ABSTRACT

Current educational operation for informal science institutions tend to be based on the staff’s experience and intuition rather than on educational theories or research findings. This status study sought research evidence to develop an educational scheme for informal science institutions. Evidence for this scheme came from surveys to determine specific circumstances of educational operations and visitor behaviors, observational research in museums, and from the literature of informal science education.

The Provus discrepancy model, seeking gaps between the actual and desired states, guided this investigation of how informal science education institution staff view the nature and status of educational operations. Another investigation sought visitors’ views of the effectiveness of viewing the main idea for exhibit understanding, effective labels, expectations toward on-site lessons, and possibilities for assessments of museum operations.

Institutional data were collected via a web portal, with a separate site created for administrators, exhibit developers, and program planners. The survey asked about actual and desired states in terms of goals and roles of staff, contents of exhibits and programs, assessment, and professional development. Four additional visitor surveys were administered individually at the North Carolina Museum of Natural Sciences.

The institutional survey found that most institutions focus on attitudinal reinforcement rather than visitor learning, do not overtly value research or long-term assessment, and value partnerships with K-12 schools more than other groups. At the same time, the staff do not have a clear vision of the nature or function of an operations manuals. Large gaps were found between the actual and desired states in terms of assessment (administrators, exhibit developers, and program planners), professional development (exhibit developers and program planners), and partnerships (program
planners), indicating that their current visions and attempts are not consistent and may need improvement.

The survey of effective labels did not find a preference for any one particular type of label, and, although visitors prefer concise labels, they perceive “being concise” in a variety of ways. Student visitor expectations toward on-site lessons closely matched that of their teachers, which is for science learning beyond the classroom. Assessment of daily operation indicated that a tailored design for long-term assessments could overcome perceived drawbacks of feasibility (for the staff to interpret the results and for the visitors to fill in the survey) and measurement of visitor learning. No statistically significant difference was found between respondents who were provided the main exhibit ideas those who were not.

Four notions were generated from these five surveys: (1) Assessment instruments must include evaluation of visitor learning as well as their state of mind of them; (2) Staff professional development sessions must include acquisition of assessment skills and general knowledge in science and science education; (3) K-12 partnerships can be an initial step in bridging between institutions and their visitors; and (4) An operations manual could help direct an informal science institutions to more effective educational operations. The importance of a fair and systematic assessment system would help achieve all these notions.
Toward Enhanced Learning of Science: 
An Educational Scheme for Informal Science Institutions

by

Midori Suzuki

A dissertation submitted to the Graduate Faculty of 
North Carolina State University 
in partial fulfillment of the 
requirements for the Degree of 
Doctor of Philosophy

Science Education

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2005

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_____________________________
Dr. Tzuoo-Yee Chen
DEDICATION

To my dear mother, Noriko,

who has provided selfless love and strong support during my crisis.

She has made this journey possible.
BIOGRAPHY

Midori Suzuki was born in Shizuoka, Japan, on August 27, 1972. Shizuoka is a beautiful city with both mountains and oceans. Midori lived in Shizuoka until the age of seven, surrounded by the immeasurable love of her parents and sister. As a young girl, Midori would play out in the field and appreciate the natural color of the sky and leaves. It was then that a sense of wonder and intimacy toward nature began growing within her. Midori has good memories of her grandfather, who was a high school biology teacher, teaching her an awe of life and showing enthusiasm toward learning all through his life. Though Midori and her family moved around Japan, Shizuoka has remained her beloved hometown.

Midori studied Japanese philosophy and thoughts using methods of comparative studies in culture at the University of Shizuoka. There, she first experienced the real excitement of intellectual activities. After her undergraduate program, she began studying science education at Shizuoka University where she was exposed to the forefront of science education research in Japan and engaged in a number of projects and action research. Investigating the possibility of introducing constructivism into Japanese junior high school culture using the skills in anthropology, her advisor, Dr. Yoshisuke Kumano, broadened Midori’s perspective, and encouraged her to pursue her Ph.D. in the United States.

In the doctoral program at North Carolina State University, Midori focused on research in informal science education, using the skills of comparative studies in culture. She found it both challenging and exciting to discuss issues on her research with her advisor, Dr. John Penick. Midori’s work at the North Carolina Museum of Natural Sciences taught her much about dynamics of visitor behavior, as well as the culture of museum staff.

Midori is excited about her future and the prospect of engaging in informal science education activities and learning more about the nature of visitor learning and museum operations.
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Dr. Beaman also provided information on participating teachers who took the survey of visitor expectation toward the on-site lessons. A special thank you goes to elementary school science teachers Ms. Gretchen Tulloch and Ms. Trish Villareal, who participated with their students in the survey of the on-site lessons.

Ms. Jan Weems provided a chance to develop a visitor survey for her interactive area and administer it. Ms. Weems also encouraged me in various ways and broadened my perspective as a future museum educator through a variety of experiences in an actual setting. I would also like to thank Mr. Anthony Hinton, for his humor and for teaching me practical strategies for supervising the interactive area.

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CHAPTER 1 INTRODUCTION

Informal Science Institutions and the Need to Design Educational Procedures and Impacts

Museums, one form of informal science education institution, arose originally as collections to be admired or studied. Since then, informal science education institutions have evolved considerably, with many specializing in communicating science to the general public. These informal science institutions seek to bring broad understanding and education to their visitors. In the current high-information society, people need more than simple acquired knowledge about isolated individual activities encountered during visits to informal science institutions. Obtaining more useful and substantial information and conceptual knowledge requires carefully considered learning environments and institutions. This dissertation is one attempt to determine how informal science education institutions might be structured and function to provide such an environment for learning science.

Throughout the world, not only are governments, schools, and scholars calling for an enhanced emphasis on developing conceptual understanding of science, most also stress the importance of routinely using scientific thinking in daily life. Virtually all speak to the pivotal importance of applying scientific knowledge rather than merely obtaining knowledge for its own sake. Although many have written of the controversies surrounding the term “scientific literacy,” all agree that our citizens, now and even more so in the future, must have deep understanding, appreciation, and uses for scientific knowledge, processes, and skills. And, this must hold true broadly, for one’s own personal knowledge as well as for the scientific enterprise in general.

For deeper, conceptual learning and understanding, citizens need to understand not just the goals and meaning of an individual museum activity or group of activities, but those of the institution as well. Obtaining this depth of knowledge requires connecting learning outcomes to
prior knowledge, experience, and action. Accordingly, informal science institutions must shift their focus from “introducing” or “explaining” scientific concepts and natural phenomena to providing concrete experiences and connecting visitors’ prior knowledge to their museum visits.

A number of studies have examined the behaviors and ways of learning of museum visitors. Researchers have investigated potential roles that informal science institutions might take in order to promote the maximum educational potential. While we know much about the attracting and holding power of exhibits, visitor attitudes and interests, and the societal value of such institutions, almost no studies have examined knowledge construction of visitors or the educational operation of informal science institutions and most studies have not generalized or synthesized findings to produce broadly focused recommendations.

To understand and enhance the educational impact of informal science institutions, we must synthesize research and informed opinions from informal science education to develop an educational scheme for informal science institutions that provides universal and practical principles for more enhanced educational operation. This study attempted to better understand several of these issues while describing and proposing some potentially universal principles for enhancing informal science education.

Some Issues in Informal Science Education

Issues in informal science education begin with its very definition. Two current definitions of informal science education focus either on the setting or on the characteristics of informal learning. According to Tamir (1990), informal science education refers to any learning that takes place in settings outside of the classroom. Similarly, the National Science Teachers Association (NSTA) (1998) defines informal science education as experiences outside the classroom regardless of who is teaching or the types of institutions and organizations doing the teaching. Museums of natural history, museums of science and technology, science centers, nature centers, zoos, aquariums,
botanical gardens can all be considered informal science institutions.

From the perspective of characteristics, Screven (1986) defines informal learning as “non-linear, self-paced, voluntary, and exploratory.” Thier and Linn (1976) and Birney (1988) described science museums as places where visitors come by choice, and where “learners” have control over what they learn. With this in mind, Falk and Dierking (1992, 2000, 2002) use the term “free-choice” learning rather than “informal learning” as learners determine for themselves the extent of their participation, what to study, and the time they will spend on a particular task. Informal settings differ also in that learning is not always evaluated or assessed according to prescribed standards such as letter grades, and assessment can occur without pre-planning (Birney, 1988).

Informal science education includes far more than science learning at museums. Falk and Dierking (1992, 2000) regard science learning through media resource such as newspapers, books, and TV programs as a form of informal science education, thus it should increase the publics’ appreciation and understanding of science, mathematics, and technology because of these voluntary and self-directed experiences.

For this dissertation study, informal science education institutions included science museums, science and technology museums, natural history museums, science centers, nature centers, zoos aquaria, planetariums, and other public institutions where the general public can experience on-site educational activities. Since this research emphasized the visitor’s feeling of being at a live performance and immediate assistance and communication by the staff as important factors, virtual museums, those operated only on websites, were not included.

Most informal science education activities and exhibits focus on introducing and explaining scientific concepts and natural phenomena. The ways in which each activity represents the concepts and phenomena may be scientifically reasonable, but the activity design may not be based on the
visitor’s prior knowledge. In fact, the informal science staff often tend to assume that the general public has little prior knowledge in science and thus an activity may be designed in any way as long as the science is valid. Formal science education, in contrast, designs lessons more strategically around student desired goals, knowledge of cognitive development, and assumptions about what a person has learned in prior experiences.

While much research exists for exhibit and lesson development in formal science education, informal science education research has tended to focus on traffic counts, measures of interest and effectiveness of interactive exhibits, longitudinal assessment, and visitor behavior. At the same time, little is known of how the various components of informal science education are coordinated for maximizing visitor learning. Instead, staff in operations, management, exhibit design, and education may be more focused on procedures and exhibit function rather than on the learning that may be taking place. In the late 1970s, the National Science Foundation funded Project Synthesis (Harms and Yager 1981) to develop a current picture of science education and to synthesize a future-oriented “Desired State.” Thinking that such an undertaking would have great value to informal science education prompted this dissertation study.

