform the Delphi research design and data analysis.

Jones and Hunter (1995) writing about qualitative research methodologies in the field of medicine note that consensus methods are a viable means of synthesizing information, and often draw on a wider range of information than do statistical methods, and "where published information is inadequate or non-existent these methods provide a means of harnessing the insights of appropriate experts to enable decisions to be made (p. 376)." The Delphi process and the expert panel (also known as nominal group technique) are commonly adopted consensus methods (Jones & Hunter, 1995). The advantage of the Delphi process is that expert opinion is gained unshackled by the common biases that often exist in a group setting.

Largely developed by Dalky and Helmer (1963) at the Rand Corporation in the 1950s, the Delphi technique is a widely used and accepted method for achieving convergence of opinion concerning real-world knowledge solicited from experts within certain topic areas" (Hsu & Sanford, 2007). A Delphi, or the Delphi method, or Delphi technique is an often overlooked yet versatile qualitative research methodology (Murray & Hammons, 1995). Definitions of Delphi are abundant in literature; however, the often cited authoritative authors Delbecq, Van de Ven, and Gustafson (1975) define it this way:

"a method for the systematic solicitation and collection of judgments on a particular topic through a set of carefully designed sequential questionnaires interspersed with summative information and feedback of opinions derived from earlier responses" (p. 10). The authors go on to state that "the Delphi can be used for achieving the following objectives:

- To determine or develop a range of possible alternatives;
- To explore or expose underlying assumptions or information leading to different judgments;
- To seek out information which may generate a consensus on the part of the respondent group;
- To correlate informed judgments on a topic spanning a wide range of disciplines, and;
- To educate the respondent group as to the diverse and interrelated aspects of the topic." (p.11)

All of the objectives enumerated above are desired outcomes of this action-research project and therefore represent an appropriate application of the Delphi method. In this action research intervention the data analysis involved both qualitative and quantitative methods. Qualitative data was collected in the first round of questions, which were open-ended and solicited opinions; subsequent iterations employed Likert-type scales to achieve and analyze the degree of consensus through taking measures of central tendency and degree of dispersion (Hsu & Sanford, 2007).

Expert Panel

As for what constitutes expertise defined in literature, Hsu and Sanford (2007) state that "there is, in fact, no exact criterion currently listed in literature concerning the

selection of Delphi participants" (p. 3). Additionally, Delbecq et al. (1975) note that that "three groups of people are well qualified to be subjects of a Delphi study:

1. The top management decision makers who will utilize the outcomes of the Delphi study;
2. The professional staff members together with their support team;
3. The respondents to the Delphi questionnaire whose judgments are being sought." (p. 85)

In this action-research study the expert panel selected meets these criteria perfectly. The panel was selected in collaboration with the director of SESE specifically targeting their experience and valued opinions. Those selected included the senior management of SESE, faculty, professional staff, graduate students, and other university professional outreach staff and education professionals beyond the university.

In the literature, there is no consensus on the optimal number of expert panelist in a Delphi process, with some suggesting 10–15 individuals may suffice if the group is homogeneous, though they warn that fewer than 15 participants may not characterize a "representative pooling of judgments regarding the target issue" (Hsu & Sanford, 2007). Other scholars note that the approximate size of a Delphi panel is generally under 50 but more have been employed" (Witkens & Altschuld, 1995). This project solicited opinions from 30 experts. While it is was expected that less than 100% of the panelists invited would participate, the vast majority of participants selected were SESE employees, and thus, the time they invested participating in the process was considered part of their normal employment duties, not an investment of personal time.

One of the great advantages of the Delphi process is that expert panel participants are anonymous to one another. Their identities are not revealed even after the final report is published. Such anonymity prevents any of the participants from dominating the process by virtue of their position, authority, or personality, which minimizes the "bandwagon" effect and allows all participants to more freely express their opinions and criticisms, affording each the option of changing his or her viewpoint after considering the input of others (Delphi Method, 2009). Due to anticipated strong and diverse opinions, participant anonymity was an important feature of this intervention.

The Delphi Process

The person coordinating the Delphi, the facilitator, sends out questionnaires, surveys, etc. Participants are asked to respond to a survey and identify themselves with a self-made code, in the case of this study consisting of the first two digits of their street address and the first and last initial of their mother's maiden name. Responses are subsequently collected and analyzed, and then common and conflicting viewpoints are identified.

Hsu and Sandford (2007) identify controlled feedback and statistical analysis as two additional advantages of the Delphi that are described throughout literature. Controlled feedback consists of a well-organized summation of the prior questionnaire iteration that is distributed to the panelists to help them generate greater insight, furnishing an opportunity to modify or clarify their positions. Controlled feedback also helps eliminate noise emanating from individual interests, which could be irrelevant and thus distort the data. Statistical analysis allows opinions to be well represented and for a balanced summation of the collected data (Dalkey, 1972; Ludlow, 1975; Douglas, 1983).

In the second iteration of questions, the researcher/facilitator invites "the panel of experts to consider, rank and/or rate, to edit, and to comment upon the responses developed during Round 1" (Murray & Hammonds, 1995, p. 424). Ranking and rating is typically accomplished with simple Likert scales. The results are tabulated and calculated and then used to determine a variety of statistical measures such as frequency distributions, central tendency (mode, median and mean), and standard deviation to characterize the dispersion of individual responses about the mean for each question. In the subsequent round of questionnaire administration, the participants are provided feedback on the panel's comments from the previous round as well as composite and individual rankings/ratings. In the third round, they are asked to again rank and/or rate, edit, and comment on each item. Also, panelists can be asked to "specify reasons if remaining outside of the consensus" (Pfeiffer, 1968, p.152). With the results of the third round tabulated. consensus or stability of responses should be achieved, enabling a final report to be prepared and presented to the panelists as well as management.

Measuring for consensus. The literature reports that what actually constitutes consensus is somewhat subjective. Hsu and Sanford (2007) note that "the kind and type of criteria to use to both define and determine consensus in a Delphi study is subject to interpretation" (p. 4). Miller (2006) suggested that consensus on a topic can be determined if a certain percentage of the votes fall within a prescribed range, while Ulschak (1983) points out that one criterion of consensus is when 80 percent of panelist votes fall within two categories on a seven-point scale. Green (1982) recommends that at least 70 percent need to rate three or higher on a four-point Likert-type scale and the median has to be 3.25 or higher. Others suggest that using percentages are wholly

inadequate, and one must continue successive rounds until stability is achieved (Scheibe, Skutsch, & Schofer, 1975).

Organizational Theory

Classical organizational theorists like Weber, Taylor, and Fayol thought that there was "one best way" to organize. However, most organizational theorist today believe that there is not one best way; rather, it is important for there to be a good fit between an organization's structure, size, technology, and environment. This perspective is known as "contingency theory," which informs my theoretical framework for this action research study (Borgatti, 2001). According to Johnson (2011), "the key concept behind contingency theory is adjustment. The internal structure of the firm is 'contingent' on the pressure put on it by outside market forces." In a similar way, the reality addressed in this study is that SESE's outreach operations will need to adjust to operate in a new environment with different resources and a diverse group of stakeholders sharing common facilities.

Higher education culture. Universities can be complexly organized, decentralized, loosely coupled, horizontally structured, and diffuse organizations. In such an institution, even plans that are well developed can be thwarted by the resistance of individual actors or subcultures within the organization. Staff and faculty can comply ritually and do the minimum to comply with an order or new initiative (Birnbaum, 1991; Julis, Baldridge, & Pfeffer, 1999; Kezer & Eckel, 2002). In higher education, one can appear to adopt an idea—but really not embrace it—and therefore stop or undermine it. Resistance can come from many different levels and take many forms in the higher

education organization and power structures and alliances may shift over time (Bower & Gilbert, 2007).

Unlike most hierarchical organizations, the leadership in postsecondary institutions cannot rely on positional authority to implement initiatives. Rather, college and university leaders typically must try to influence the behavior of faculty members through persuasion and targeted incentives within the constraints of an "organized anarchy" (Birnbaum, 1991). While management is often most effective by inspiring consent, the culture in academe is often rife with complaint and dissent. This makes initiatives that achieve any nominal level of opinion merger, or building of consensus, particularly rare and valuable.

Since a number of the questions that emerged in the process of this research relate to fee-based programming, it is worth noting that the anti-entrepreneurial attitude endemic to the higher education culture is correlated with the well documented abnormally high numbers of faculty who subscribe to a progressive liberal political ideology and its associated socialist economic schema (Mariani & Hewitt, 2008; Horowitz 2007). This phenomenon appears to have asserted a strong influence in this research study, where a strong aversion to a fee-for-service funding model is clearly revealed.

Summary

This chapter has provided an overview of the relevant literature that has informed this study: literature about action research, the Delphi Technique and organizational theory as applied to higher education culture. Drawing on the literature on action research led me to design an intervention that built on the engagement of the previous exhibit

design charrette and produce immediate actionable feedback. Reviewing published work on the Delphi Technique led me to realize that I could tap into the knowledge and opinions of multi-disciplinary stakeholders, help better inform them through feedback and actually measure the degree of consensus and agreement on specific topics. The literature on organizational theory as applied to higher education settings led me to realize that I should manage my expectations about engagement in the study, the degree of consensus and agreement that could be achieved and the adoption of an entrepreneurial operations model.

In an action research study, the literature selected must be explicitly applicable in its ability to direct the researcher's action plan and methods of collecting and analyzing short term evaluation data that will inform next steps in an organization's continuous process of local, functional improvement.

CHAPTER 3

STUDY DESIGN AND RESEARCH METHODOLOGY

Introduction

The purpose of this Delphi study was to engage and inform a group of expert panelists about new resources available to conduct education and public outreach in the new Interdisciplinary Science and Technology Building 4 (ISTB4). The intent of this engagement was to serve as an intervention to develop consensus or a merging of opinion about how to best establish new standard operating procedures for education and public outreach (EPO) operations within the School of Earth & Space Exploration. This section will present the recursive data collection methodology I employed using the Delphi Technique of (a) disbursing questions and receiving responses back from the panel of expert participants, (b) synthesizing those results, which were then used (c) to provide summative controlled feedback to the panelists and (d) to formulate new questions (e) for subsequent rounds of dissemination to participants.

The Delphi Technique Methodology

Writing about qualitative research methodologies in the field of medicine, Jones and Hunter (1995) note that consensus methods such as the Delphi technique provide an alternative means of synthesizing information, especially in areas where published information is scarce or not available. Such methods are "liable to use a wider range of information than is common in statistical methods," and "provide a means of harnessing the insights of appropriate experts to enable decisions to be made" (p. 376). The Delphi process and the nominal group technique (also known as the expert panel) are commonly adopted consensus methods (Jones & Hunter, 1995). The advantage of the Delphi process

is that expert opinions are gleaned without the common biases that can emerge in a group setting.

Largely developed by Dalky and Helmer (1963) at the Rand Corporation in the 1950s, the Delphi technique is a widely used and accepted method for achieving convergence of opinion concerning real-world knowledge solicited from experts within certain topic areas (Hsu & Sanford, 2007). A Delphi, or the Delphi method, or Delphi technique is an often overlooked yet versatile qualitative research methodology (Murray & Hammons, 1995). Definitions of Delphi abound in the literature; the often cited authoritative co-authors Delbecq et al. (1975) define it this way: "a method for the systematic solicitation and collection of judgments on a particular topic through a set of carefully designed sequential questionnaires interspersed with summative information and feedback of opinions derived from earlier responses" (p. 10). The authors go on to state that "the Delphi can be used for achieving the following objectives:

1. To determine or develop a range of possible alternatives;
2. To explore or expose underlying assumptions or information leading to different judgments;
3. To seek out information which may generate a consensus on the part of the respondent group;
4. To correlate informed judgments on a topic spanning a wide range of disciplines, and;
5. To educate the respondent group as to the diverse and interrelated aspects of the topic." (p.11)

Each of the objectives enumerated above are desired outcomes of this action research project. Further, the Delphi is appropriate for a study that incorporates both qualitative and quantitative data. In this study, the data analysis involved both kinds of data. Qualitative data were collected in the first round of questions, which were open ended and solicited opinions; and subsequent iterations of data collection employed Likert-type scales, which were used to analyze consensus employing measures of central tendency and degree of dispersion (Hsu & Sanford, 2007).