A Desired State Document for Informal Science Education

To create a document that reflects what museum staff and others desire required understanding and synthesizing existing research and determining various interests and needs related to ongoing educational operation of informal science education institutions. Thus, this study investigated the perspectives of various groups within informal science education, seeking to bring together ideas and research to produce a description of how an informal institution might enhance its focus on education. While there is no clear and universal consensus, we call this first synthesis or approximation a “desired state” (as opposed to the actual or current state) for informal science education.
The collective experience of a wide variety of institutions and published research articles provided valuable information. However, the diversity of informal science institutions and lack of generalizations from the literature make it difficult for museum staff to use the findings in their own institutions. As the case studies in the articles are often highly specific in terms of the research questions, settings, and methodology, museum staff find it difficult to use such information unless they work in similar environments. Thus, we find informal science education research in need of a synthesis of research (Dierking, Falk, Rennie, Anderson & Ellenbogen, 2003) with useful and effective suggestions related to actual operations.

This study was designed to improve these two deficiencies (lack of focus on education and need for a synthesis) and to provide potentially universal suggestions about educational operations that might be useful for many institutions. In developing these universal or desired principles, this study focused on investigating the actual operation and the needs of informal science institutions while clarifying relevant research and editorial publications in hopes of making the desired state scheme pragmatic for those who might use it, the informal science education institutions themselves.

A Synthesized Educational Scheme for Informal Science Institutions

Affecting visitor knowledge requires that informal science institutions design effective activities that allow visitors to enjoy the learning processes while comprehending the topics and messages of the activities. To do so, institutions need a set of guiding principles for design and operation. This synthesized desired state document provides informal science educators with such principles to enhance their educational effectiveness in the daily operation. If practical, and universally usable, informal science institutions that welcome diverse visitors will apply it for their own settings and prosper. The proposed scheme respects and encourages the initiative of each institution allowing flexibility and creativity in use.
Research Questions of the Study

This research examined the desired and actual states of operations in informal science institutions and visitor understandings. A thorough examination of these states in informal science education settings revealed practical strategies for effective museum offerings that enable the visitors to understand science and nature with depth and breadth. The focus of this study was to determine the nature of a model of informal science education (an *Educational Scheme for Informal Science Institutions*) and how it might function. This study sought answers from institutions and the literature. Phrased as research questions, these were:

1. What is the desired state of informal science education?
   a. What are the desired components of assessment?
   b. What resources do informal science educators wish to obtain in designing activities?
   c. What kinds of professional development do informal science educators need?
   d. What kinds of partnerships do informal science educators wish to have?
   e. What components do informal science educators need in an operations manual?
   f. What components do informal science educators wish to include in docent/volunteer training?

2. What is the current state of informal science education?
   a. What outcomes do informal science educators assess?
   b. What resources do informal science educators use in designing activities?
   c. What kinds of professional development training are available for informal science educators?
   d. What kinds of partnerships do informal science educators have?
   e. What components do informal science educators include in an operations manual?
   f. What components do informal science educators include in docent/volunteer training?
   g. How do the main ideas of exhibits enhance visitor understanding?
   h. What kind of exhibit labels do the visitors like?
i. What do the visitors expect from the on-site museum lessons?

j. What are considered effective assessment instruments for daily operation?

3. How can we achieve the desired state?

Limitations of the Study

Although a small study, with only a small non-random sampling of institutions, this study offers concrete and validated ideas for informal science education and provides a starting point for a more thorough synthesis. As a synthesis document this study has limitations related to how well the sampled groups are representative of informal science education in general, their biases, and the inherent biases of the researcher. But, as with all synthesis documents, this one offers some common ground for discussion, suggestions for additional investigation, and, perhaps, a more focused view of the purposes, procedures, and potential of informal science education.
CHAPTER 2 REVIEW OF THE LITERATURE

This study began by looking at broad goals for science education, especially the US *National Science Education Standards (NSES)* (National Research Council, NRC, 1996). With such goals as science literacy and application of knowledge in mind, the study explored ways in which informal science education institutions could benefit general educational efforts. Understanding the relationship of goals, institutional operations, and public needs and interests required a thorough review of the literature, presented in this chapter. Broadly, this review covers published and expressed goal statements, the *National Science Education Standards*, the rise of informal science education, and various aspects of this study’s methodology, especially the development of a prospective synthesis.

Goals of Science Education and the *National Science Education Standards*

*Goals of Science Education*

Why is science education important? Two broad lines of answers have been provided for the goals of science education: to appreciate the beauty of science (Girod, Rau & Schepige, 2003) and to produce citizens who can participate in democracy (Longbottom & Butler, 1999). Girod et al. state that the goal of school and education should be more than to get a good job, to educate responsible citizens, or to prepare children to compete in a global society. Education should provide aesthetic experiences and facilitate aesthetic and artistic ways of viewing, acting, and living in the world. Therefore, they continue, the goal of education should be to foster aesthetic understanding of important and compelling ideas (science ideas). Girod et al. follow Dewey’s notion of “aesthetic experience,” claiming that science learning is aesthetic understanding in which creativity, passion, and beauty play a significant role. They also state that learning science from this perspective is best viewed as an integrated act, rather than solely cognitive or discursive. This sense of connectedness
is not only at the level of individual cognition; it comes from a desire to know with one’s heart and mind, emotions and cognitions, imagination and reason.

Furthermore, aesthetic perspective allows one to blend cognitive and discursive ways-of-knowing with all important affective and artistic ways-of-knowing into more unified, holistic, human understanding (Girod et al., 2003). Since this perspective takes root in the essential notion that humans have positive attitudes toward knowing, learning in this way joins cognition, affect, and action in productive and powerful ways. In other words, in aesthetic understanding, “learning is something to be swept-up in, yielded to, and experienced” (p. 575).

Longbottom and Butler (1999) define the goals of science education as growing citizens who can deal with democracy. They define democracy as a system in which all citizens express their humanity by making rational choices about their own lives, and where each of them is able to join others in influencing the general direction of society. According to them, science teaching aims at linking scientific ways of thinking with the advancement of democratic society. Students must learn science, but they must also learn about science (Longbottom & Butler, 1999; Chiappetta, 1997), they must develop a scientific view of the world, and they must adopt some of the creative and critical attributes of scientists. Therefore, Longbottom and Butler (1999) feel the goal of science education is the production of citizens who are creative, critical, analytical, and rational.

Longbottom and Butler state that the goal of science education should include improving the quality of human existence, and more essentially, to promoting rational ways in which citizen can influence the conduct and direction of human affairs.

Longbottom and Butler (1999) then propose three aims of science education in schools designed to help achieve the goal of science education: (1) children should understand that scientists are successful in developing understanding the world even though they do not have a fail-safe method, but that science is fallible (thus avoiding a positivist view); (2) children should
acknowledge scientific knowledge as the best we have, and therefore accept that it is rational to trust in expert knowledge (thus limiting skepticism to a justified level); and (3) children should adopt many of the critical and creative attributes of scientists (giving them the skills to take seek and evaluate evidence and to take part is reasoned debate). These three aims attribute to the immediate goal of science education: children learning science.

In the long run, children will gain the abilities and skills to live intelligently in democratic society. Scientific understanding exists at various levels of sophistication and by using an appropriate level of sophistication students at most any age could study almost any topic. The key is that students must understand the science that they learn in the sense of being aware of some of the evidence that justifies the knowledge, and also in the sense of having the confidence to apply knowledge to explain the world around them (Longbottom & Butler, 1999).

The National Science Education Standards

The National Science Education Standards (NSES) (NRC, 1996) state that the goal of science education is to educate students who are able to experience the richness and excitement of knowing about and understanding the natural world; use appropriate scientific processes and principles in making personal decisions; engage intelligently in public discourse and debate about matters of scientific and technological concern; and increase their economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers. These goals are integration of the two lines of goals mentioned in the last section, and using the NSES require thoughtful effort and close attention to the meaning of learning goals. Collins (1998) and NRC (1996) describe how the NSES was developed.

Publication of A Nation at Risk (National Commission of Excellence in Education, NCEE, 1983) was the response to “the widespread public perception that something is seriously remiss in the educational system” (NCEE, 1983, p.1). Following this publication, innovative curricula were
published by a variety of societies. In 1989 the American Association for the Advancement of Science (AAAS) published *Science for All Americans* (AAAS, 1989b), providing concise but broad definitions of adult science literacy, encompassing ideas from the natural and social sciences, mathematics, and technology (Roseman, 1997).

With this beginning, the NRC developed the *NSES* by involving a large number of scholars, including science educators, scientists, classroom teachers, academic societies and so on in the discussion. At the same time, NSF funded a variety of compatible curriculum projects such as BioCom, Active Physics, and EarthComm (NRC, 1996). *Benchmarks for Science Literacy* (AAAS, 1993) provided further help by translating the ideas in *Science for All Americans* into a coherent set of specific learning goals for grades K-2, 3-5, 6-8, and 9-12 (Roseman, 1997).

In putting the *NSES* (NRC, 1996) into practice, the process of the *NSES* development and implementation needed to value and be responsive to local input, deliberation, and decision making—an option potentially available to users of the *NSES* (Bianchini & Kelly, 2003). The standards in the NSES get validity by persuading the populace through the formulation of the best evidence for their case, not by coercing teachers and students with high-stakes tests.

*Implementation of the NSES*

Standards-based lessons have been implemented in many classrooms in many states. Most state frameworks used the *NSES* (NRC, 1996) to develop and implement science lessons, referring to the Science Content Standards for appropriate grade level and introducing the external resources based on Science Education System Standards. Most state assessments are closely aligned with the *NSES*.

Vogt’s (1997) practice describes how to modify the teacher’s existing teaching plan to a Standards-based science lesson. She suggests three steps: (1) check what the *NSES* says about what the students should know by referring to the Science Content Standards; (2) find out what the *NSES*
says about how to teach the content; and (3) determine the assessment method(s) that accurately reveal the students’ learning outcomes. She designed assessment instruments so that she can assess the students’ initial understandings and abilities, monitor student progress, and collect information to grade student achievement. Thus, the final evaluation determined how successful the student’s procedure was and whether they were able to accurately test their procedures, gather the needed data, and make appropriate use of formulas.

This method is appropriate for developing comprehensive lesson plans, for Radford (1997) states that teachers are asked to reflect on what they are experiencing and to consider how they might integrate the content and teaching methods into their teaching. This method also helps the teachers convey “minds-on” to students, as the NSES promotes. Vogt (1997) and Evans (2002) confirmed the effectiveness of the Standards-based lessons in spite of the problem that it is time-consuming for the teacher to plan, the teachers feel anxiety to shift from their existing teaching to the Standards-based way, and many teachers wish to avoid complexity of arranging external resources by contacting people and obtaining permissions. Radford (1997) supports this, saying that reflection about whether students are learning from their successes and failures and getting feedback about the reflection helps teachers develop their professionalism.

A View of the Science Classroom from the NSES

Learning Theories

In order to prepare stimulating and challenging classrooms, teachers must not only teach the contents but also make efforts to facilitate students’ learning. For that, teachers must be familiar with students’ learning styles and motivations. Odom and Kelly (1998) compared and contrasted learning theories produced by Ausubel and Piaget. According to them, Ausubel’s verbal learning is defined as the nonarbitrary, substantive relating of new ideas or verbal propositions to cognitive structure. For meaningful learning to occur, the new ideas must have potential meaning and the
learner must possess relevant concepts that can anchor the new ideas. The learner must also relate the new ideas or verbal propositions to relevant aspects of his or her current knowledge structure in a conscious manner.

Piaget’s theory of cognitive development emphasizes the development of conceptual knowledge as a result of self-regulation, physical interaction, and social dialogue. During the process of self-regulation, the learner is actively involved in mentally forming concepts through the process of assimilation and accommodation. The process of conceptual development via self-regulation is accentuated through physical manipulation of materials and objects involving the concept and through social interaction that occurs between individuals discussing the concept.

In addition to these two theories, constructivism offers another explanation of learning. According to Schulte (1996), constructivism was led by studies of Piaget and others since the 1970s. Driver and Oldham (1986) view learning as a change in conceptions. The view to this change in the way knowledge is structured by the individual learner is known as constructivism. Constructivism seems to take root in Bloom’s statement (1956) that knowledge that is organized and interrelated is better learned and retained than knowledge that is specific and isolated. Adding to Driver and Oldham, Lutz (1996) points out that constructivism is often referred to as building on prior knowledge “but only in the sense that prior knowledge is connected to new data during the process of creative construction of meaning” (p. 42). Thus Yager (1991) emphasizes that context-driven learning is the key to a constructivist approach.

Tobin, Tippins and Gallard (1994) state from a constructivist perspective that learning is a social process of making sense of experience in terms of extant knowledge. All knowledge is constructed and, accordingly, social and cultural phenomena are also personal constructs. However, an individual is born into a social and cultural environment in which all of the objects and events that are encountered have particular meanings that were also constructed. In this way, a view of
social constructivism emerged. In social constructivism, knowledge has a social component and cannot be seen as constructed by an individual acting alone.

Von Glasersfeld (1995) harmonized personal constructivism and social constructivism by introducing the idea of “intersubjectivity,” which refers to as shared meanings constructed by people in their interactions with each other and used as an everyday resource to interpret the meaning of elements of social and cultural life. He defines radical constructivism as follows:

It starts from the assumption that knowledge, no matter how it is defined, is in the heads of persons, and that the thinking subject has no alternative but to construct what he or she knows on the basis of his or her own experience. What we make of experience constitutes the only world we consciously live in. It can be sorted into many kinds, such as things, self, others, and so on. But all kinds of experience are essentially subjective, and though I may find reasons to believe that my experience may not be unlike yours, I have no way of knowing that it is the same. The experience and interpretation of language are no exception. (von Glasersfeld, 1995, p.1)

In either view of constructivism, it is commonly said that it requires learners to take responsibility for their own learning (Lutz, 1996). The learner must first recognize that his or her current knowledge is insufficient to explain an experience. As the learner experiences this conflict between misconceptions and newly discovered scientific explanations, a state of disequilibrium occurs and the student becomes uncomfortable. Students who gain an understanding of scientific concepts through constructivist strategies successfully accommodate scientific knowledge with their own view of how the world works.

Classroom Preparation for Effective Science Learning

Johnson (2000) evaluated constructivist learning environments in terms of Personal Relevance, Critical Voice, Shared Control, and Student Negotiation, and found that the constructivist learning environment was effective in all these aspects. In actual classrooms, students learn in different ways. Thus, constructivist learning environments need to include a variety of activities that draw upon students’ own ways of knowing and constructing knowledge (Sinclair & Coates, 1999). Furthermore, in the constructivist classroom, Schulte (1996) states, the focus in not
on meeting objects or mastering tests as this does nor sufficiently determine how much learning has occurred or track the process of conceptual change. Therefore, practices in constructivist classrooms are often student-centered, consistent with STS and hands-on learning. Rita (1998) propose a set of six strategies that achieve a constructivist learning environment: (1) give students the autonomy to pursue their own questions; (2) use open-ended questions; (3) increase wait-time; (4) accept student responses with a neutral “okay” that neither confirms nor rejects their answers; (5) start units by asking what students think about a topic before giving input; and (6) occasionally start a unit with a hands-on activity rather than lecture, giving students something to mentally refer to during lecture. These strategies are usable for any topics and any grade levels, and deal with students with diverse learning styles and at the same time promote learning.

Another key to preparing stimulating classrooms is to introduce multidisciplinary teaching that recognizes multiple intelligences. Multiple intelligences include logical/mathematical, linguistic, visual-spatial, musical, bodily-kinesthetic, interpersonal, intrapersonal, and naturalist (Sinclair & Coates, 1999). Meers and Wiseman (2002) implemented two physics classes; one theoretical and one applied, and compared whether differences exist in the multiple intelligences of students enrolled in both courses. They found remarkable growth of spatial, interpersonal, musical, and logical/mathematical areas in those students in the theoretical class and interpersonal, bodily/kinesthetic, spatial, musical, and intrapersonal areas in the applied science students. They confirmed the effectiveness of science classes utilizing multiple intelligences as students in both groups were able to direct their learning activities and felt comfortable within their dominant intelligences, and they gained personal ownership of the process.

Science learning that involves multiple intelligences and multiple disciplines (such as multidisciplinary learning and integrated science) brings enhanced understanding of science to students. Johnson and Jett (1993) state that interdisciplinary teaching includes any science classes
that make connections—between the disciplines, between the classroom and real life, between students and teachers, and between the teachers in a team. Nyckel (2000) found that integrated science lessons grow students’ logical and creative thinking skills, problem solving, the scientific method, experimental techniques and design, graphing and measurement skills. He reported multidisciplinary or integrated science learning to be effective for students’ understanding from classroom practice.

Incorporating learning cycles and teaching models is also said to be critical to provide effective learning environment. Odom and Kelly (1998) explain that the learning cycle is a methodology, grounded in Piaget’s theory of cognitive development, that provides students with concrete experiences prior to or in place of the introduction of terminology. The Piagetian approach suggests that students who reason at the concrete level can benefit from hands-on activities by constructing their own knowledge based on their sensory experiences of the world. This learning cycle can be referred to as experiencing the phenomena or concept, applying terminology to the concept, and applying the concepts to additional conceptual frameworks. They emphasize that concept mapping in the learning cycle provides both concrete experiences and cognitive structure that are required for meaningful learning to occur. Indeed, in their study, they found evidences that students performed best when both students and the teacher took active roles. Deming and Cracolice (2004), Evans (2004), Colburn (2000), Dougherty (1997), and Eyster (1997) conducted science lessons using the 5E Teaching Model (Engage, Explore, Explain, Elaborate and Evaluate) (Bybee, 1997), and confirmed the effectiveness of the model. According to Dougherty (1997), the 5E Model is constructivist because it recognizes that students are active agents in learning who construct meaning out of their interactions with phenomena, the environment, and other individuals. Burton and Campbell (1997) developed a 7E Teaching Model based on the combination of the inquiry method, multiple intelligences, and student-centered learning. The 7E Teaching Model
includes Expectation, Enticement, Engagement, Explanation, Exploration, Extension, and Evidence. Burton & Campbell (1997) state that the 7E Model provides students with ample opportunities to be involved in inquiry or discovery learning where they acquire knowledge that is uniquely their own because they have discovered it themselves.

None of these learning theories and teaching models succeeds without students’ positive attitudes toward science learning. Cultivating students’ motivation that takes root in the context of science learning is of necessity. Students are motivated when they are engaging in science to solve a potentially real problem, given multiple chances to succeed, and have a clear idea of what is required to succeed and are able to meet the challenge (Adams, Gitomer & Duschl, 1995). Hoover (1995, cited from Liggitt-Fox, 1997) states that students only internalize new information when the knowledge has been proven useful. Information that does not have to be used will be relegated to trivia and will not be available for later problem-solving situations; thus the real-world tasks provide student with a concrete reason to assimilate new knowledge and skills. However, in typical classroom discussions, students with right answers are recognized and rewarded and those with incorrect answers are ignored or corrected (Adams et al. 1995). Adams et al. point out that often there is little discussion that addresses the reasons why one answer or solution may be better than another. But, there is evidence that problem solving can be motivating (Pheeney, 1997). Motivation has great power to engage students in science learning. Once motivated, they learn more on their own than the teacher can teach them Therefore, motivation should not be slighted; rather, it must be emphasized when teachers plan any class using any teaching strategies.