Summary of Data Collection Activities

This study involved five total data collection streams: a pilot study, Rounds 1–3 of the Delphi study, and a follow-up questionnaire sent to a subset of the participants to gather perceptions on the overall usefulness of the study and the Delphi methodology. The pilot study was conducted to test the questions and web delivery methodology to ensure their feasibility. The three rounds of the Delphi garnered qualitative data in Round 1 that informed the development of questions used in Rounds 2 and 3 The later rounds employed Likert scaled responses generating quantitative data, which were used to measure the degree of consensus.

Selection of Expert Panelists

The data in this study were gleaned from expert stakeholders representing the various fields that coalesce within the School of Earth & Space Exploration. In examining what constitutes expertise, Hsu and Sanford (2007) state: "there is, in fact, no exact criterion currently listed in literature concerning the selection of Delphi participants (p. 3). Additionally, Delbecq et al. (1975) note that that "three groups of people are well qualified to be subjects of a Delphi study . . .

1. The top management decision makers who will utilize the outcomes of the Delphi study;
2. The professional staff members together with their support team; and
3. The respondents to the Delphi questionnaire whose judgments are being sought." (p. 85)

For this action research study, the expert panel selected meets all the terms of these criteria. The panel was selected in collaboration with the director of SESE specifically for their experience and valued opinions. Those selected include the senior management of SESE, faculty, professional staff, and graduate students (many of whom participated in the expert panel of the design charrette), in addition to other university professional outreach staff and several museum and other education professionals beyond the university. In the literature, there is no consensus on the optimal number of expert panelists for a Delphi process. Some suggest that 10–15 may suffice if the group is homogeneous, warning that fewer than 15 may not characterize a "representative pooling of judgments regarding the target issue" (Hsu & Sanford, 2007). Others note that the approximate size of a Delphi panel is generally under 50, but more have been employed" (Witkens & Altschuld, 1995). Thirty panelists is a common number used in many studies. For this project 27 expert panelists were identified as participants, with the vast majority being SESE employees who were identified by the respective school's director. As a result participants were not required to invest personal time; the time panelists were asked to dedicate to the study was considered part of their normal employment duties.

One of the advantages of the Delphi process is that expert panel participants are anonymous to one another during the study, and their identities are not revealed even

after the final report is published. Such anonymity prevents any participant from dominating the process because of his or her position, authority, or personality, thus minimizing the "bandwagon" effect and allowing all participants to freely express their opinions and criticisms. In addition, being anonymous also affords participants the latitude to change their opinions after considering the input of others (Delphi Method, 2009). Due to strong and diverse opinions, participant anonymity was an important feature of this intervention, a fact that was highlighted in the letter of invitation that was sent to panelists explaining the study.

Description of Pilot Study and Survey Instrument Development

The survey instrument used for the Delphi study was composed of ten open-ended questions, which were administered via the online software Survey Monkey. The questionnaire was piloted in May 2012 with a doctoral level SESE staff member who volunteered to act as an expert panelist to perform a pilot study. This person has extensive experience in education and public outreach programming, both within SESE and beyond. The professional "pilot" responded to the ten survey questions employing the Survey Monkey tool in exactly the manner that was to be presented to the entire panel. This process allowed me to verify both the appropriateness of the survey questions and the effectiveness of the online survey methodology.

After the results of the pilot study were collected I met with the volunteer role-playing the panelist for a face-to-face interview. We discussed the broad scope of the detailed material that was developed for a web page for the panelists to review prior to responding to Round 1 questions of the Delphi. We found the website to be both appropriate and comprehensive, including architectural floor plans of the EPO

programming rooms, an exhibit gallery, exhibit design drawings and descriptions, and theater space. (This information was provided to the panelists at http://istb4.sese.asu.edu/). An example of the type of information reviewed by the panelists through the website can be reviewed in a summary document (Inside ISTB4) found in the appendices (Appendix B).

We also reviewed each of the Round 1 questions and made minor edits to ensure they were stated as clearly as possible. The following table presents the ten finalized questions implemented in the first round of the Delphi.

Table 1

Round 1 Open-ended Delphi Questions

School of Earth & Space Exploration Delphi Study Questionnaire Items	
Q1.	How should we use the ISTB4's EPO space on the 1st and 2nd floors to best tell the SESE story?
Q2.	How can we use the ISTB4 EPO space to enhance "existing" EPO programs?
Q3.	How can we use the ISTB4 EPO space to enhance "existing" EPO events?
Q4.	Are there new EPO programs and/or events that we should develop due to the new EPO space & assets?
Q5.	Are there any SESE core research & teaching activities that cannot be shared with visitors using the new space, exhibits and assets that have been defined? Are there exhibits or technologies that should be added to enhance EPO programs?
Q6.	Describe the SESE EPO program, or suite of programs, that we should offer the K12 community to enhance the current STEM curriculum. Please consider demand, target grades, standards alignment, teacher pre & in-service, staffing and overhead cost.
Q7.	What type of EPO experience should we offer undergraduate and graduate students? What type of EPO experience should we offer the general public?
Q8.	Please identify any high-def videos/movies/documentaries or planetarium shows that you (or some1 you know) could host and provide a "value added" presentation
Q9.	What should the staffing structure be to manage and execute EPO operations in the gallery and the theater? Please consider the operational modalities of school/youth fieldtrip programs, teacher professional development workshops, self-directed visitations, public events, etc.
Q10.	SESE EPO operations must be financially self-sustaining. Please suggest budget expenditures (such as labor, maintenance, expendables, show leases, etc.) and off-setting sources of revenue (contributed & earned) for your suggestions of operation.

Overview of the Delphi Study.

I launched the Delphi study with an email invitation to the panelists that explained they had been selected by SESE's director because of their experience and valued opinions, and were being asked to serve anonymously on a panel of experts in a Delphi study. The initial round of questions went out within several weeks of the September 2012 grand opening of the new ISTB4 building and the installation of most of the Phase I exhibits and other EPO assets. An email provided the panelists with instructions on (a) how to access the website to preview the proposed exhibits and new facilities as well as (b) how to access the Delphi Questionnaire via Survey Monkey. I also attached a copy of the graduate college approved recruitment letter.

Delphi study model: Flowchart of steps. The following model (Figure 1) outlines the steps taken to accomplish the SESE Delphi study.

Step 1: Preparation of Review Materials

a. Researcher developed website describing new EPO assets
b. Researcher developed an open-ended Preliminary question set ➔

Step 2: Delphi Pilot Study

a. Subject Matter Expert Volunteer reviewed Website materials➔
b. Volunteer piloted online survey of Preliminary questions delivered through Survey Monkey➔
c. Researcher gathered results and discussed them with Volunteer, using feedback to revise open-ended Preliminary questions to form the Round 1 open-ended question set (see example next section: *Question #7*)➔

Step 3: Delphi Round 1

a. Researcher sent Round 1 question set to Panelists via a link to Survey Monkey➔
b. Panelists completed the survey➔
c. Researcher coded results and identified themes from Round 1 responses (first using NVIVIO software and later by hand)➔
d. Researcher aggregated and analyzed the qualitative data derived from Round 1 responses to produce a set of qualitative summative feedback statements, or "controlled feedback" (see example below: *Summative Feedback from Q7*)➔
e. Researcher used the results and analyses from Round 1 to develop a Likert-scaled question set for use in Delphi Rounds 2 and 3 (see example below: *questions 2.71, 2.71, 2.73*)➔

Step 4: Delphi Round 2

a. Researcher sent the Round 1 summative feedback statements along with the Likert-scaled Round 2 question set to the Panelists➔
b. Panelists completed the survey, informed by the Round 1 summative feedback statements➔
c. Researcher compiled an aggregated response report of Round 2 question responses displayed to reveal measures of central tendency and frequency distribution➔

Step 5: Delphi Round 3

a. Researcher sent the Round 2 aggregated response report along with the Round 3 question set (questions identical to Round 2) to the Panelists➔
b. Panelists completed the survey, informed by the Round 2 aggregated response report➔
c. Researcher compiled a feedback report organizing the aggregated Round 3 question responses to display measures of central tendency and frequency distribution➔
d. Researcher performed quantitative analyses that compared results of Round 2 and Round 3 responses➔
e. Researcher sent Panelists a summary of all study outcomes

Step 6: Post-Delphi Survey

a. Research developed a likert-scaled question set for post-Delphi survey delivered through Survey Monkey➔
b. Panelists completed the survey➔
c. Researcher compiled question responses, summarized and analyzed the data, and created a report of findings.

Figure 1. Model of Delphi process.

As shown in the model above, the SESE Delphi study consisted of three rounds of questions sent out to the 27 panelists during the two-month period from mid-October to mid-December 2012. After analyzing the results of the first round, open-ended questions, I created a set of qualitative summative feedback statements for the panelists to review. The statements also informed my development of the Likert-scaled questions that were used in Rounds 2 and 3 of the Delphi to gather opinions on the ideas that were emerging from the participants.

Delphi study model: Elements. The following are examples of a Round 1 open-ended question, a qualitative summative feedback statement developed from the emergent themes, and the questions developed for use in Rounds 2 and 3 (Appendix C).

- *Question #7*: What type of EPO experience should we offer undergraduate and graduate students? What type of EPO experience should we offer the general public?
- *Summative Feedback Q7*: Most respondents suggested a brochure to support self-guided exhibit exploration and scheduled theater shows and lectures. A surprising number responded with suggestions that student experiences be in the delivery of programs (as docents) instead of being a recipient of programming. Others suggested strategies to recruit undergraduates and conduct fee-based continuing education programs for the public.

Questions for Rounds 2 and 3:

- 2.7.1 Should SESE majors and/or graduate students have a "service learning" requirement to serve as a docent (or otherwise) in support of EPO programming?

- 2.7.2 On a scale of 1-5 (5 having the most priority) please rank the priority of EPO programs to recruit undergraduates & graduate students into SESE programs.
- 2.7.3 On a scale of 1-5 please rank the priority of EPO programs to conduct fee-based continuing education for the public.

Recursive cycle of data collection and examination. As expected, the opened-end questions initially generated a voluminous amount of qualitative data. My initial plan was to organize, review, sort, code, and theme this data using QSR International's NVIVO (v7) software. This software imports text (such as from the web-based questionnaire) and manipulates and analyzes the contents. For example, all responses to a question can be culled and an automated word frequency search conducted by the program. The results of the word frequency can then be used to conduct an automated text search, the results of which create an individual node/code. The text can then be manually reviewed by the researcher to identify themes. Identifying themes is critical in providing the summative controlled feedback to the panelists after Round 1 and informing the development of questions for future rounds.

After gathering the data from the Delphi Round 1, I downloaded all responses into NVIVO7; unfortunately, the software's automated function coded the qualitative data at too fine a level to be useful. Thus, I had to work with the raw data manually and review it in detail to find the reoccurring topics, which I coded using colored highlighters. This process produced emergent themes. Once coded, I re-entered the raw data into NVIVO7, the themes were identified as "nodes," which then provided statistical analysis of the percentage of respondents who mentioned something related to one theme or another. My

use of NVIVO7 was opposite to what I envisioned. Instead of the software automating word counts and creating codes and their frequencies to extract themes, I manually coded the data and identified the themes. Then I re-entered the themes into NVIVO7 as "nodes" to calculate the frequency of the emergent themes.

After this analysis was completed, it was possible for me to summarize the panelists' responses into the controlled feedback for the panel's consumption. As discussed in Chapter 2, Hsu and Sanford (2007) identify controlled feedback as one of the two additional advantages of a Delphi study. According to these authors, controlled feedback reflects a well-organized summation of the prior iteration that is subsequently distributed to the panelists to generate greater insight and an opportunity for them to modify or clarify their positions. Controlled feedback also helps eliminate noise from individual interests that may be irrelevant and distort the data.

Based on the emergent themes and summative feedback, new questions emerged for use in rounds 2 and 3, as summarized above. As described in Chapter 2, in the second iteration of questions, a researcher will invite "the panel of experts to consider, rank and/or rate, to edit, and to comment upon the responses developed during Round 1" (Murray & Hammonds, 1995, p. 424). Ranking and rating is typically accomplished with simple Likert scales. Results for each question are then calculated to develop descriptive statistics such as measures of central tendency, frequency distribution, and standard deviation to characterize the level of dispersion.