Inquiry-Based Learning

The NSES stress learning by inquiry and Hinman (1998) differentiates inquiry into two types: general inquiry and scientific inquiry. According to him, the key difference between the two is that in scientific inquiry the question is framed in a form that can be tested and retested by experiments,
and typically the question is framed with the means of testing in mind. General inquiry is learning science “by” inquiry, and scientific inquiry is learning science “as” inquiry (Chiappetta, 1997). Open or full inquiry is defined as a student-centered approach that begins with a student's question, followed by the student designing and conducting an investigation or experiment and communicating results. It requires higher-order thinking and usually has students working directly with the concept and materials, equipment, and so on. Having students ask the questions that guide their own investigations is the key (Martin-Hansen, 2002).

In order to implement inquiry-science lessons in school settings, the fundamental steps of scientific inquiry need to be included in a lesson. This is often represented by hypothetical/deductive reasoning (Hackett, 1998). Harwood (2004) states that observing, defining the problem, forming the question, investigating the known, articulating the expectation, carrying out the study, examining the results, reflecting on the findings, and communicating with others are the steps of inquiry. These components should focus on questions, because asking questions is central to any scientific inquiry. Identifying questions prior to the activity helps students understand the concept (Bernstein, 2003).

Concrete thinkers have difficulty understanding abstract concepts. Therefore, inquiry learning should oriente activities toward concrete, observable concepts; centering activities on questions that students can answer directly via investigation; emphasizing activities using materials and situations familiar to students; and choosing activities suited to students' skills and knowledge to ensure success (Bernstein, 2003). Therefore, science curriculum and instructional materials should be based on the logical and sequential development of fundamental science concepts and also should provide opportunities for students to develop understandings about inquiry and abilities to conduct scientific inquiry. And, at the end of scientific inquiry lessons, student investigation would result in explanations based on evidence and its logical analysis. In student-originated and -directed inquiries,
both inquiry abilities and subject matter understanding are outcomes (Hackett, 1998). Ends and means alternate during the investigation; each alternately appears in the foreground and in the background.

Chiappetta and Adams (2004) further differentiate science inquiry into two types: school-based scientific inquiry and general scientific inquiry, and state that school-based scientific inquiry has a much broader purpose than general scientific inquiry in terms of the following five aspects: (1) understanding of fundamental facts, concepts, principles, laws, and theories; (2) development of skills that enhance the acquisition of knowledge and understanding of natural phenomena; (3) cultivation of the disposition to find answers to questions and to question the truthfulness of statements about the natural world; (4) formation of positive attitudes toward science; and (5) acquisition of understanding about the nature of science.

Hands-on activities are a major component of scientific inquiry and enable students to own questions by doing activities by themselves. Hands on leads students to personalize understanding of the topic (Ridgeway & Padilla, 1998) as lab activities serve as a means for students to construct their own understanding of scientific concepts. Hands-on activities encourage students to become involved in missions or projects through tasks that define their roles. As a result, students feel responsibility and connection to the mission and to the group (Oetinger & Hickel, 1997). When students make connections, they are often motivated to continue to study science (Nelson, 2004).

Martin-Hansen (2002) points out that structured inquiry in which students are guided and directed by the teacher often results in a cookbook lesson. Sometimes this approach is appropriate to use in the classroom; however, student engagement in the task is often limited to following teacher instructions rather than a full range of goals. Teacher goals for students during scientific inquiry are to: (1) convey self-confidence; (2) use critical thinking skills; (3) understand the nature of science; (4) identify and solve problems effectively; (5) use communication and cooperative
skills; (6) actively work towards solutions to local, national, and global problems; (7) be creative and curious; (8) set individual goals, make decisions, and self-evaluate; (9) convey a positive attitude about science; (10) access, retrieve, and use the existing body of scientific knowledge to investigate phenomena; (11) demonstrate a deep robust understanding of the science concepts they are using rather than the mastery of many insignificant, isolated facts; and (12) demonstrate an awareness of the importance of science in many careers (Clough & Clark, 1994).

In order to include all these aspects in the inquiry, the teacher plays a significant role. The teacher must possess certain attitudes and skills to encourage student success in the inquiry-based classroom. Teachers must ask open-ended questions, use wait time, paraphrase students, avoid telling them what to do, and maintain a disciplined classroom (Chiappetta, 1997; Colburn, 2000). In addition, students do not usually have a sufficient amount of knowledge to implement some inquiry activities all through the way. Edwards (1997) found that students are not used to applying proper controls and making careful measurements. Sumrall (1997) points out that hands-on activities can be too much work, too time consuming, too chaotic, and teachers may lack science content knowledge and materials. And, since students approach labs without the same experience as teachers, students often do not make the connections that seem obvious to teachers. Students are not discovering new ideas but should uncover the science underlying an activity (Ridgeway & Padilla, 1998).

Several types of inquiry exist. Guided inquiry is where the teacher helps students develop inquiry investigations in the classroom (Martin-Hansen, 2002). Usually the teacher chooses the question for investigation. Students may then assist the teacher with deciding how to proceed with the investigation. It is a natural lead-on to open inquiry. Martin-Hansen (2002) also describes coupled inquiry, which is a combination of a guided-inquiry and an open-ended inquiry. By beginning with an invitation to inquiry along with the guided inquiry, the teacher chooses the first
question to investigate, specifically targeting a particular standard or benchmark. After the guided inquiry, a more student-centered approach is taken for implementing an open-inquiry investigation. In all inquiry methods teachers play a role of mentor or guide, giving as little direction as possible (Edwards, 1997).

Conducting student discussion effectively after experiments confirms students’ understandings of the topic. During discussion, Ridgeway and Padilla (1998) state that students should be encouraged to share and compare their responses to the statements in the guide and to explain their thinking. They continue that it should be made clear to students that the most important part of students' responses is their line of reasoning, backed up with evidence from the laboratory experience, for decisions made relative to statements on the guide.

Effective Assessment

Assessments, while rarely seen in informal science education, are the norm in schools. Assessments provide grades, diagnose (prior knowledge), measure cognitive (intellectual ability) and affective (attitudes, values, interests and awareness) domains of students (Wright, 2001). Assessment refers to collecting data about what learners understand and can do, evaluating those data, and making decisions based on that evaluation (Dougherty, 1997). However, he points out, if teachers use assessment data only to inform students, their parents, or the school administration of what students know, then much of the power of assessment as a learning tool is lost. In order to utilize assessment most effectively, Dougherty (1997) suggests that teachers: (1) evaluate periodically student’s cumulative knowledge and understanding, a process known as summative assessment; and (2) evaluate continually students’ progress in learning, a process known as formative assessment. Serri (1999) proposes a more comprehensive assessment model that evaluate student learning continuously during progress through the science program. In addition to the assessment for the sake of students’ learning, Ochanji (2000) mentions the value of assessment from
the teacher’s perspective: teachers use assessment data to improve classroom practice, plan curricula, develop self-directed learners, report student progress, and research teaching strategies.

In classrooms, formative and summative assessments are mainly used with student learning. In addition to these two assessments, Luft (1999) suggests educative and evaluative assessment. According to her, an educative assessment assists students in learning how to learn, and evaluative assessment furnishes teachers with knowledge about their science instruction.

Assessment formats that are currently administered in classrooms include performance assessment, portfolio assessment, time-series design assessment, and predict-and-explain assessment (Wright, 2001). In time-series design assessment, a single question is given at times and the answers are formatively assessed. Wright states that it is a good way to monitor students’ learning and teaching effectiveness. In predict-and-explain assessment, students are given information and asked to make a prediction. It is said to be a good way to assess inquiry skills and can be integrated into lab activities. In responding to the emphasis on science as inquiry that is described in the NSES, a number of attempts assign students to complete a lab report in a scientific manner. For example, Licata (1999) introduced a narrative lab report in which students tell a story about their experiments. In this report, students include four topics: What was I looking for; How did I look for it; What did I found; and What does this mean? Similar approaches to complete lab reports were done by Colburn and Clough (1997), Friend (2002), Hand and Keys (1999), Timmons (2003) and Hinman (1998).

The Roles of Classroom Teachers for Effective Science Lessons

As the NSES (NRC, 1996) state, teachers play a significant role in science classes. Nason (1993) notes that an effective teacher: (1) ensures learning occurs by structuring the learning environment; (2) actively guides students in the learning process; and (3) are actively involved in tracking and assessing student learning. Also, he state that teachers should be concerned with the
nature of the learning, making sure that students are learning, that they understand how to get the information, present it, and make it relevant. Teachers should be available to help the students find information. In this view, the teacher's role becomes that of a facilitator guiding students groups that are working at different lab stations (Wygoda & Cain, 1994)

In implementing inquiry-based lessons, the teacher must possess certain attitudes and skills to encourage student success in the inquiry-based classroom: asking open-ended questions, using wait time, paraphrasing students, avoiding telling them what to do, and maintaining a disciplined classroom (Colburn, 2000). Clark, Clough, and Berg (2000) state, at one extreme, that students must either passively follow a cookbook laboratory procedure or, at the other extreme, investigate a question of their own choosing. They note that these extremes miss the large and fertile middle ground that its typically more pedagogically sound than either end of the continuum. Effective science teachers creatively modify activities to incorporate students' prior knowledge, engender active mental struggling with prior knowledge and new experiences, and encourage metacognition.

However, some teachers hesitate to introduce such learning in their classes. Colburn (2000) points out that the common reasons why teachers do not use inquiry learning is confusion about the meaning of inquiry; the belief that inquiry instruction only works well with high-ability students; teachers feeling inadequately prepared for inquiry-based instruction; inquiry being viewed as difficult to manage; an allegiance to teaching facts; and the purpose of a course being seen as preparing students for the next level.

To overcome these problems, teachers must become familiar with inquiry-based lessons and form teams to support developing and implementing such lessons. The training for individual teachers includes developing their own philosophies and rationales in education, developing questioning and educational skills that facilitate student discovery. For developing educational philosophy and rationale, Penick (1995) states that the effective teacher of science literacy must
have a clear and well-justified rationale for teaching and classroom skills to implement it. Goodnough (2000) supports this, saying that students learn in many different ways and have unique learning needs results in student-teacher partnerships. Furthermore, Fischer (2000) suggests the teachers focus on their own strength and live a balanced life in order to cultivate rich humanity. For questioning skills, Penick (1993) and Clark, et al. (2000) suggest asking students to make concise observations and in a way that students can identify their questions and promote interpretations of the result. Keys (1996) suggests asking high quality questions in order to increase the quality of the investigation.

Educational skills to facilitate students’ discovery include teachers possessing a variety of teaching approaches (Fischer, 2000), creating safe environments where students can take risks without the threat of reprisal and engaging in collaboration with respect (Goodnough, 2000), paying attention at all students (Ivy, 1994), not guiding all the way and at the same time having all students participate (Penick, 1991), systemically interacting with students to determine their ideas and seeking ways to intervene as they construct new meaning (Penick, 1995), and providing students useful suggestion without giving them the direct answer (Vogt, 1997).

Additional Thoughts about the NSES

Anderson and Helms (2001) examine future implications of Standards-based science lessons, raising six aspects: (1) The dramatic changes called for in the new Standards are very difficult to put into full practice and where attempted generally fall far short of the mark; (2) The difficulties of making the desired changes are highlighted by the many dilemmas teachers face in the process; (3) Fundamental reform of this nature requires significant changes in teachers’ values and beliefs about science education practice; (4) Departments within schools are the most important setting for change, although most research addresses whole school change; and (5) Substantial teacher collaboration in the work context- not just in in-service education-can be a powerful changing
influence on teachers' values and beliefs; (6) Parents often resist reforms and they have a strong influence on science education reform efforts; without local parental support of the reform ideas and practices, their implementation falls short.

Anderson and Helms (2001) point out that we do not know: (1) The most productive roles for students when addressing science content in ordinary classroom settings are not known in any practical detail; (2) In addition to student roles, the nature of the desired student work and the means of engaging students in it within ordinary classroom contexts, is not known in any practical detail; (3) How teachers can best be engaged (over a period of years) in reassessing their personal values and beliefs and taking major personal responsibility for acquiring needed new professional competencies is not well understood; and (4) It is not clear how to involve parents most effectively in the science education reform process so that they are educated about the issues involved and can influence their children's education most positively.

Future studies on Standards-based science lessons should focus on the following implications: (1) be approached from multiple perspectives, (2) be conducted in the “real world,” (3) focus on interventions into conventional school practice, (4) not assume that change can be driven from the top down, (5) be interpretive in nature, (6) focus on student roles and student work, (7) give major attention to teacher learning (which includes addressing values and beliefs), (8) attend to parents' concerns, and (9) be approached systemically (Anderson & Helms, 2001).

Science Literacy

Three Types of Science Literacy

The economic competitiveness of the United States reawakened interest in science literacy in the Early 1980’s (AAAS, 1989). Hazen and Trefil (1991) provide four answers to the question “Why is science literacy important?” and suggest four answers: (1) development of national economy; (2) greater support for science itself; (3) public expectations of science; and (4) the
relationship between science and culture so that the public respond to science without mixture of adulation and fear. In addition, they emphasize that (1) more knowledgeable citizens are able to negotiate their way more effectively in the society; (2) produce citizens feeling more confident and competent to deal with science-technology-related matters; (3) they may be able to be in a favorable position to exploit new job opportunities; and (4) intellectual, aesthetic, and moral benefits of individuals increases.

Extending across all elements of the NSES (NRC, 1996) and other goal documents, generalized science literacy might be the most pursued goal of science education, both formal and informal, and worldwide. In some ways defying definition, researchers describe and define science literacy in a number of ways. These can be roughly categorized into three groups: definitions based on human intelligence, on current society, and operational definitions.

Definitions that concern internal abilities or human intelligence are more independent across the ages. Societal definitions focus on practical values that derive from changes of social systems and progress of science and technology, thus these definitions of science literacy change accordingly. Operational definitions of science literacy provide criteria about what people should know and be able to do, and include perspectives of the other definitions. In some ways, the first two types of definitions focus on what personal aspects or characteristics of the person should be included in science literacy, while operational definitions provide criteria about what science literate people should know and be able to do. The next section will expand on these three ways of understanding science literacy.

*Science Literacy as Human Intelligence*

In this perspective, science literacy is an understanding of science as a way of knowing, focusing on people’s abilities regarding science. This assumes that human intelligence is universal no matter how society changes. Laugksch (2000) developed a conceptual view of scientific literacy
with four categories; ways of measuring, purposes, conceptual definitions, and nature of concept. Human aspects take a place at the center of this concept (Duscl, 1988; Stinner, 1995; Hurd, 1998; Carson, 1997; Donnelly, 2004) based on the belief that science is a human endeavor. Donnelly’s definition provides (1) an appeal to an autonomous self with the right and capacity to make independent judgments and interpretations; (2) indeterminacy in the subject matter of these judgments and interpretations; (3) a focus on meaning, in the context of human responses, actions, and relationships, and especially on the ethical, aesthetic, and purposive; and (4) the possibility of commonality in standards of judgment and interpretation, under conditions of indeterminacy. In addition, Duschl (1988), Donnelly (2004), and Stinner (1995) state that science literacy for human intelligence sustains the claim of science education reforms to extend and enrich the educational purpose of science in the curriculum.

In the same vein DeBoer (2000) sees science literacy as a desired familiarity with science on the part of the general public, noting it enhances the public’s understanding and appreciation of science. In this way, science literacy, rather than just acquiring knowledge and skills in science, seeks meaningful integration of science with other human intelligence activities as well as the nature of science.

Pella et al. (1966) categorize science literacy as (1) ethics that control the scientist in his work; (2) the nature of science; (3) the difference between science and technology; and (4) interrelationships of science and humanities. A scientifically literate person must be able to have a personal understanding that relates to the nature of science, or as some call it, scientific worldview (Aikenhead, 1986, 1996, 1997; Cobern, 1996; Hawkins & Peas, 1987; Jegede, 1997; Louden et al, 1994). From this perspective, scientific literacy implies an appreciation of the nature, aims, and general limitations of science, coupled with some understanding of the more important scientific ideas.
Enger and Yager (1993, 2001) organize science literacy around six domains: Concepts, Processes, Applications, Positive Attitudes, Creativity, and the Nature of Science. These six domains cover all aspects of scientific activities, with a strong alignment toward the real abilities in science. The Six Domains of Science focus on the state of human thought or intelligence and they offer ideas for assessing each domain in the classroom.

Science Literacy and Current Society

People need appropriate skills to live safely and comfortably in a highly developed society (Mbajiorgu & Ali, 2003). Many have combined scientific and technological literacy into what is usually called Science, Technology, and Society (STS) (Gennaro & Lawrenz, 1992; Cajas, 2001; Holbrook, 1992; Yager, 1992; Bingle & Gasket, 1994; Fourez, 1995; Mbajiorgu & Ali, 2003), or science for citizenship (AAAS; 1989; Ratcliffe, 1996; Kolsto, 2001). As education levels rose and society became highly informed, people started to think that they had to become able to use knowledge optimally and learn cutting edge science and technology such as genetics, nuclear science, and cloning technology (Hurd, 1998).

In this perspective, a scientifically literate person has an ability to think critically, identify and solve socioscientific problems, take part in collective decision-making, and communicate effectively in a technoscience culture (Botero, 1997; Hurd, 1998). Others such as Millar (1998), focus on knowledge needed for intelligent participation in science-based social issues (Gallagher, 1971; Hurd, 1970; Hofstein & Yager, 1982; Eylon & Linn, 1988; Ryan & Aikenhead, 1992).

Science literacy of this type focuses on national wealth and economic competitiveness as well. In order to sustain the national wealth, AAAS (1989) state that science literacy must relate to the global economy as well as environmental problems. In addition, they emphasize that (1) more knowledgeable citizens are able to negotiate their way more effectively in society; (2) we must produce citizens who feel more confident and competent to deal with science-technology-related
matters; (3) scientifically literate people may be able to be in a favorable position to exploit new job opportunities; and (4) with science literacy, intellectual, aesthetic, and moral benefits of individuals increases.

**Operational Definitions**

Operational definitions of science literacy can integrate various types of science literacy (AAAS; 1989a; NSTA, 1990b; Hazen & Trefil, 1990; NRC, 1996; AAAS, 1993; AAAS, 2001). Science literacy stands for what the general public ought to know about science; defining abilities and providing the criteria give a clear idea of who are the scientifically literate. Hazen and Trefil (1990) make a clear distinction between doing science and using science, and state that science literacy only concerns “using” science. According to them, science literacy can be defined as the knowledge we need in order to understand public issues. Furthermore, they believe that scientifically literate individuals should be able to place news of the day about science in a meaningful context.

Shamos (1995) assumes that “scientific literacy requires some level of understanding of science,” (p.86) and proposes three levels of science literacy based on this assumption: cultural scientific literacy, functional scientific literacy, and true scientific literacy. Using these three levels, he establishes a hierarchy of science literacy. According to him, the first level is met by almost all high school graduates, and the second by those who might be classified as “serious” students. The third level of science literacy is what we expect of science students by the time or after they graduate from college.