Participants are then given feedback on the panel's composite rankings/ratings in a third round and asked, after considering the groups' response in Round 2, to again rank and/or rate each item. The results of Round 3 are calculated for the same descriptive

statistics, which are then compared with Round 2 results to measure the difference or change between rounds. In the SESE Delphi study, I constructed and evaluated all of these measures for the purpose of determining the degree and nature of opinion convergence or divergence, and the change that occurred between Rounds 2 and 3. After Round 3, I returned all the aggregated, summarized, and quantified information to the panelists with a statement telling them that the report concludes the study. This and other data analysis results are expounded on further in Chapter 4.

Lastly, in an effort to triangulate a measure of efficacy in this intervention, a post-Delphi survey was conducted with 15 of the 27 of the expert panelist. This Likert scale survey (Appendix F) was used to sample the panelists' opinions about the usefulness of the process (a) in informing the panelists on the topic, (b) generating ideas, (c) changing opinions, and (d) creating consensus.

Summary

In this chapter I outlined and described the processes I employed to implement the SESE Delphi study and the methods by which qualitative data was gathered in Round 1 and used to develop the questions for subsequent rounds of the survey. Also discussed were the different data gathering techniques I employed in Rounds 2 and 3 using Likert scaled responses so that data could be compared and measured for shifts in opinion. In Chapter four I will describe the results of the data gathered, the way the data was analyzed, and the findings of my analysis.

CHAPTER 4

ANALYSIS AND RESULTS

Introduction

Part of my job responsibilities at SESE is to recommend organizational and operational structures to efficiently deploy the new assets associated with the new ISTB4 building. My review of the Delphi literature convinced me that this methodology would be the perfect application to facilitate an increase in consensus among members of a group with widely disparate viewpoints. I approached this intervention idealistically and perhaps a bit naively in my assumptions about how easy it would be to cultivate reflective engagement in the Delphi process. This chapter presents my results and the challenges and opportunities I faced in implementing the study and notes how the Delphi method interacts with the higher education culture in general and the SESE culture in particular.

Delphi Round 1

As discussed in preceding chapters, the Delphi method is an iterative process that provides controlled feedback to panelists between successive rounds of questions and data collection. As such, data collection and analysis are dynamic steps that occur during and as part of the surveying process. Since data collected in Round 1 modifies subsequent parts of the research design (i.e., the results of Round 1 dictate the questions used in Rounds 2 and 3) in the Delphi, the traditional linear sequence beginning with a pre-specified research design and the supporting methodology (as defined in Chapter 3) followed by data analysis and results (as presented in Chapter 4) is transformed into a cyclical process that produces a series of iterative results.

Results of data collection and analysis. The opened-end questions of Round 1 generated a large amount of qualitative data. Typical responses to each of the 10 Round 1 questions were paragraph length, with 63 percent of the invited panelists responding to the first round of questions. This first round yielded approximately 17 paragraphs of qualitative raw data for each of the 10, Round 1, questions. To manage and evaluate this information, I had planned to organize, review, sort, code, and theme this data using QSR International's NVIVO software, version seven (NVIVO7).

NVIVO7 allows a researcher to import text(responses to the questionnaire) and manipulate and analyze the contents. Here is an overview of how it works: responses to each question are collected and an automated word frequency search conducted. The leading results of the word frequency are used to conduct an automated text search, which creates an individual node/code. First, the text is manually coded, after which the software identifies themes in the data. The emergent themes are used by the researcher to provide the summative controlled feedback to the panelists and to develop the questions for further survey rounds. In my study, I gathered all of the responses to question 1 from each participating panelist's completed survey into a document labeled Question 1 Results. I did likewise for responses to questions two through ten, each creating a separate document and then imported the data into the NVIVO7 software for analysis.

Unfortunately, the NVIVO7 automated function coded the qualitative data at too fine a level to be useful. Analysis results produced a separately coded "node" for too many distinctive terms and were unable to group semantically equivalent comments intuitively. Thus, I took the raw data and reviewed it in detail manually and coded reoccurring topics using separately colored highlighters. From this process I identified

emergent themes in the responses to each of the open-end questions. Once coded manually, I re-entered the data-entered into NVIVO7 software and manually identified the emergent themes as "nodes," which then provided statistical analysis of the percentage of respondents that mentioned something related to one theme or another.

See Appendix G for the themes that emerged from Round 1 after manually coding the data and the percentage of respondents that mentioned this topic as calculated by NVIVO7.

In the end, I used NVIVO7 in a manner that was the reverse of what I had originally envisioned: Instead of using the software to automate word counts and create codes and their frequencies to facilitate manually extracting themes, I manually coded the data and identified the themes, then used NVIVO7 to calculate the thematic frequencies. Responses to each of the ten questions contained between three and eight emergent themes that I used to create the summative feedback to the panel and to develop the questions used in Rounds 2 and 3 of the Delphi.

Controlled feedback. During the process of reading and coding approximately 170 paragraphs of responses, I began to see some expected themes emerge. A number of responses advocated doing things "the way they had always been done," whereas others that were thoughtfully open-minded. Some participants thought that adding all of the new EPO resources in the new ISTB4 building, the Gallery of Scientific Exploration, and the Marston Exploration Theater should be a new add-on option to the separately operated existing programs. Others recognized that the ISTB4 building could incorporate the existing programs and create a single-point fieldtrip destination. With a history of debate over fee-based planetarium shows, the fee vs. free responses were notable. Again, some

panelists showed ardent support for providing all programs and theater shows for free, with others providing recommendations for how to structure fees.

After the analysis of approximately 12,000 words of Round 1 raw data, I was able to synthesize and distill the panelists' responses into a controlled feedback message for their reflection and analysis (presented in Appendix H) as they considered the next round of questions.

Delphi Rounds 2 and 3

Consistent with Delphi methodology, the questions developed for use in Rounds 2 and 3 were natural outflows from the distilling and summarizing responses to Round 1 questions. I was inclined to develop questions that drill down and explore the topic further. For instance, question 10 asked for recommendations about how EPO operations could become financially self-sustaining. The feedback summarized comments about overhead cost, contributed funding and earned revenue. The four follow-up questions developed for use in Rounds 2 and 3 asked panelists if SESE should establish fee-based (a) K12 fieldtrip programs, (b) non-educational entertainment film showings in the MET, (c) nominal gate for planetarium shows during large public events, and (d) or require EPO funding to be added to all SESE grants. The majority of Round 2 and 3 questions asked panelist for a Likert scale response for agreement. The only variation on this method appeared in 6 of the 27 questions that asked for a rating response.

Results of data collection and analysis. Using Excel formulas, I manipulated the data to calculate a variety of descriptive statistics to measure central tendencies as well as standard deviation to characterize the level of dispersion about the mean for each question. Each of the responses were also converted into a percentage so the data could

be read as follows: "for Question X, (1) 5% strongly agree, (2) 25% agree through to (5) 10% strongly disagree."

The participants were then given feedback on the panel's composite rankings and ratings for each question showing the percent response to each Likert scale, along with the mean and the standard deviation. Very little data analysis occurs at this point in the study. While I was curious about the Round 2 results, what was more important was where their opinions would land after being exposed to and influenced by reading the group's responses; how much would their opinions change between rounds?

Table 2

Sample Question with Round 2 Data

Question 2.1: The current Gallery of Scientific Exploration (GSE) exhibits and digital projection assets, viewable laboratories, and Marston Exploration Theater (MET) capabilities are sufficient to explain the current scientific exploration conducted within SESE. (Scale: Strongly Disagree 1 < === > 5 Strongly Agree)							
Results for Q2.1	1	2	3	4	5	Average	Standard Deviation
Round 2	13%	13%	37%	31%	6%	3.06	1.09

Table 2 provides an example of a question with results from Round 2. You can see that the majority of the panelist replied neutral or agree creating a mean of 3.06 with votes distributed in each of the five Likert scale producing a fairly large standard deviation of 1.09. The researcher can infer then that a majority of respondents think that the assets in ISTB4 do a fair job of providing the capability to "explain the current scientific exploration conducted within SESE" but there is not much consensus due to the broad distribution of responses. Again however, there is very little analysis performed on this Round 2 data since it will serve only as the baseline of which to compare Round 3 data.

In the third round, panelists were asked to consider the results of the group's responses from Round 2 and to again rank or rate each of the same questions. The directions reminded the panelists that they were free to change their answers from the previous round. Round 3 data was downloaded into Excel and I performed the same manipulations and calculations as described above for Round 2, converting response data into percentages, measures of central tendency, and standard deviation to display the statistical dispersion about the mean.

Table 3

Sample Question with Round 2 and Round 3 Data

Question 3.1: The current Gallery of Scientific Exploration (GSE) exhibits and digital projection assets, viewable laboratories and Marston Exploration Theater (MET) capabilities are sufficient to explain the current scientific exploration conducted within SESE. (Scale: Strongly Disagree 1 < === > 5 Strongly Agree)

Results for Q3.1	1	2	3	4	5	Average	Standard Deviation
Round 2	13%	13%	37%	31%	6%	3.06	1.09
Round 3	0%	41%	47%	12%	0	2.71	.50

Table 3 provides an example of a question with results from Round 3 added to the response from the previous round. In order to measure for potential consensus between Rounds 2 and 3, I entered the calculated mean and standard deviation for both rounds for each question into a table using Excel. By comparing the data in this way I was able to observe and measure the difference in these values, which will show if distribution is narrowing toward the mean, creating a consensus, and if the mean has shifted. If the standard deviation between Rounds 2 and 3 has narrowed, then a merging of opinion has occurred. Moreover, calculating the amount of difference will determine the degree of consensus building or opinion merger that has occurred. In this example I can see that after panelist reviewed the group's first response (collected in Round 2) and asked to reconsider the question and rescore there was considerable change measured. Consensus

was measured by the change in standard deviation showing that for Round 3 the data was much more bunched around the mean and that the mean had shifted to slightly disagree.

Measuring for Consensus

Recall from Chapter 2 that a review of literature indicates that what actually constitutes consensus is somewhat subjective. Hsu and Sanford (2007) note: "the kind and type of criteria to use to both define and determine consensus in a Delphi study is subject to interpretation" (p. 4). Some state that consensus on a topic can be decided if a certain percentage of the votes fall within a prescribed range, one criterion of consensus is if 80 percent of panelist votes fall within two categories on a seven-point scale, another recommends that at least 70 percent need to rate three or higher on a four-point scale and the median has to be 3.25 or higher (Miller , 2006; Ulschak, 1983; Green 1982). Others suggest that using percentages are wholly inadequate, and one must continue successive rounds until stability is achieved (Scheibe et al., 1975).

The degree of realistic consensus is a function of culture. In vertically structured organizations with a clear chain of command, engagement and unanimity is assumed. Higher education organizations tend to be extremely horizontally structured. In the postsecondary higher education culture, debate and being contrary and oppositional with articulateness, creativity, and sophistication of argument is a virtue. In this study, consensus (or lack thereof) is reported along a continuum from the most converge response to the most divergent as measured by comparing the change in the level of dispersion (standard deviation) between Rounds 2 and 3. I have not defined a threshold for consensus. Rather, I identify and report on the spectrum of consensus (or divergence) along a continuum for each of the questions asked. Again, in a higher education setting

where opposition is considered a value, any degree of consensus, no matter how slight, is valuable. With this in mind, the results of calculating the difference in standard deviation are expressed as a percentage and are then rank-ordered so that one can see which questions have the greatest to least consensus.

This information is valuable to decision makers in leadership roles to determine which issues investigated have the most and least concurrence among those surveyed, especially in a multi-stakeholder, multi-disciplinary project such as this one. Appendix I shows the questions rank ordered from most to least consensus measured by the amount of convergence or divergence in standard deviation between rounds.