Norris and Phillips (2003) suggest that science literacy must (1) comprise the interpretive strategies needed to cope with science text, (2) be conceptualized so that neither the reader nor the text is supreme, (3) include an essential role of text in science, (4) capture the recognition that texts, although fixed, invite and allow interpretation and reinterpretation, (5) imply that the very words
and other textual elements matter as constraints on allowable interpretation, and (6) hold that science is a result of cumulative discourse that trades on the fixities of text and on what is taken for graphed by that text.

Although true scientific literacy as Shamos (1995) defines it may be impossible to achieve, he and others firmly believe in the value of individuals:

[b]eing … aware of some of the major conceptual schemes (the theories) that form the foundations of science, how they were arrived at, and why they are widely accepted, how science achieves order out of a random universe, and the role of experimentation in science. This individual also appreciates the elements of scientific investigation, the importance of proper questioning, of analytical and deductive reasoning, of logical thought processes, and of reliance upon objective Evidence (Shamos, 1995, p. 89).

The Nature and History of Informal Science Education

Definitions and Characteristics

Although many researchers use the term “informal science education,” there is an ongoing discussion of appropriate terminology to express such learning. Dierking (1991) raised an initial question on validity of the term “informal” by stating that, depending on the structure of the learning opportunity and the perception of the individual, each of these settings can be formal and informal, and concludes that distinction between formal and informal is inappropriate. She emphasizes “learning is learning, and strongly influenced by setting, social interaction, and individual beliefs, knowledge, and attitudes” (p.4 Dierking, 1991). Later, Dierking and Falk started to use the term “free-choice learning” in order to express this learning (Falk & Dierking, 1992, 2000, 2002; Falk, 2001).

Research journals, such as Science Education and the Journal of Research in Science Teaching started to discuss an appropriate term and definition that paraphrases “informal science education” and established new sections to report or relate to research on informal science education. Science Education initiated a permanent special section on informal science education.
followed by the success of a special issue devoted to that topic in 1997, *Volume 81*(6). Later, the name of this section was changed to “Science Learning in Everyday Life” (Dierking et al., 2003).

Although the Informal Science Education Ad-Hoc committee of the National Association for Research in Science Teaching agrees that there are many possibilities to describe this learning (out-of-school, free-choice or lifelong science learning, public understanding of science) they chose not to use the current term, “Informal Science Education” (Dierking et al., 2003). However, to avoid confusion, this dissertation uses the term “informal science education” applying the term to any kind of science-related museum or center, excluding mass media (TV programs and newspapers) and virtual museums that have only the websites.

Broadly defined by settings, informal science education is any science learning that occurs outside of school (Falk & Dierking, 1992; Maarschalk, 1988; Ramey-Gassert, Walberg, III, & Walberg, 1994; Tamir, 1990). Defined by characteristics, informal science education is said to be science learning that is hands-on, nonsequential, self-pacing, nonassessed, and often involving everyone who wishes to learn science (Greenfield, 1995; Birney, 1988; McManus, 1992; Ramey-Gassert et al., 1994). Falk (1999, 2001) and Falk and Dierking (2002) state that informal science learning is self-motivated, voluntary, and guided by the learner’s needs and interests, learning that is engaged in throughout his or her life. Screvan (1986) defines informal learning as “non-linear, self-paced, voluntary, and exploratory.”

Informal learning is not always evaluated or assessed according to prescribed standards such as a letter grade, and it can occur without pre-planning (Birney, 1988). Ramey-Gassert et al. (1994) define informal science education from its advantages, nurturing curiosity, improving motivation and attitudes, engaging the audience through participation and social interaction, and enrichment (Wellington, 1990). In 1997, Ramey-Gassert compiled existing articles on informal science education in order to describe informal science education programs and implications for enhanced

Wellington (1990) summarized features of informal science education through comparisons and contrasts with formal science education. Ramey-Gassert et al. (1994) used these same perspectives in examining informal science education (Table 1).

Table 1: Features of formal and informal science learning

<table>
<thead>
<tr>
<th>Informal learning</th>
<th>Formal learning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Voluntary</strong></td>
<td>Compulsory</td>
</tr>
<tr>
<td><strong>Unsequenced</strong></td>
<td>Structured</td>
</tr>
<tr>
<td><strong>Unstructured</strong></td>
<td>Sequenced</td>
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<tr>
<td><strong>Nonassessed</strong></td>
<td>Assessed</td>
</tr>
<tr>
<td><strong>Unevaluated</strong></td>
<td>Evaluated</td>
</tr>
<tr>
<td><strong>Open-ended</strong></td>
<td>Closed-ended</td>
</tr>
<tr>
<td><strong>Learner-led</strong></td>
<td>Teacher-led</td>
</tr>
<tr>
<td><strong>Learner-centered</strong></td>
<td>Teacher-centered</td>
</tr>
<tr>
<td><strong>Out-of-school context</strong></td>
<td>Classroom context</td>
</tr>
<tr>
<td><strong>Non-curriculum-based</strong></td>
<td>Classroom-based</td>
</tr>
<tr>
<td><strong>Many unintended outcomes</strong></td>
<td>Fewer unintended outcomes</td>
</tr>
<tr>
<td><strong>Less directly measurable</strong></td>
<td>Empirically measured outcomes</td>
</tr>
<tr>
<td><strong>Social intercourse</strong></td>
<td>Solitary work</td>
</tr>
<tr>
<td><strong>Nondirected or Learner-directed</strong></td>
<td>Teacher-directed</td>
</tr>
</tbody>
</table>

The focus on motivation and mental affect, such as enjoyment and non-threatening atmosphere, is another feature that is critical in informal science settings (Beer, 1987; Csikszentmihalyi & Hermanson, 1995; Grinell, 1988; Korn, 1995; Semper, 1990). Indeed, many feel that entertainment is critical and essential for informal learning. For example, Birney (1988), Thier and Linn (1976), Rix and McSorley (1999) and Rennie and Williams (2002) state that acquiring new information satisfies human emotional needs and that learning is inherently enjoyable. And many associate gaining new knowledge with an increase in their own social value.

Others point out that hands-on experiences, experimental activities, and devices for personal
learning must be emphasized in order to gain deeper understanding of science concepts. (Ames, 1988; Carr, 1989; Downs, 1989; Edeiken, 1992; Falk, Koran, & Dierking, 1986; Hofstein, Bybee, and Legro 1997; Resnick, 1987; Wolf, 1986). Carr (1989) says that museum learning proceeds from “authentic encounters with order and meaning, pattern and explanation” and continues that “museums should be prepared so that people can explore and develop what they know, invite an avalanche of questions, and foster web-work of connections that configure a learning life” (p.55). Wolf (1986) also points out that informal science institutions have a great potential that promotes visitor’s learning by relating their personal experiences to interesting objects, science and technology through the medium of the past, present, and future and exhibits that can encourage participation and focus attention of visitors. Activities that have a connection to real-life situation are usually open-ended, with a clear message to convey, leading to a broader understanding of science and nature.

Informal science education also includes a social component (Bresler, 1991; Birney, 1988; Diamond, 1986; Falk & Dierking, 1992, 2000, 2002; Miller, 1992; Ramey-Gassert, 1997; Semper, 1990; Wellington, 1990), referring to visits in family groups and school groups, visits with friends, placing learning in a social context. In a broader view of social interaction, informal science institutions can prepare an opportunity of social interaction in the community in responding to public awareness, which is one of the key roles of informal science education (Emery, 2001; Rix & McSorley, 1999). Emery (2001) states that society (community) needs to be a part of museum activity.

**History of Museums**

The Muses were the nine daughters of Zeus, who presided over the arts and learning, including history, epic and lyric poetry, music, tragedy, dance, comedy, astronomy, and religious music. “Museum” comes from the Greek word, *mouseion*, which means “place of the Muses”
(Glaser & Zenetou, 1996: Kotler & Kotler, 1998). Reflecting the evolution of society, museum development in the United States is described in four overlapping phases, the age of the private society (cabinet of curiosities), the age of “popular” or commercial museums (self-education through entertainment), the age of the academic museum (research and teaching), the rise of the public museum (more democratic), the emergence of the educational museum (increasing professionalism), and museums as they are today (Glaser & Zenetou, 1996). The earliest museum may have been in third-century Alexandria, Egypt, although the term “museum” was first used to describe a collection in Renaissance Florence. Early museums were collections of art and objects amassed by the church or wealthy families and objects were not exhibited in any planned way. Until the late eighteenth and early nineteenth centuries museums were still exclusively for the noble, the elite, and the highly educated; they were not intended for the public.

The British Museum, opened in London in 1759, was only a little more accessible than the private museums of the Renaissance, as entry was limited to sixty visitors a day. Later in 1879, the British Museum became the first true national museum opened to the public on a daily basis. Public museums in the United States began late in the eighteenth century and featured local natural history and art by American painters.

The first public museum in the United States opened in South Carolina with natural history and other eclectic collections. In 1875, the Peale Museum in Philadelphia was established for the purpose of displaying “natural curiosities,” with a mission to enhance public education as well as scientific and historical research. The Peale Museum eventually became the Philadelphia Academy of Natural Sciences.

P.T. Barnum’s American Museum, opened in 1841 in New York City, exploited the demand for popular learning in the United States in a commercial way using a collection of curiosities and exotic performers. With a display collections of natural features, he also had performing fleas,
whales and a white elephant from Siam, much like a circus. Barnum created wax figures and built some of the earliest dioramas. He offered opportunities for the public to observe and learn how these exotic animals look and live. Inviting open skepticism, he sought to challenge, and raised debates about affecting the educational and entertainment power of museums.

By 1850, public and educational research collections were established in academies, universities, and learned societies. With an emphasis on scholarly research, objects were arranged categorically, as in many university science museums today. The Smithsonian Institution, established in 1846, directed that the institution should provide for “the increase and diffusion of knowledge among men.” Even then, while most people felt that research should play an important role, it was been argued that a balance with education should prevail, as museums increasingly became major learning resources for their communities.

In the second half of the nineteenth century changes in museum operations occurred with the shifting of goals toward education. As collections grew, a new kind of expertise was required, and the position of curator came into being. Changes in museum governance took place as well, partly to satisfy the wealthy collectors who were donating collections and establishing museums. Around 1920 museums began to cooperate with schools and to establish schools of their own (Spiess, II, 1996), emerging as truly public institutions. At this time, serious consideration was given to the organizational structure of museums. A museum training course at Harvard University, “Museum Work and Museum Problems,” started in 1921, covering such topics as museum management, collecting, conservation, exhibition, history of museums and ethics (Spiess, II, 1996).

Along with training, displays became more sophisticated as collections were interpreted around themes. Period rooms, natural habitats, dioramas, live demonstrations and outdoor living history museums all testify to the growing bank of knowledge that started to make museum work a true profession (Glaser & Zenetou, 1996; Spiess, II, 1996). With the increase in museum attendance,
the quality and quantity of collections increased. The proliferating museum activities attracted the attention of behavioral psychologists, who assessed the learning experiences of museum visitors and examined the relationships between exhibitions and learning. About 1930, museums began to evidence a serious interest in conservation of objects, and conservation began to be recognized as an integral part of a museum’s mission. Despite conflicts between conservation and curatorship, and between conservation and exhibiting, the field of conservation has steadily progressed. In the 1930s a number of outdoor museums emerged and succeeded (Spiess, II, 1996).

After World War II, well-educated, middle- and upper-class women, usually members of civic and professional groups, became museum volunteers, contributing greatly to the expansion of museum educational programs (Zeller, 1996). Museums in the 1970s began emphasizing environmental education, presenting exhibitions and programming on such topics as endangered species, urban sprawl and habitat preservation, water pollution, health problems in inner cities, and city planning. Federal funds were available to all institutions that provided “community education programs on preserving and enhancing environmental quality and maintaining ecological balance and education was the focus of expansion in museum activities in the 1980s and 1990s.

As museums started to make more efforts to attract visitors, popularize their programs, and provide services for the disadvantaged and for special audiences, they explored their successes of quality: Was quantity superceding quality? Was entertainment superceding education? What is excellence in museums? and By whose standards? The Kellogg Foundation/Smithsonian Educational Project, the Exploratorium in San Francisco, and the Field Museum in Chicago became leading institutions trying to answer these questions (Glaser & Zenetou, 1996). The need for experimental work to determine visitor behavior and educational results reemerged as an important museum activity.

More attention began to be paid to professionalism (ethics and standards) in the ranks of staff,
as well as to specializations, institutional needs, and training. Museum studies programs began proliferating in the 1970s as more students became interested in museums, and as universities, facing declining enrollments, sought to add new programs (Anderson, 1988; Frasier-Abder, 1996; Genoways, 1996; Silverman et al., 1996).

More and more professional organizations, institutions, and outside consultants began offering mid-career training. Emphasis was placed on expanding interpretive exhibitions with audiovisuals, using docents as guides (Diamond et al., 1987; Nein, 1993; Grinell & Curtin, 1990), up-to-date registration methods, the basics of museum management (Ames, 1989; Butterfield, 2001; Danilov, 1990; Yang, 1989), refining living history techniques, computer usage for record keeping, and participatory, experimental, and interactive exhibitions.

As museums evolved, many broadened their focus beyond science and natural history. According to Danilov (1976), the earliest science and technology museum was established in Paris in 1799, followed rapidly by similar institutions in other European countries. Two principal aims of those museums were (1) to acquire and preserve scientific and technological heritage of Western Civilization and (2) to explain the construction, use and operation of various tools, machines and instruments not so much to the general public but rather to the “working man” of the day (Orchiston and Bhathal, 1984).

In the US in the 1960s, many saw a need for educating children and providing true experiences rather than just knowledge. The resulting science centers are very much a North American and Asian phenomenon (Orchiston and Bhathal, 1984). The excitement of science centers stem from exhibits that are interactive, as both children and adults engage in do-it-yourself experiments. The Exploratorium in San Francisco (Oppenheimer, 1970, 1975) is an early exemplar of this type. While differing greatly in their specialties and disciplines, there is a thread of commonality among all the various types of informal science education institutions: most of them
collect, preserve, research, exhibit, and interpret, though in very different ways. They also educate, enlighten, and uplift the human spirit in an uncertain and changing world.

Although museums have common purposes and functions, their diverse subject matter has prompted increased specialization among staff. Background in the discipline of the museum is not as simple as it used to be when art, history, or the sciences were the sole focus of museums. Additional advanced and mid-career studies are often required for staff to keep pace with the ever-changing and developing museums field.

History of Informal Science Education Research

Curator has been published by the American Museum of Natural History since 1958. Its articles since then provide an excellent reflection of trends and issues in informal science education. Curator has two primary goals: one is to offer peer-reviewed publication for the international community and the other is to provide a forum for that community (Colbert, 1958). The first editorial statement describes the background as follows:

[Museums] have become vastly more varied and complex. The skill and competence now required to organize and administer a modern museum, to explain and prepare exhibits, to serve and deal with the public and for education and knowledge, to use and maintain collections, and to control the manifold interrelations of all these other things as well, have taken on a highly professional character that culture and the high standards of performance that museum have taught the public to expert” (Colbert, 1958, p. 5).

Until the end of 1960s, Curator focused on introduction of various techniques, newly built institutions, persons who had rendered distinguished service for museum development, and discussion of general idea of museum management. Introduction of techniques was the dominant topic and included ways to prepare exhibits (Meryman, 1960, 1961; Sills, 1958; Stark, 1958), how to display exhibits effectively (Ellis, 1967; Matheson, 1961; Besson, 1963; Wilson, 1965), and how to prepare museums (Gratacap, 1960; Amadon, 1964, 1971; Lemon, 1967; Pryor, 1967; Smith, 1966). The articles that discuss general ideas mainly focus on roles of museums (Ubell, 1958; Rodeck, 1960; Colbert, 1960; Multhauf, 1960; Parr, 1962, 1963a, 1963b). A few case studies have
been reported in the journal (Chambers, 1958; Petersen, 1958), however, those did not include
discussion on a firm basis since they were the first case studies in the journal, and probably the first
case studies in museum studies as well. Several articles proposed standards in aspects such as
education (Flynt, 1959; Swinson, 1958) exhibit design (Witteborg, 1958), and professional
standards (Donson, 1959). These articles were the responses to Curator trying to set standards to
establish a certain position of museums as well as providing guidelines for museum management in
various aspects. Although it has not been a major discussion topic, this movement can be seen
throughout its history (Bergmann, 1976a, 1976b; Wolf, 1976; Yang, 1989).

In the 1970s, reports of evaluation studies started to emerge, mainly related to exhibits (Eason
of the Exploratorium in 1969 triggered examination of goals and roles of science museums
and Danilov (1973, 1974) introduced facilities and educational activities at many in the United
States. In the second half of the 1970s, visitor surveys started to be used to inquire about what
exactly the visitors see and examine during the visit and what they say about it (Serrell, 1977;
Cohen et al., 1977; Cone & Kendall, 1978).

Visitor surveys became the mainstream of informal science education research in 1980s
(Carlisle, 1985; Diamond, 1986; Koran, Jr. et al., 1986; Rosenfeld & Terkel, 1980). In this time
conceptual frameworks were developed (Orchiston & Bhathal, 1984; Screven, 1986), and visitor
surveys came to seek depth, with the aim of application to institutions broadly and clarification of
visitor behavior in various settings. Since this time, bibliographies were published in Curator at
times in order to summarize the achievements in informal science education research and provide
organized resources to the researchers (Borun & Chambers, 1995; Rounds, 2000; Screvan, 1984;
Stansfield, 1985). Articles varied from general discussion of education (Nelving, 1984; Baird, 1986;
Ames, 1988; Bierbaum, 1988) to strategies to enhance science literacy of the visitors, to family behavior (Diamond, 1986), effective interaction (Kerr, 1986), school field trips (Gottfried, 1980; Balling & Falk, 1980; Falk, 1983) and effective exhibits (Kerr, 1984; Thier, 1985; Danilov, 1986; Feher & Rice, 1985; Ucko, 1985). Less emphasis was placed on programs (lessons offered by informal science institutions) and more on roles, impacts and outcomes. The term “informal science education,” first used by Screvan (1986) in *Curator*, reflects this changing emphasis.

In the 1990s and 2000s, visitor surveys and case studies remained the mainstream of the research. *Curator* established “Forum,” where the readers contribute short opinion notes to share information and enhance discussion among the museum practitioners (Taylor, 1992). The focus of visitor surveys has been shifting to more direct topics of education (rather than museum functioning or exhibits) and cognition such as family learning (Borun, Massey, & Lutter 1996; Falk, 1991); visitor behavior (Adelman et al., 2000; Chiozzi & Andreotti, 2001; Korn & Jones, 2000), learning settings (Falk et al., 1998; Chermayeff, Brandford, & Losmos, 2001; Walter, 2002), and visitor interest (Boone & Britt, 1994; Connors, 1991; Diamond, 1994; Korn, 1995). Partnerships between universities (Maccarone & Batdorf, 2003) and between schools (Falk & Dierking, 1997; Tuckey, 1992) also attracted more focus.

While *Curator* was aimed at the professional museum community, other groups were also taking interest in informal science education. *Science Education* launched a research focus group “Science Learning in Everyday Life” in 1997 in response to growing interest in research focused on a broad view of informal science that arose from meetings. Groups and agencies showing interest and activity included the National Science Foundation (NSF), the National Association for Research in Science Teaching (NARST), the American Educational Research Association (AERA), and the Association for the Education of Teachers in Science (AETS)\(^1\) (AAM, 1995; ASTC, 1996; 1996; 1995).