Note that a topic may have a high consensus meaning that there was much merging of opinion, however, that opinion may be one of strong disagreement or vice versa. It is also worth noting that the top five questions with the highest measured consensus also showed fairly even disbursement across the spectrum for agreement; ranked 8, 3, 1, 16 and 25 respectively. This demonstrates that in this study opinions hardened regardless of topical agreement or disagreement. Another example of this disassociation is found in the question (4.2) with the least consensus, ranked last (27) and by far the most divergence of opinion between rounds (49%). Regarding "agreement," the establishment of a Research Experience for Teachers program question scores 94% and is ranked at the top of rank order for agreement. A closer look at the Round 2 and 3 data reveal that everyone supported this initiative in Round 2, yielding a zero standard deviation. In Round 3, one of the participants either changed their vote or a newcomer to the round voted neutral for agreement and drove the standard deviation to .49, creating

the largest shift (divergence in this case) in the study. The cautionary takeaway here is that it is worth reviewing data carefully.

After calculating and comparing the standard deviations using the five-point scale rating information for each question, I found that 48% converged while 52% diverged. So, as to my overarching research question, "To what extent will using a Delphi study bring greater convergence of opinion or consensus among a group of multi-stakeholders in a multi-disciplinary project?" data shows that in this intervention, convergence occurred in nearly half of the 27 questions investigated.

After measuring and determining the amount of convergence the logical next step is to dig deeper into the richness of the data to discover trends or nuances valuable to leadership teams. When I further reviewed the data, immediately apparent was that questions related to fee-based programming and EPO funding showed the least degree of convergence. It was also interesting to note that the questions with the most and least degree of convergence were closely related and concerned the development of educational programs in EPO rooms and spaces on the second floor.

Table 4

Question Dichotomy—Greatest and Least Convergence

Rank Order: Agreement	Rank Order: Consensus	Question	Convergence
8	1	Q3.2: Should programming and activities be developed for the 2nd floor auditorium, the TEAL room and the large EPO workroom during public events?	47%
9	26	Q2.3: Do you think that in addition to the MET and GSE experience that the 2nd floor auditorium, the TEAL room and the large EPO workroom should be used to enhance teacher professional development workshops?	25% Divergence

Question 3.2, which asked if programs should be developed using these EPO assets for use with public events, had the greatest convergence in the study, whereas developing programs using these same assets for use in teacher professional development workshops had the second least degree of consensus. Table 4 above shows these two questions and their associated data. The first column is the question's rank order for agreement, and the second column shows the question's rank order for convergence. The last column shows the level of convergence or divergence between Rounds 1 and 2 expressed in percentage.

Further Analysis

The data also yields a wealth of additional information that can be very valuable to those in leadership positions. While knowing which topics panelists' opinions

converged on is useful, knowing the degree of convergence and divergence on topics and knowing the topics of most and least agreement is more pragmatic. I conducted further analysis on the data to identify the most and least agreed on topics as well as conducting a compare and contrast exercise to determine any insightful correlations between convergence/divergence and agreement/disagreement on topics. This analysis was accomplished by comparing each question's rank for convergence/divergence with that question's rank for agreement/disagreement and vice versa.

Rank order analysis. To rank order questions based on agreement/disagreement Strongly Agree and Agree data columns were merged to prevent outliers or a question with a very high Agree score but a low Strongly Agree score from being ranked with a low agreement ranking. Likewise, Strongly Disagree and Disagree data was merged creating a three-point scale of Agree, Neutral, and Disagree. To facilitate comparison of this rank order with the rank order for consensus, the consensus data was also condensed into a three-point scale in like fashion.

When recalculating the condensed data for consensus on a three-point scale, the first thing I noticed was a slight increase in the overall level of convergence; 56% of the Round 2 and 3 questions exhibited convergence, only 37% exhibited divergence, and 7% neither converged or diverged when measured in this way.

It was immediately apparent that while there was weak correlation between convergence and agreement for some questions, there was a significant disassociation on other topics. Agreement (or lack thereof) to particular questions or topic statements is perhaps the data most useful to the decision maker. The top ranked agree question asked whether the new ISTB4's $1.7 million dollar GSE and MET should be added-on as a new

field trip option for schools visiting other SESE EPO programs. Surprisingly, the third most agreed upon question was to establish and hire an EPO program coordinator as the primary contact to custom coordinate all school fieldtrips. The results of the data clearly indicate that the most agreed upon topic with one of the top three ranks for consensus was to keep operating with separate autonomous EPO programs, add the ISTB4 assets onto the menu of SESE EPO destinations but hire a coordinator to remove the burden of reservations and intra-EPO synchronization. Also in the top five were expanded free public lecture series, the development of a Research Experience for Teachers program, and program modules that can be used by students participating in existing ASU outreach programs (i.e., High School-to-College, Upward Bound, Hispanic Mothers and Daughters, etc.).

Quartile observations. When analyzing questions and their topics for degrees of agreement and convergence, it was useful to examine the data in quartiles. Quartiles were developed by first removing the six questions that used a rating scheme and then dividing the 21 remaining questions, which were rank ordered for agreement, into four equal groups. Each question included its associated consensus ranking. This method allowed the questions and topics to be reviewed in four groups from most to least agreed. In Appendix J the first quartile (most/strongest agreed) is easily compared to questions and topics that the panel least agreed. Again, each question's associated rank of consensus, percent of agreement, mean and standard deviation appears for quick reference aiding in analysis.

Historically and currently, fee-based educational outreach programs have been a contentious topic within SESE. For example, SESE has provided free planetarium shows

to local K12 schools for many years. There have been periodic attempts during this period to charge a nominal fee to offset operational cost but every attempt has failed due to internal resistance. As expected, this resistance to charging groups for any programs was reflected in this study with very low rankings of agreement. When rank ordered, four fee-based programming questions appear in Quartile 3 and six in Quartile 4.

Oddly enough, highest ranking among fee-based questions was "Develop and market a regularly scheduled fee-based series of planetarium/astronomical shows, movies and films in the MET." This question had a 59% agreement rate and surprisingly ranked 11 of 27, putting it in the Quartile 3 of the ranked data set. Moreover, this question had the second to lowest rate of convergence (ranked 26) with just 3%. This tells me and the decision maker that a solid "average" majority at nearly 60% support the idea of this required revenue stream but that there is a wide spread of responses about that average. For this question the standard deviation between rounds two and three remained high and was 1.49 and 1.54 respectively.

The only other "fee-based" question garnering more than half of the respondents' support was regarding a series of fee-based teacher professional development workshops at 53% agreement (Quartile 2). Again, caution is advised to the decision maker since it, too, had a convergence ranking in the lowest quartile being ranked 21. The only question asking about non-educational entertainment movies and films in the theater ranked 16, in the Quartile 3. The remaining six fee-based program's questions all fell in the lowest quartile, with an average agreement rate of 31% (Quartile 2) and tighter rates for standard deviation. Conversely, all other program development questions that implied no user or participant cost ranked in the top two quartiles, with the one question that overtly asked

about expanding a free public lecture series ranking in the first quartile with 88% agreement.

Clearly, the panelists surveyed expressed strong attitudes about the cost of educational programming being borne by the recipient. From my first review of the open-ended qualitative data in Round 1 all the way to the Likert data collected in Round 3, I sensed a very palpable aversion for the business side of education where (a) needs are identified, (b) programs are developed to meet those needs, and then (c) marketed, (d) sold, and (e) delivered to those with the need. This did not surprise me, since I have led successful large scale fee-based educational outreach programs for over 20 years with two of the five organizations being university based. I know full well the anti-entrepreneurial attitude inculcated by the appropriated funds culture of higher education. My experience working at five universities is that the anti-entrepreneurial attitude endemic to this culture is correlated to the well documented abnormally high numbers of faculty that ascribe to a progressive liberal and socialist political ideology (Mariani & Hewitt, 2008; Horowitz, 2007). Further evidence is the common disdain by the public and private professoriate for the for-profit postsecondary institutions.

Measuring for engagement. Higher education culture is distinctive in that debate and being oppositional are seen as virtues and therefore the culture is non-compliant by nature. Faculty, and occasionally staff, often view themselves as independent operators and followership is rare on the university campus. In my 30-year professional experience working in military, for-profit, non-profit, and higher education organizations, I have observed elevated rates of patently resistant behaviors in higher education work environments that are not the norm in the other professional work environments. Thus, I

believe these tendencies toward non-cooperation and non-compliance affected the efficacy of the Delphi method used in this study.

I believe that, compared to other professional work environments, employing the Delphi technique in a higher education culture may have resulted in a decrease in participation rate and consensus, and an increase in jump-in/jump-out behavior during the three iterative rounds. While assumed in most work environments, engagement in a multi-stakeholder exercise is a high bar to meet in the higher education culture. From this perspective, the Delphi method is not a weak intervention in this setting, in that the study itself created more engagement than there would have been without it, and a disengaged staff is worse than a feuding engaged staff.

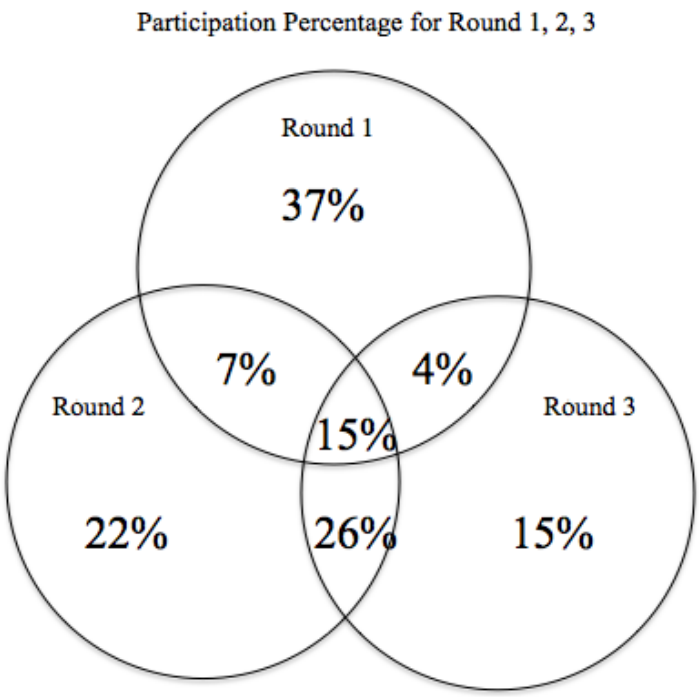

Figure 2. Panelist participation in Delphi rounds 1, 2, and 3.

Participation rates in the three rounds were about what I had expected, perhaps a bit higher. Figure 1 shows participation percentages for panelists who participated in each round. The overlapping portions of the diagram indicate the percentage of panelists who participated in multiple rounds.

Of the twenty-seven invited panelists, the participation rates were 63%, 70%, and 59% for Rounds 1–3 respectively. As expected, I did see significant jump-in/jump-out rates between and among rounds including four panelists who only participated in the final round. A caveat is that the participation analysis is difficult to determine with certainty since participants may have used different codes to log into different rounds

either accidently or to further ensure their anonymity. One final thing to note is that several of the Round 2 participants who had not participated in the Round 1 open-ended questions accepted the survey's invitation for further comment in addition to Likert-scale responses. A number of these comments were thoughtful, and thus could have affected the summative feedback and development of Round 2 and 3 questions, had they been available.

Post Delphi Survey

I conducted a post-Delphi survey within several days of providing the final feedback to the panel. Fifteen of the participants whom I thought were most likely to respond to the four-question survey were selected from the panel of 27. These 15 people were sent an email (anonymous to the others selected) and asked to once again log into an online survey instrument. This Likert-scale survey was used to sample the panelists' opinions about the usefulness of the Delphi process for (a) in informing the panelists on the topic, (b) generating ideas, (c) changing opinions, and (d) creating consensus by responding to a scale of 1 to 5 with 1 = Not Very Helpful, 3 = Somewhat Helpful, and 5 = Very Helpful.

At this point in the study I sensed that participants were experiencing survey fatigue and became concerned about how many would be willing to provide this evaluation. A deadline was set and 11 panelists responded by that date. The data were gathered, entered into Excel spreadsheet and the mean was calculated for each. On a five-point scale the mean score for the usefulness of the process (a) in informing the panelists on the topic was 3.45, (b) for generating ideas was 3.45, (c) for changing opinions was 2.82, and (d) for creating consensus was 2.73.

I was somewhat disappointed with these results, particularly a 3.45 for the usefulness of the process for informing the panelists on the topic (scope of the project) given the online resources provided could not have been more extensive. Results for the other three questions may have been higher if the final feedback to the panelists provided more succinct analysis of the data.

Perhaps a better metric of the usefulness of the data in this study comes from the organization's decision maker. I met with the founding director of SESE and provided a report of my findings from this study. He was very receptive and thought that the results provided very valuable organizational intelligence. Since that time, however, he has announced his resignation. I plan to present the new director, who may lack organizational history, with a more extensive summary of this study and recommendations.

Summary

In this chapter I have demonstrated how the Delphi method is different from the traditional linear sequence of research projects that begin with a pre-specified design followed by data analysis and results. Rather, the process is a cyclical process that produces a series of iterative results. The method for gathering and synthesizing qualitative data was described and the results provided insight into the participants' opinions. Follow-up questions were created related to the summative information for use in Rounds 2 and 3. The Likert-scale quantitative information was compared between these rounds and the degree of consensus and agreement measured was reported. This data provides useful information about the stakeholders' positions on relevant substantive matters for use by the responsible leader in crafting an effective way forward.

In the case of SESE we now know that strong resistance to change exists concerning a centralized EPO operation as well as a strong aversion to the development of fee-based programming. The data has also shown me that there is more acceptance than I first thought for charging a box office gate fees for planetarium-like shows to school groups and the public but not during public outreach events. The data also shows strong support for a centralized program coordinator position, an undergraduate conscript docent core and the expansion of free EPO programs. I have also discussed the influence that the higher education culture may have on these opinions, panelist participation and the efficacy of the Delphi technique.

CHAPTER FIVE

CONCLUDING THOUGHTS AND RECOMMENDATIONS

Introduction

This action research project was intended to have a real and pragmatic impact on the way that SESE structures and executes its education and public outreach enterprise. The opening of a new building with approximately $1.7 million dollars of assets dedicated to the education and public outreach mission provides the organization an ideal opportunity to re-evaluate this activity and implement a new standard operating procedure. To accomplish this I selected an intervention methodology designed to better inform key stakeholders about the new assets available to support these programs, but more importantly, to expose them to the anonymous opinions of fellow experts and provide an opportunity to develop and measure consensus.

Researcher Reflections

Facilitating this project has made what I have always known implicitly more explicitly clear: organizational change is hard. People are creatures of habit, and change can evoke feelings of fear, insecurity, and vulnerability. The opinions that I gathered in this study clearly demonstrated a real and measured resistance to change. For instance, reluctance to change was particularly highlighted in the responses to the question (2.2) where 94% of the panelists asserted that the new building and all of its assets should just be added to the menu of SESE destinations a teacher can currently choose to visit on a fieldtrip. This question had the highest rank for agreement and was ranked third for the high degree of consensus. This lack of departure from wanting to do “what has always

been done," and the lack of creativity and engagement it reflects, was disappointing to me but not entirely unexpected.

The other message that emerged was the strong aversion panelists expressed toward fee-based educational programming. While this topic historically has centered on charging a gate fee for planetarium shows, I was surprised to find that there was much more agreement (59%) with this idea compared with all other questions related to fee-based programming, which ranked in the lowest quartile for agreement. Considering the clear explanation of the need to identify offsetting forms of programming revenue, again, the strong resistance to charging even nominal fees for outreach programs was disappointing to me but not entirely unexpected.

I am a first generation college student and began my academic career at a military college. I started my professional career as a combat-arms officer in the U.S. Army before returning to graduate school, postsecondary teaching, and educational programming and project management. I have spent nearly 20 years of my career at universities and non-profit organizations building and operating fee-based educational programs to enhance science, technology, engineering, and mathematics education. For me, the resistance of academicians to a more businesslike approach to managing educational outreach programs is nothing new. Entrepreneurialism has been a growing objective in higher education over the past decade and is one of the core tenets of the "New American University" pioneered at ASU. In many ways this seems counter-cultural, and based on the results of my study, the entrepreneurial principle does not appear to be thoroughly embraced within SESE.

Higher education institutions have distinctive cultures and complex structures; at times I have felt like a stranger in a strange land. Followership is rare on the university campus. Achieving engagement (far short of consensus) can be a high bar in this culture of independent thinkers, and convergence of opinion difficult to facilitate. Higher education management, administration, and leadership require the use of consensus building and persuasion to effect change or implement new initiatives much more so than in many other communities of practice. It's a much more nuanced, almost a dressage approach to management where nothing can resemble a directive. For that reason, the Delphi technique is a good choice as a method for intervention to increase engagement and provide a safe and anonymous means to solicit opinion. Not only is this a good way to develop organizational intelligence, but in this study it has proven to be somewhat effective at producing a merging of opinion toward the building of consensus.

Information generated by a Delphi exercise can be valuable to a decision maker in higher education organizations. Armed with deeper insight about the topics and issues that faculty and staff members coalesce around (pro and con), the manager or administrator can know which policies will be relatively easily implement and which will be met with resistance. The wise leader can use the information gained in a Delphi study to develop strategies that will enhance the success of new policies or initiatives much more so than without this information. This methodology could be effective in soliciting information from senior and mid-level management about what works, what does not, what challenges recommended changes will face, and how to increase operational efficacy or to manage expectations within an organization. The Delphi method could be

very useful in the strategic planning process and for surfacing internal differences of opinion.

The action research method was foreign and ethereal to me when first introduced in the course of the ASU Higher and Postsecondary Education doctoral program. I was skeptical about it and was admittedly biased in favor of a more traditional approach to doctoral research. However, I have always worked in jobs that were somewhat atypical to higher education. I have often been the change agent creating something new under the direction of a CEO, establishing an innovative facility and program to meet an assessed need, marketing, selling, and delivering in a way that exceeds expectations. The action research methodology is extremely well suited for the environment where real and effective change is needed. I have come to strongly embrace this approach and find it rational, reasonable, and practical. I wish that I had been aware of action research and the Delphi method earlier in my career.

The results of any single action research study are not intended to be generalizable to other settings. Rather, the results of an action research study should be provocative, generating thinking about the application of any particular intervention. I can think of many situations in the past where these tools would have been useful for a person in my professional role, and know that I will use the skills that I have developed in this research project to become a more effective leader in the future.

Lessons Learned

As a consequence of this action research Delphi study, it has become clear which policies would be most supported, which would be met with apathy, and which would be most resisted. Those subjects or topics that are least supported will take more

explanation to increase buy-in and support. This study shows that implementing policies where students incur an obligation to serve as docents, student led demonstrations, establishing a central program coordinator, and a Research Experience for Teachers program are all strongly supported. Conversely, this study shows that we need to rethink the way in which we develop and implement fee-based programs and that Phase II of exhibit development needs to have more earth science exhibits then were planned. This intervention has measured the level of consensus that was achieved, measured the level of topical agreement, increased engagement of disparate groups, produced better informed panelists/stakeholders, and initiated a provocative thought process.

Recommendations

I briefed the director of SESE on the results of the study, and noted topics that showed the most and least degrees of conversion and degrees of agreement and disagreement. My original plan was to schedule a follow-up meeting with the director to begin a dialogue about policies SESE should be implementing for new EPO standard operating procedures. However, soon after my presentation of the study's results, the director announced his resignation effective July 2013. Based on the results of this study, I intend to make the following recommendations to the new director.

- Develop an EPO staff structure consisting of a full-time director, theatre manager, and program coordinator.
- Establish a service-learning requirement that undergraduate SESE majors incur an obligation to volunteer 10 hours per week during one semester as a docent to support GSE and MET operations.

- Require all separate EPO operations to advise, assist, and contribute in the development of curricula, activities and/or exhibits to adequately represent their specific operation within the new ISTB4 building.
- Have the marketing and public relations director perform a market analysis of other informal education destinations to determine the types of programs offered, respective target markets, and fees charged.
- Establish a routine schedule of weekly fee-based planetarium and film offerings for the general public and school groups.
- Create an ISTB4 centric, fee-based package of educational experiences that are correlated to K12 education standards that can be marketed, sold, and delivered as a fieldtrip experience.

The insight gained through this research project and dissertation will be invaluable to establish the best business model and standard operating procedures for the new ISTB4 education and public outreach operations. I believe this strategy and methodology would be useful for future interventions such as a strategic planning tool for the development of Phase II exhibitory in the ISTB4 gallery, including a sustainable funding model and business plan and for the development of exhibition digital content. The practical knowledge of using action research and the Delphi technique that I developed in this action research dissertation study will become valuable tools for me in providing leadership in changing times in higher education at institutions that incorporate a shared governance model of management.

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APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

ASU Knowledge Enterprise Development

Office of Research Integrity and Assurance

To:	Christopher Clark LSE 218
From:	Mark Roosa, Chair Soc Beh IRB
Date:	03/20/2012
Committee Action:	**Exemption Granted**
IRB Action Date:	03/20/2012
IRB Protocol #:	1203007580
Study Title:	Soliciting Expert Opinion and Increasing Consensus in a Multi-stakeholder, Multi-disciplinary Project

The above-referenced protocol is considered exempt after review by the Institutional Review Board pursuant to Federal regulations, 45 CFR Part 46.101(b)(2) .

This part of the federal regulations requires that the information be recorded by investigators in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects. It is necessary that the information obtained not be such that if disclosed outside the research, it could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

You should retain a copy of this letter for your records.

APPENDIX B

INSIDE THE INTERDISCIPLINARY SCIENCE AND TECHNOLOGY BUIDLING 4 (ISTB4)

Inside the Interdisciplinary Science and Technology Building 4 (ISTB4)

FIRST FLOOR – VISUALIZING SCIENCE

The first floor invites visitors to explore earth and space sciences through digital media, public lectures, visible laboratories, and interactive displays. A focal point of the building is a state-of-the-art theater, as well as an expansive exhibit hall dedicated to interactive exhibits. The focus of the first floor spaces is on dynamic experiences to invite participatory exploration. The exhibits are as much about communicating how earth and space scientists do science and achieve a scientific worldview as they are about scientific facts and figures.

THE HIGH-DEFINITION EXPERIENCE

The Marston Exploration Theater is a 238-seat venue for high-definition documentary movies with earth and space science themes, 3-D planetarium-style shows (although on a flat screen), and media-rich undergraduate classes. In addition to regularly scheduled showings of science films, faculty will be providing regular public "chatauquas" on themes such as the origin of the universe, biological evolution, and the measurement of time. Special presentations will include NASA spacecraft launches and landings (with full Surround-Sound). The theater will be a research facility to explore the effective use of high-end media in both formal and informal earth and space science education. The space will be used for scientific visualization research and for public outreach during the weekdays, as well as in the evenings and on weekends.

VISIBLE LABORATORIES

Major research laboratories on the first floor will be enclosed in glass for public viewing of research activity. These facilities will include a control center for future missions, a large assembly cleanroom for the fabrication of satellite and lander instrumentation, and dynamic laboratories for the study of volcanic eruptions, mudflows, and hydrodynamics. Recorded descriptions of research activities by scientists will be streamed to visitors and many viewing stations will be staffed by ASU student docents.

GALLERY OF EARTH AND SPACE EXPLORATION

Roughly 4,300 square feet of the first floor is dedicated to interactive exhibits that engage visitors in the history of scientific exploration (from the voyage of HMS Darwin to NASA's Mars Science Laboratory) and invite them to contemplate future voyages of discovery. The space is outfitted with kiosk-style exhibits and large-format, high-definition monitors that display video from earth-observing satellites and robotic probes of other worlds.

• CURIOSITY ROVER REPLICA

While the Mars rover Curiosity explores the red planet, those of us here on Earth can see a replica of the vehicle in the lobby of ISTB 4. Curiosity weighs nearly 2,000 pounds including 180 pounds of scientific instruments. It is 9 feet, 6 inches long, nearly 9 feet wide and a little over 7 feet tall. The ASU replica matches the dimensions of the real thing except it weighs 450 pounds.

• EARTHSCOPE
The EarthScope exhibit provides an interactive, touch-screen computer-based earth science display experience known as Active Earth Monitor. In addition to the general seismicity content in Active Earth Monitor, the exhibit also projects a real-time current and recent earthquake activity through the IRIS earthquake channel.

• GLOBAL IMAGINATION'S MAGIC PLANET
Magic Planet, a digital video globe, helps to improve the way people understand and act upon dynamic global systems and situations. It uses duel high-definition internal digital video projectors with a six-foot diameter sphere-shaped screen to present dynamic global and extra-terrestrial information in the most compelling and interactive way. The system uses data from NASA, NOAA and others to present archived and real-time data about the Earth, Moon, Sun and planets.

• GREELEY PANORAMA
The Greeley Panorama is in memory of Ronald Greeley (August 25, 1939 - October 27, 2011). The 360˚ panorama shows the spectacular view from Greeley Haven, the 2011-2012 Martian winter resting spot for NASA's Mars Exploration Rover Opportunity. It was constructed from 817 separate images taken by the rover's Panoramic Camera between Dec. 21, 2011 and May 8, 2012. The site's informal name, bestowed by the science team for the Mars Exploration Rovers, is a tribute to the late Ronald Greeley, a geologist, science team member, and Regents' Professor in ASU's School of Earth and Space Exploration.

• I2E2 "INTERACTIVE IMMERSIVE EXHIBIT ENVIRONMENT"
I2E2 allows users to be immersed in a customized version of JPL's "Eyes on the Solar System" as well as exotic terrestrial destinations where SESE scientist work in the field.

SECOND FLOOR – VISUALIZING SCIENCE
The second floor houses ASU's meteorite collection and laboratory, as well as a variety of learning spaces for K-12 students and educators.

CENTER FOR METEORITE STUDIES
Relocated and expanded for greater public access, the Center for Meteorite Studies now features interactive displays, touchable specimens, and a video display of the collection's specimens. Hands-on artifacts are placed around the area and backlit specimen cases are mounted in the walls. Touch-screen controls let visitors explore a series of short media pieces with supplementary information about meteorites, their discovery and analysis.

TECHNOLOGY-ENABLED ACTIVE LEARNING LABORATORY
The Technology-Enabled Active Learning Laboratory (TEAL), a technology-mediated classroom focused on active learning, stimulates discovery and exploration of earth and space science concepts through hands-on experiments and problem-solving exercises.

THE EDUCATOR'S WORKSHOP
Expanded to include foci beyond the Red Planet, the "Earth and Space Science Education Program" will emphasize the design, prototyping, and propagation of new pedagogies to enhance K-12 science learning. A 75-seat auditorium will be used for professional development courses and seminars.

The School of Earth and Space Exploration is an academic unit of the College of Liberal Arts & Sciences.

APPENDIX C

ROUND #1 QUESTIONS, FEEDBACK AND ROUND #2 & #3 QUESTIONS

Round #1 Questions, Feedback and Round #2 & #3 Questions

Question #1: How should we use the ISTB4's EPO space on the first & second floors to best tell the SESE story?

Feedback: The majority of respondents said that we should use the space for both public and K12 school groups employing self-guided and guide tours of exhibits showcasing the past, present and future of scientific exploration with an emphasis on "current" exploration conducted within SESE. Several menti1d that tours of exhibits would be enhanced with printed brochures and QR codes. Others noted using the theater and TEAL room for EPO programs as well as using the space for various events.

2.1.1 The current Gallery of Scientific Exploration (GSE) exhibits and digital projection assets, viewable laboratories and Marston Exploration Theater (MET) capabilities are sufficient to explain the current scientific exploration conducted within SESE?

Question #2: How can we use the ISTB4 EPO space to enhance "existing" EPO programs? (Current programs include: LROC Science Operations Center (SOC) tour, Mars Space Flight Facility tour, Mars Student Imaging Project (MSIP), Mars Exploration Student Data Teams (MESDT), Mars Educator Workshop, Starlab Teacher Professional Development, Astrobiology Virtual Fieldtrips, EarthScope Interpretive Teacher Workshop, NASA Triad Teacher Professional Development Workshop, CMS Tours, CMS Classroom Loaner Kit, Planetarium Shows, Space Photography Lab tour and packets).

Feedback: Responses to this question were split between adding the ISTB4 MET and GSE experience as a new optional "tour" stop as teachers and school groups visit MSSF (Moeur Bldg), LROC (Admin A Bldg), and RGCPS/SPL (Bateman Physical Science Bldg) or using ISTB4 as a single-point destination for fieldtrips. To the later, it was noted that large school groups could have an experience in the MET and then divide into smaller groups (<30) and rotate through standards-correlated experiences in the GSE, 2nd floor auditorium, educational technology experience in the TEAL room and hands-on activities in the large EPO workroom. It was also noted that rotational activities could be developed to ensure that MSFF, LROC and RGCPS were well represented. Several panelists noted that the GSE, 2nd floor auditorium, the TEAL room and the large EPO workroom could be used to enhance the MSIP, MESDT programs as well as teacher professional development workshops.

2.2.1 Do you think that the ISTB4 EPO spaces should be developed as a single-point destination for K12 school fieldtrips visiting SESE?

2.2.2 Do you think that the MET/GSE experience should be added as 1 of several optional "tour" stops for K12 school fieldtrips visiting SESE?

2.2.3 Do you think that in addition to the MET and GSE experience that the 2nd floor auditorium, the TEAL room and the large EPO workroom should be used to enhance teacher professional development workshops?

Question #3: How can we use the ISTB4 EPO space to enhance "existing" EPO events? (Current programs include: Earth & Space Exploration Day, Astronomy Night open House, ASU Homecoming).

Feedback: Panelist overwhelmingly support using ISTB4 for public outreach events with many emphasizing the importance of maximizing the use of the MET's programs and shows/films as well as access to the roof during monthly open house events. It was also noted that there is little opportunity to use ISTB4 during the Homecoming Block Party event.

2.3.1 Should SESE charge a nominal box-office fee to cover staffing, equipment and content cost for MET programs during public outreach events?

2.3.2 Should programming and activities be developed for the 2nd floor auditorium, the TEAL room and the large EPO workroom during public events?

Question #4: Are there new EPO programs and/or events that we should develop due to the new EPO space & assets? (i.e., exhibits, theater, Technology Enabled Active-learning Laboratory)

Feedback: Panelist offered numerous ideas in response to this question. Please indicate the development priority of these recommendations below. Please use "5" for the highest priority and "1" for the lowest priority and 2, 3, 4 as gradations.

2.4.1 Develop program modules that can be used by students participating in existing ASU outreach programs (i.e., High School-to-College, Upward Bound, Hispanic Mothers and daughters, etc.)

2.4.2 Develop a Research Experience for Teachers (RET) program.

2.4.3 Develop a series of fee-based Teacher Professional Development (TPD) programs.

2.4.4 Develop and market a regularly scheduled fee-based series of planetarium/astronomical shows, movies and films in the MET.

2.4.5 Develop a fee-based summer camp program centered largely on the TEAL room.

2.4.6 Develop a routine schedule of student-led activities/demonstrations (i.e. solar viewing) outdoors in front of ISTB4.

2.4.7 Develop an expanded free public lecture series perhaps by merging and growing the existing Astronomy and Earth and Space Lecture series'.

Question #5: Are there any SESE core research & teaching activities that cannot be shared with visitors using the new space, exhibits and assets that have been defined? Are there exhibits or technologies that should be added to enhance EPO programs?

Feedback: Panelist noted that exhibits and digital content should be developed specifically for MSFF, LROC and RGCPS (SPL). Also noted was the need for more content or exhibits related to earth science.

2.5.1 Please rate the balance of earth science and space science content in existing digital projection and exhibitory in the GSE.

5 - Way too much space science content
4 - A little too much space science content
3 - Just the right balance
2 - A little too much earth science content
1 - Way too much earth science content

Question #6: Describe the SESE EPO program, or suite of programs, that we should offer the K12 community to enhance the current STEM curriculum. Please consider demand, target grades, standards alignment, teacher pre & in-service, staffing and overhead cost.

Feedback: The panel of experts made numerous valuable suggestions on this topic. "Tours" or educational fieldtrips including exhibits, theater shows, use of the TEAL room and project based/ hands-on activities including robotics were recommended. There were split opinions about these programs being fee-based or free. In addition to STARLAB, some panelist recommended establishing a standards-based classroom loaner kit program related to SESE research. Fee-based pre-service and in-service teacher professional development workshops were also menti1d.

2.6.1 In addition to MET and GSE experiences, should K12 educational field trips include an educational technology program in the TEAL room and hands on activities in the EPO workroom?

2.6.2 Classroom loaner kit programs are labor intensive (particularly if college student facilitated). On a scale of 1-5 (5 having the most priority) rank the priority of this program.

2.6.2 On a scale of 1-5 (5 having the most priority), please rank the priority of the fee-based teacher professional development workshops.

Question #7: What type of EPO experience should we offer undergraduate and graduate students? What type of EPO experience should we offer the general public?

Feedback: Most respondents suggested a brochure to support self-guided exhibit exploration and scheduled theater shows and lectures. A surprising number responded with suggestions that student experiences be in the delivery programs (as docents) instead of being a recipient of programming. Others suggested strategies to recruit undergraduates and conduct fee-based continuing education programs for the public.

2.7.1 Should SESE majors and/or graduate students have a "service learning" requirement to serve as a docent (or otherwise) in support of EPO programming?

2.7.2 On a scale of 1-5 (5 having the most priority) please rank the priority of EPO programs to recruit undergraduates & graduate students into SECE programs.

2.7.3 On a scale of 1-5 please rank the priority of EPO programs to conduct fee-based continuing education for the public.

Question #8: Please identify any high-def videos/movies/documentaries or planetarium shows that you (or some1 you know) could host and provide a "value added" presentation.

Feedback: Excellent recommendations were made for sources and specific content (NASA Museum Alliance, National Geographic, Discovery, Atlas of the Digital Universe, Hubble 3D, Powers of 10, etc.). Alignment to SESE relevant research was identified as a priority. Also suggested were programs that compare "science fiction" movies to real science.

2.8.1 How frequently should the MET offer fee-based programs through box office/ticket sales?

5 - Every weekend and during academic breaks
4 - Twice a month
3 - Once a month
2 - Once a semester
1 - Never

Question #9: What should the staffing structure be to manage and execute EPO operations in the gallery and the theater? Please consider the operational modalities of school/youth fieldtrip programs, teacher professional development workshops, self directed visitations, public events, etc.

Feedback: Most respondent mention these professional staff members to support EPO operations: An EPO director, a theater manager and an administrative program coordinator. It was further noted that part-time student workers, student interns and

volunteers are needed to support theater programming, exhibit maintenance, content development and docent led educational programs. It was also noted that faculty and graduate students could augment professional EPO staff in conducting teacher training and additional students could be used to support large events.

2.9.1 Should an EPO program coordinator be established as a primary contact to coordinate all school field trip reservations, workshops and events?

2.9.2 An EPO Director, theater manager and program coordinator is the correct staffing level of professional staff to support MET/GSE operations, develop content, deliver programs and recruit and train student workers/volunteers.

Question #10 SESE EPO operations must be financially self-sustaining. Please suggest budget expenditures (such as labor, maintenance, expendables, show leases, etc.) and off-setting sources of revenue (contributed & earned) for your suggestions of operation.

Feedback: Recognizing the real overhead cost associated with staff salaries, exhibit and theater maintenance, content development/procurement, marketing and programming expendables most panelists recognize the need for contributed funding (grants & donations) but also fee-based earned revenue generation. Although informal education organizations (zoos, aquaria, museums, science centers, planetarium, botanical gardens, etc.) routinely charge for field trips, programs and events, several panelists insist that SESE proved programs to teachers, students and the public free of charge. The majority of panelist emphasized the ability to generate box-office revenue through theater programming and to minimize labor overhead with student and public volunteers. Others recommendations included: state/RID/grant funded staff lines, fee-based field trips, fee-based teacher workshops, fee-based summer camps, facility rental events, EPO "add-on" funds for SESE grants, EPO specific grants, donations and fund-raising events.

2.10.1 Should SESE establish programs fees for K12 fieldtrips and teacher workshops similar to other informal education organizations?

2.10.2 Should SESE establish a nominal "gate" fee ($1- $2) for large public events?

2.10.3 Should all SESE grants have an EPO add-on to their funding requests in order to support an EPO budget?

2.10.4 Should the MET offer non-educational entertainment type movies/films as a way to generate EPO revenue?

APPENDIX D

RANKING BY LEVEL OF AGREEMENT

Ranking by Level of Agreement

Ranking/ Ranking: consensus		#	Question	% Agree	Mean	SD
1	3	2.2	Do you think that the MET/GSE experience should be added as 1 of several optional "tour" stops for K12 school fieldtrips visiting SESE?	94%	2.88	.5
2	27	4.2	Develop a Research Experience for Teachers (RET) program.	94%	2.88	.49
3	2	9.1	Should an EPO program coordinator be established as a primary contact to coordinate all school field trip reservations, workshops and events?	94%	2.94	.24
4	25	4.6	Develop a routine schedule of student-led activities/demonstrations (i.e. solar viewing) outdoors in front of ISTB4.	88%	2.82	.53
5	9	4.7	Develop an expanded free public lecture series perhaps by merging and growing the existing Astronomy and Earth and Space Lecture series'.	88%	2.88	.33
6	7	4.1	Develop program modules that can be used by students participating in existing ASU outreach programs (i.e., High School-to-College, Upward Bound, Hispanic Mothers and daughters, etc.)	76%	2.71	.59
7	10	7.1	Should SESE majors and/or graduate students have a "service learning" requirement to serve as a docent (or otherwise) in support of EPO programming?	76%	2.65	.70
8	1	3.2	Should programming and activities be developed for the 2nd floor auditorium, the TEAL room and the large EPO workroom during public events?	70%	2.71	.47
9	26	2.3	Do you think that in addition to the MET and GSE experience that the 2nd floor auditorium, the TEAL room and the large EPO workroom should be used to enhance teacher professional development workshops?	65%	2.65	.49
10	6	9.2	An EPO Director, theater manager and program coordinator is the correct staffing level of professional staff to support MET/GSE operations, develop content, deliver programs and recruit and train student workers/volunteers.	65%	2.65	.49
11	19	4.4	Develop and market a regularly scheduled fee-based series of planetarium/astronomical shows, movies and films in the MET.	59%	2.29	.92
12	24	4.3	Develop a series of fee-based Teacher Professional Development (TPD) programs.	53%	2.29	.85

13	18	6.1	In addition to MET and GSE experiences, hould K12 educational field trips include an educational technology program in the TEAL room and hands on activities in the EPO workroom?	53%	2.47	.62
14	4	10.4	Should the MET offer non-educational entertainment type movies/films as a way to generate EPO revenue?	47%	2.00	1.00
15	11	2.1	Do you think that the ISTB4 EPO spaces should be developed as a single-point destination for K12 school fieldtrips visiting SESE?	38%	2.13	.81
16	12	10.1	Should SESE establish programs fees for K12 fieldtrips and teacher workshops similar to other informal education organizations?	35%	1.88	.93
17	14	10.3	Should all SESE grants have an EPO add-on to their funding requests in order to support an EPO budget?	35%	1.94	.90
18	20	3.1	Should SESE charge a nominal box-office fee to cover staffing, equipment and content cost for MET programs during public outreach events?	29%	1.82	.88
19	5	4.5	Develop a fee-based summer camp program centered largely on the TEAL room.	29%	2.24	.56
20	8	1.1	The current Gallery of Scientific Exploration (GSE) exhibits and digital projection assets, viewable laboratories and Marston Exploration Theater (MET) capabilities are sufficient to explain the current scientific exploration conducted within SESE?	12%	1.71	.69
21	13	10.2	Should SESE establish a nominal “gate” fee ($1- $2) for MET shows at large public events?	12%	1.53	.72

Rank order: consensus		Rating Questions	Mean (5 point scale)	SD
10	5.1	Please rate the balance of earth science and space science content in existing digital projection and exhibitory in the GSE. 5 - Way too much space science content 4 - A little too much space science content 3 - Just the right balance 2 - A little too much earth science content 1 - Way too much earth science content	3.25	.68
23	6.2	Classroom loaner kit programs are labor intensive (particularly if college student facilitated). On a scale of 1-5 (5 having the most priority) rank the priority of this program.	3	1.11
22	6.3	On a scale of 1-5 (5 having the most priority), please rank the priority of the fee-based teacher professional development workshops.	3.5	1.26

21	7.2	On a scale of 1-5 (5 having the most priority) please rank the priority of EPO programs to recruit undergraduates & graduate students into SECE programs.	4.07	.80
14	7.3	On a scale of 1-5 please rank the priority of EPO programs to conduct fee-based continuing education for the public.	2.94	1.06
16	8.1	How frequently should the MET offer fee-based programs through box office/ticket sales? 5 - Every weekend and during academic breaks 4 - Twice a month 3 - Once a month 2 - Once a semester 1 – Never	3.59	1.00

APPENDIX E

RANKING BY CONSENSUS

Ranking by Consensus

Rank # of Agreement		#	Question	Convergence
8	1	3.2	Should programming and activities be developed for the 2nd floor auditorium, the TEAL room and the large EPO workroom during public events?	47%
3	2	9.1	Should an EPO program coordinator be established as a primary contact to coordinate all school field trip reservations, workshops and events?	43%
1	3	2.2	Do you think that the MET/GSE experience should be added as 1 of several optional "tour" stops for K12 school fieldtrips visiting SESE?	36%
16	4	10.4	Should the MET offer non-educational entertainment type movies/films as a way to generate EPO revenue?	29%
25	5	4.5	Develop a fee-based summer camp program centered largely on the TEAL room.	23%
10	6	9.2	An EPO Director, theater manager and program coordinator is the correct staffing level of professional staff to support MET/GSE operations, develop content, deliver programs and recruit and train student workers/volunteers.	21%
6	7	4.1	Develop program modules that can be used by students participating in existing ASU outreach programs (i.e., High School-to-College, Upward Bound, Hispanic Mothers and daughters, etc.)	16%
26	8	1.1	The current Gallery of Scientific Exploration (GSE) exhibits and digital projection assets, viewable laboratories and Marston Exploration Theater (MET) capabilities are sufficient to explain the current scientific exploration conducted within SESE?	15%
5	9	4.7	Develop an expanded free public lecture series perhaps by merging and growing the existing Astronomy and Earth and Space Lecture series'.	13%
19	10	5.1	Please rate the balance of earth science and space science content in existing digital projection and exhibitory in the GSE. 5 - Way too much space science content 4 - A little too much space science content 3 - Just the right balance 2 - A little too much earth science content 1 - Way too much earth science content	12%
7	11	7.1	Should SESE majors and/or graduate students have a "service learning" requirement to serve as a docent (or otherwise) in support of EPO programming?	11%
18	12	2.1	Do you think that the ISTB4 EPO spaces should be developed as a single-point destination for K12 school fieldtrips visiting SESE?	6%
22	13	10.1	Should SESE establish programs fees for K12 fieldtrips and teacher workshops similar to other informal education organizations?	5%

21	14	7.3	On a scale of 1-5 please rank the priority of EPO programs to conduct fee-based continuing education for the public.	3%
27	15	10.2	Should SESE establish a nominal "gate" fee ($1- $2) for large public events?	1%

		#	Question	Neutral
15	16	8.1	How frequently should the MET offer fee-based programs through box office/ticket sales? 5 - Every weekend and during academic breaks 4 - Twice a month 3 - Once a month 2 - Once a semester 1 - Never	0%
23	17	10.3	Should all SESE grants have an EPO add-on to their funding requests in order to support an EPO budget?	0%

		#	Question	Divergence
13	18	6.1	In addition to MET and GSE experiences, should K12 educational field trips include an educational technology program in the TEAL room and hands on activities in the EPO workroom?	3%
11	19	4.4	Develop and market a regularly scheduled fee-based series of planetarium/astronomical shows, movies and films in the MET.	3%
24	20	3.1	Should SESE charge a nominal box-office fee to cover staffing, equipment and content cost for MET programs during public outreach events?	5%
14	21	7.2	On a scale of 1-5 (5 having the most priority) please rank the priority of EPO programs to recruit undergraduates & graduate students into SECE programs.	12%
17	22	6.3	On a scale of 1-5 (5 having the most priority), please rank the priority of the fee-based teacher professional development workshops.	13%
20	23	6.2	Classroom loaner kit programs are labor intensive (particularly if college student facilitated). On a scale of 1-5 (5 having the most priority) rank the priority of this program.	19%
12	24	4.3	Develop a series of fee-based Teacher Professional Development (TPD) programs.	22%

4	25	4.6	Develop a routine schedule of student-led activities/demonstrations (i.e. solar viewing) outdoors in front of ISTB4.	24%
9	26	2.3	Do you think that in addition to the MET and GSE experience that the 2nd floor auditorium, the TEAL room and the large EPO workroom should be used to enhance teacher professional development workshops?	25%

APPENDIX F

POST DELPHI INTERVIEW QUESTIONS

Post Delphi Interview Questions

On a scale of 1 to 5 with 1 = not very, 3 = somewhat and 5 = very

1. How useful do you think the Delphi method was for informing you about the scope and nature of the project?

   Comments:

2. How useful do you think the Delphi method was for soliciting opinions and generating new ideas?

   Comments:

3. How effective do you think the iterative summative feedback from other panelist was for changing opinions?

   Comments:

4. How useful do you think the Delphi method was for creating consensus?

   Comments:

APPENDIX G

ROUND ONE EMERGENT THEMES

Question 1	Add Quick Response (QR) Codes to Exhibits	4/14= 29%
	Exploration Theme	5/14 = 36%
	Guided and Self-guided Tours	6/14 = 43%
	Utilize the TEAL Room	1/14 = 7%
	Free Programs	2/14 = 14%
Question 2	ISTB4 Single-Point Destination	4/14= 29%
	Utilize the TEAL Room	3/14= 21%
	ISTB4 as Optional Tour Stop	9/14 = 64%
Question 3	Storage	3/14= 21%
	Utilize the TEAL Room	1/14= 7%
	Marston Exploration Theater (MET)	7/14= 50%
	Roof-top Astronomical Viewing	8/14= 57%
Question 4	Free Public Lectures	3/14= 21%
	Summer Camps	2/14= 14%
	Marston Exploration Theater (MET)	6/14= 43%
	Utilize the TEAL Room	2/14= 14%
	Become Add-On Program	1/14= 7%
	Research Experience for Teachers	2/14= 14%
	Consolidate EPO Programs into ISTB4	1/14= 7%
	Teacher Professional Development Workshops	4/14= 29%
Question 5	Lunar Reconnaissance Orbiter Camera	2/14= 14%
	Mars Space Flight Facility	2/14= 14%
	R. Greely Center for Planetary Studies	2/14= 14%
	Earth Science	3/14= 21%
	Other	6/14= 43%
Question 6	Fees/Cost	2/14= 14%
	Project Based	3/14= 21%
	Teacher Professional Development Workshops	3/14= 21%
	Loaner Kits	4/14= 29%
	Tours	5/14= 36%

Question 7	Self Guided Tours	6/14= 43%
	Public Events	2/14= 14%
	Work as a Docent	2/14= 14%
	Marston Exploration Theater (MET)	6/14= 43%
Question 8	Digital Universe	2/14= 14%
	Alignment to SESE Research	2/14= 14%
	NASA	2/14= 14%
	Nat Geo, Discovery Channel, etc.	3/14= 21%
	Sci Fi vs. Science	3/14= 21%
Question 9	Student Docents	3/14= 21%
	Program Coordinator	7/14= 50%
	Professional Staff	9/14= 64%
	Marston Exploration Theater (MET)	5/14= 36%
Question 10	Free Programs	5/14= 36%
	Facility Rental	2/14= 14%
	Donations	4/14= 29%
	Fee-Based Programs	7/14= 50%
	Fee-Based Films/Shows	8/14= 57%
	University Funds	1/14= 7%
	Grants	6/14= 43%

APPENDIX H

ROUND 1 QUESTIONS AND THEIR SUMMATIVE FEEDBACK

Question #1: How should we use the ISTB4's EPO space on the first & second floors to best tell the SESE story?

Feedback: The majority of respondents said that we should use the space for both public and K12 school groups employing self-guided and guide tours of exhibits showcasing the past, present and future of scientific exploration with an emphasis on "current" exploration conducted within SESE. Several mentioned that tours of exhibits would be enhanced with printed brochures and QR codes. Others noted using the theater and TEAL room for EPO programs as well as using the space for various events.

Question #2: How can we use the ISTB4 EPO space to enhance "existing" EPO programs?

Feedback: Responses to this question were split between adding the ISTB4 MET and GSE experience as a new optional "tour" stop as teachers and school groups visit MSSF (Moeur Bldg), LROC (Admin A Bldg), and RGCPS/SPL (Bateman Physical Science Bldg) or using ISTB4 as a single-point destination for fieldtrips. To the later, it was noted that large school groups could have an experience in the MET and then divide into smaller groups (<30) and rotate through standards-correlated experiences in the GSE, 2nd floor auditorium, educational technology experience in the TEAL room and hands-on activities in the large EPO workroom. It was also noted that rotational activities could be developed to ensure that MSFF, LROC and RGCPS were well represented. Several panelists noted that the GSE, 2nd floor auditorium, the TEAL room and the large EPO workroom could be used to enhance the MSIP, MESDT programs as well as teacher professional development workshops.

Question #3: How can we use the ISTB4 EPO space to enhance "existing" EPO events? (Current programs include: Earth & Space Exploration Day, Astronomy Night open House, ASU Homecoming).

Feedback: Panelist overwhelmingly support using ISTB4 for public outreach events with many emphasizing the importance of maximizing the use of the MET's programs and shows/films as well as access to the roof during monthly open house events. It was also noted that there is little opportunity to use ISTB4 during the Homecoming Block Party event.

Question #4: Are there new EPO programs and/or events that we should develop due to the new EPO space & assets? (i.e., exhibits, theater, Technology Enabled Active-learning Laboratory)
Feedback: Panelist offered numerous ideas in response to this question. Leading recommendations were to develop: (a) program modules that can be used by students participating in existing ASU outreach programs (i.e., High School-to-College, Upward Bound, Hispanic Mothers and daughters, etc.) (b) a Research Experience for Teachers (RET) program, (c) a series of fee-based Teacher Professional Development (TPD) programs, (d) develop and market a regularly scheduled fee-based series of planetarium/astronomical shows, movies and films in the MET, (e) a fee-based summer camp program centered largely on the TEAL room, (f) a routine schedule of student-led activities/demonstrations (i.e. solar viewing) outdoors in front of ISTB4, (g) an expanded free public lecture series perhaps by merging and growing the existing Astronomy and Earth and Space Lecture series.
Question #5: Are there any SESE core research & teaching activities that cannot be shared with visitors using the new space, exhibits and assets that have been defined? Are there exhibits or technologies that should be added to enhance EPO programs?
Feedback: Panelist noted that exhibits and digital content should be developed specifically for MSFF, LROC and RGCPS (SPL). Also noted was the need for more content or exhibits related to earth science.
Question #6: Describe the SESE EPO program, or suite of programs, that we should offer the K12 community to enhance the current STEM curriculum. Please consider demand, target grades, standards alignment, teacher pre & in-service, staffing and overhead cost.
Feedback: The panel of experts made numerous valuable suggestions on this topic. "Tours" or educational fieldtrips including exhibits, theater shows, use of the TEAL room and project based/ hands-on activities including robotics were recommended. There were split opinions about these programs being fee-based or free. In addition to STARLAB, some panelist recommended establishing a standards-based classroom loaner kit program related to SESE research. Fee-based pre-service and in-service teacher professional development workshops were also mentioned.

Question #7: What type of EPO experience should we offer undergraduate and graduate students? What type of EPO experience should we offer the general public?
Feedback: Most respondents suggested a brochure to support self-guided exhibit exploration and scheduled theater shows and lectures. A surprising number responded with suggestions that student experiences be situated in the delivery programs (as docents) instead of being a recipient of programming. Others suggested strategies to recruit undergraduates and conduct fee-based continuing education programs for the public.
Question #8: Please identify any high-def videos/movies/documentaries or planetarium shows that you (or some1 you know) could host and provide a "value added" presentation.
Feedback: Excellent recommendations were made for sources and specific content (NASA Museum Alliance, National Geographic, Discovery, Atlas of the Digital Universe, Hubble 3D, Powers of 10, etc.). Alignment to SESE relevant research was identified as a priority. Also suggested were programs that compare "science fiction" movies to real science.
Question #9: What should the staffing structure be to manage and execute EPO operations in the gallery and the theater? Please consider the operational modalities of school/youth fieldtrip programs, teacher professional development workshops, self-directed visitations, public events, etc.
Feedback: Most respondent mention these professional staff members to support EPO operations: An EPO director, a theater manager and an administrative program coordinator. It was further noted that part-time student workers, student interns and volunteers are needed to support theater programming, exhibit maintenance, content development and docent led educational programs. It was also noted that faculty and graduate students could augment professional EPO staff in conducting teacher training and additional students could be used to support large events.

Question #10 SESE EPO operations must be financially self-sustaining. Please suggest budget expenditures (such as labor, maintenance, expendables, show leases, etc.) and offsetting sources of revenue (contributed & earned) for your suggestions of operation.
Feedback: Recognizing the real overhead cost associated with staff salaries, exhibit and theater maintenance, content development/procurement, marketing and programming expendables most panelists recognize the need for contributed funding (grants & donations) but also fee-based earned revenue generation. Although informal education organizations (zoos, aquaria, museums, science centers, planetarium, botanical gardens, etc.) routinely charge for field trips, programs and events, several panelists insist that SESE proved programs to teachers, students and the public free of charge. The majority of panelist emphasized the ability to generate box-office revenue through theater programming and to minimize labor overhead with student and public volunteers. Others recommendations included: state/RID/grant funded staff lines, fee-based field trips, fee-based teacher workshops, fee-based summer camps, facility rental events, EPO "add-on" funds for SESE grants, EPO specific grants, donations and fund-raising events.

APPENDIX I

QUESTIONS RANK ORDERED FROM MOST TO LEAST CONSENSUS

Rank # of Agreement		#	Question	Convergence
8	1	3.2	Should programming and activities be developed for the 2nd floor auditorium, the TEAL room and the large EPO workroom during public events?	47%
3	2	9.1	Should an EPO program coordinator be established as a primary contact to coordinate all school field trip reservations, workshops and events?	43%
1	3	2.2	Do you think that the MET/GSE experience should be added as 1 of several optional "tour" stops for K12 school fieldtrips visiting SESE?	36%
16	4	10.4	Should the MET offer non-educational entertainment type movies/films as a way to generate EPO revenue?	29%
25	5	4.5	Develop a fee-based summer camp program centered largely on the TEAL room.	23%
10	6	9.2	An EPO Director, theater manager and program coordinator is the correct staffing level of professional staff to support MET/GSE operations, develop content, deliver programs and recruit and train student workers/volunteers.	21%
6	7	4.1	Develop program modules that can be used by students participating in existing ASU outreach programs (i.e., High School-to-College, Upward Bound, Hispanic Mothers and daughters, etc.)	16%
26	8	1.1	The current Gallery of Scientific Exploration (GSE) exhibits and digital projection assets, viewable laboratories and Marston Exploration Theater (MET) capabilities are sufficient to explain the current scientific exploration conducted within SESE?	15%
5	9	4.7	Develop an expanded free public lecture series perhaps by merging and growing the existing Astronomy and Earth and Space Lecture series'.	13%
19	10	5.1	Please rate the balance of earth science and space science content in existing digital projection and exhibitory in the GSE. 5 - Way too much space science content 4 - A little too much space science content 3 - Just the right balance 2 - A little too much earth science content 1 - Way too much earth science content	12%
7	11	7.1	Should SESE majors and/or graduate students have a "service learning" requirement to serve as a docent (or otherwise) in support of EPO programming?	11%

18	12	2.1	Do you think that the ISTB4 EPO spaces should be developed as a single-point destination for K12 school fieldtrips visiting SESE?	6%
22	13	10.1	Should SESE establish programs fees for K12 fieldtrips and teacher workshops similar to other informal education organizations?	5%
21	14	7.3	On a scale of 1-5 please rank the priority of EPO programs to conduct fee-based continuing education for the public.	3%
27	15	10.2	Should SESE establish a nominal "gate" fee ($1-$2) for MET shows at large public events?	1%

		#	**Question**	**Neutral**
15	16	8.1	How frequently should the MET offer fee-based programs through box office/ticket sales? 5 - Every weekend and during academic breaks 4 - Twice a month 3 - Once a month 2 - Once a semester 1 - Never	0%
23	17	10.3	Should all SESE grants have an EPO add-on to their funding requests in order to support an EPO budget?	0%

		#	Question	Divergence
13	18	6.1	In addition to MET and GSE experiences, should K12 educational field trips include an educational technology program in the TEAL room and hands on activities in the EPO workroom?	3%
11	19	4.4	Develop and market a regularly scheduled fee-based series of planetarium/astronomical shows, movies and films in the MET.	3%
24	20	3.1	Should SESE charge a nominal box-office fee to cover staffing, equipment and content cost for MET programs during public outreach events?	5%
14	21	7.2	On a scale of 1-5 (5 having the most priority) please rank the priority of EPO programs to recruit undergraduates & graduate students into SECE programs.	12%
17	22	6.3	On a scale of 1-5 (5 having the most priority), please rank the priority of the fee-based teacher professional development workshops.	13%
20	23	6.2	Classroom loaner kit programs are labor intensive (particularly if college student facilitated). On a scale of 1-5 (5 having the most priority) rank the priority of this program.	19%
12	24	4.3	Develop a series of fee-based Teacher Professional Development (TPD) programs.	22%
4	25	4.6	Develop a routine schedule of student-led activities/demonstrations (i.e. solar viewing) outdoors in front of ISTB4.	24%
9	26	2.3	Do you think that in addition to the MET and GSE experience that the 2nd floor auditorium, the TEAL room and the large EPO workroom should be used to enhance teacher professional development workshops?	25%
2	27	4.2	Develop a Research Experience for Teachers (RET) program.	49%

APPENDIX J

QUARTILES 1 AND 4, RANK ORDERED FOR STRONGEST AGREED TO STRONGEST DISAGREED WITH ASSOCIATED CONSENSUS RANK ON A 3 POINT SCALE

Ranking	Ranking of Consensus	Question		Mean 3 pt. scale	SD
1	3	Q2.2: Do you think that the MET/GSE experience should be added as 1 of several optional "tour" stops for K12 school fieldtrips visiting SESE?	94%	2.88	.5
2	16	Q4.1: Develop a Research Experience for Teachers (RET) program.	94%	2.88	.49
3	2	Q9.1: Should an EPO program coordinator be established as a primary contact to coordinate all school field trip reservations, workshops and events?	94%	2.94	.24
4	18	Q4.6: Develop a routine schedule of student-led activities/demonstrations (i.e. solar viewing) outdoors in front of ISTB4.	88%	2.82	.53
5	9	Q4.7: Develop an expanded **free** public lecture series perhaps by merging and growing the existing Astronomy and Earth and Space Lecture series'.	88%	2.88	.33
6	7	Q4.1: Develop program modules that can be used by students participating in existing ASU outreach programs (i.e., High School-to-College, Upward Bound, Hispanic Mothers and daughters, etc.)	76%	2.71	.59
18	12	Q10.1: Should SESE establish **program fees** for K12 fieldtrips and teacher workshops similar to other informal education organizations?	35%	1.88	.93
19	15	Q10.3: Should all **SESE grants** have an EPO add-on to their funding requests in order to support an EPO budget?	35%	1.94	.90
20	21	Q3.1: Should SESE charge a **nominal box-office fee** to cover staffing, equipment and content cost for MET programs during public outreach events?	29%	1.82	.88

21	5	Q4.5: Develop a **fee-based** summer camp program centered largely on the TEAL room.	29%	2.24	.56
22	8	Q1.1: The current Gallery of Scientific Exploration (GSE) exhibits and digital projection assets, viewable laboratories and Marston Exploration Theater (MET) capabilities are sufficient to explain the current scientific exploration conducted within SESE?	12%	1.71	.69
23	14	Q10.2: Should SESE establish a nominal **"gate" fee** ($1- $2) for large public events?	12%	1.53	.72