\(^1\) In January 2005 AETS changed its name to the Association of Science Teacher Educators (ASTE).
An entire issue of *Science Education* (Vol. 81 Issue 6) was devoted to informal science education research in order to establish a new outlet for research. The articles in this issue were mostly exploratory studies, trying to introduce critical aspects to implement informal science education, such as desirable orientation of informal science learning (Griffin & Symington, 1997) and necessary tips to be included in enhanced learning in informal settings (Fisher, 1997; Allen, 1997, Gilbert & Priest, 1997; Sandifer, 1997). Those articles point out the importance and necessity of research in informal science education, but they did not reach the step of synthesis of research findings.

Hein (1998) completed an annotated bibliography on informal science education research. His project started from an issue that certainty cannot be pursued in research on informal science education due to lack of bibliographical resources to rely on. He also points out the lack of rationale and philosophy for informal science education, and that make museum operation less efficient. He states “If no conscious effort is made to adopt a theory of education, the museum’s exhibitions, layout, and general atmosphere will still express a point of view about education and visitors will still receive powerful images, but these may be mixed and/or contradictory and visitors may be confused” (p.14).

Based on this impending crisis, he synthesized research findings that consist of educational theories, educational programs, audience research, and evidence for learning in the museum. the most notable point is that he devoted a chapter on constructivism, aiming at coordinating theories, practices, and the evidences of educational achievements.

In 2004, *Science Education* published another special issue on informal science education (Vol. 88 Issue S1) to reflect on the achievements of informal science education research of the prior decade. This issue noted progress in terms of learning designs that incorporated the nature of
science and more values than just entertainment (Rennie & Johnston, 2004; Allen, 2004). The issue described the use of research findings for family learning and issues-based learning (Ellenbogen, Luke & Dierking, 2004; Pedretti, 2004) as well as findings and implications for school group learning (Griffin 2004; Martin, 2004). The issue recommends seeking informal science education research that addresses how the complexities of these learning processes interact holistically and how to be more explicit about the scope and scale of our learning investigations. Falk (2004) notes the necessity of a synthesis of research findings of the past decades and holistic research that incorporates scale and scope in order to accommodate the true complexity of learning in informal science settings. While he did not use the exact words, he was, in essence, recommending development of a prospective synthesis related to the future of informal science education.

NARST established an Informal Science Education Ad-Hoc committee to focus on the organization’s position in regard to out-of-school science education (Dierking et al., 2003). In their policy statement on informal science education, they defined the domain of out-of-school science education and identified issues related to conduct the research of this domain (Dierking et al., 2003). With an increase in demand of research on informal science education, NARST decided to take a significant role in fostering and advancing the research into the long-term, cumulative nature of science learning which is strongly socioculturally mediated and occurs across a wide range of physical contexts beyond schooling (Dierking et al, 2003). They aim at a more holistic, large-scale understanding of the entire learning process, both inside and outside of schooling environments. As the initial step, they published articles that address theoretical perspectives and suggestion for research agenda (Anderson, Lukas & Ginns, 2003; Rennie, Feher, Dierking & Falk, 2003) and possibly brings active discussions on exhibit characteristics, family discourse and the impact of prior knowledge (Sandifer, 2003; Ash, 2003; Falk & Adelman, 2003).
Research on Informal Science Education

Goals, Roles and Mission Statements

Goals and Roles of Informal Science Institutions

People visit museums because of their interest in exhibition topics, objects, and the educational experiences that museums provide (Doering, 1999), or to learn in informal and experiential settings (Bickford, 2001). Bickford (2001) also notes that visitors expect to experience complex narratives during their museum visits and they expect museum professionals to facilitate their experiences. Ames (1988) states that education should be a primary goal of museums since visitors are often seeking educational experiences.

Museum professionals see the occasion of a visit as an opportunity to educate the public, to generate interest, or to create a “teachable moment” (Bickford, 2001, p. 275). According to Ames (1989), the education process has three steps: stimulating curiosity; imparting relevant information; and achieving understanding. The Visitor’s Bill of Rights (See Appendix 1) published by Rand (2001) addresses eleven aspects of visitor needs and gives direction as to how informal science activities should be designed and arranged, and how the staff should behave. For example, he states that visitors have a right to enjoy well-designed activities that make sense to them, have fun, be respected for their prior knowledge, ask for assistance for better understanding, and be offered something new and hands-on activities. Beer (1990) describes six characteristics of successful goals that enhance educational functions in informal science settings:

1. Goals provide a foundation for communicating the institution’s major themes and topics, illustrating significant aspects of its subject matter and allow the museum to explain its existence as a major contributor to the community and to the museum profession.

2. Goals provide an outline for preplanned, systematic investigation and collection of facts and artifacts.
3. Goals represent the philosophy of the museum.

4. Goals allow the museum to present various points of view to its subject matter and allow topics to be presented from a variety of perspectives.

5. Goals should be designed to promote agreement and collaboration among the museum’s internal departments.

6. The long-term health of a museum depends on a clear vision of where the museum is going and how it goes there, resulting in supporting strategic planning. Therefore, goals should be sustainable.

   Beer (1990) feels that the lack of agreed-upon and specific goals makes it difficult to determine what, if anything, museums are or should be accomplishing. Well-written goals help informal science educators, from administrators to practitioners, design effective operations.

   Effective operations add to the educational strength of informal science institutions, enhancing their abilities to communicate science through the presentation of concrete, relevant examples (Rix & McSorley, 1999). Hensley (1990) states that museums play the role of “science authority for the public” (p. 124) in order to achieve the goals of informal science education. By taking the role of being an authority, museums become accountable to the public for the content, nature, and quality of their scholarship, exhibits and programs, including finance as well as the acquisition, conservation, and management of collections (Boyd, 1991).

   Present-day justification of science and technology museums rises from the need to satisfy natural curiosity, to be broadly educated, to be amused, and to acquire scientific and technological literacy (Baird, 1986). Children (and perhaps all of us) do not appear to separate learning from enjoyment, implying that seeing something “new,” “different,” or “interesting” is inherently enjoyable, implying educators should design activities to enhance visitor enjoyment (Bierbaum, 1988).
Informal science educators must know and respect various learning styles and curiosity and prepare each activity to attract diverse audiences and promote their learning with the collections and exhibitions (Bickford, 2001). Doing so would follow Hensley (1990), saying that we are committed to fostering visitor experiences that provide opportunities for personal examination and exploration of individual and societal beliefs, perceptions, and attitudes relating to science and technological issues.

Mission Statements

Kotler and Kotler (1998) state that mission is the answer to two questions: What is the purpose of our organization; and What is distinctive in what we do? Well-designed mission statements encourage the institutions to attract people by opening themselves to public participation, scrutiny, accountability, and criticism. Ames (1989) supports this, saying that a mission-oriented exhibit respects the dignity of its objects and speaks at a fairly professional level, assuming its audience is highly motivated. Yang (1989) points out that good mission statements help the public understand the role of the museum in the community.

In developing mission statements, museums must have a strong sense of what their missions are (Ames, 1989) and systematic cooperation of all departments. Hensley (1990) states that planning activities requires making contact and working with a wide variety of individuals from diverse segments of society. To achieve the stated mission requires a firm system, usually where the director of the institution takes a significant role (Boyd, 1995), since the director is authorized to make the institution’s decisions. According to Boyd, the director needs the intellectual vision that will develop collections and push the basic subject matter of the museum in seminal directions; clear public identification of the museum’s educational niche; and enlargement of the financial base.

Marketing relates deeply to the institution’s mission in order to offer more educative and attractive activities to the publics. Fronville (1985) states that museum’s educational activities could
benefit from the tools of marketing analysis, planning, and control as follows: (1) Planning marketing exhibitions to meet community tastes and needs, (2) Conducting market research on the individual museum’s user population to determine demographic information on visitors, response to museum programs and services, desires for future programming or facilities, (3) Coordinating thematic programs with neighborhood museums and local merchants to build attendance or developing exhibition themes, (4) Improving internal communication and planning among the various departments of museum’s staff, as each has an important perspective in planning the successful elements, (5) Offering on-premise services for revenue, such as renting out the museum for receptions and after-hours activities, and (6) Pooling the resources of a few local and small museums to present “packaged funding requests” to corporate sponsors.

Once goals and mission statements are ready, a strategic plan or operations manual can be developed. Yang (1989) proposes the following five essential elements: (1) explanations for all operations should be clear and concise, (2) key individuals must review the manual copy for accuracy and completeness, (3) copies of the manual must be easily accessible to all employees, (4) follow-up procedures, such as user questionnaires and periodic manager meetings to discuss the effectiveness of the manual should be planned, and (5) revision to the manual must be made as needed. In other words, he states, the manual must continually evolve as the museum evolves. Strategic planning comes from a keen analysis of the environment (internal environment, marketing environment, regulatory environment, competitive environment, and macro environment) and internal resources (what kind of collections and resources they have, and what their strength and weakness are) (Kotler & Kotler, 1998) and good goal establishment. The procedures of creating and updating a manual can be a tool for ongoing self-evaluation that helps managers identify how information can be processed more effectively (Yang, 1989).
Visitor Learning

Visitor’s Motivation and Desirable Learning Environment

Museum visitors are diverse, coming to the museum with a variety of knowledge background and interests, expectations, and needs in common. Serrell (1996) states that activities must rely almost exclusively on visitor’s motivations, feeling of satisfying curiosity, gaining confidence for using skills productively, meeting one’s own expectations, and getting positive feedback (Serrell, 1996). Csikszentmihalyi and Hermanson (1995) state that the motivation for science learning in informal settings is self-rewarded regardless of people’s learning styles. According to Csikszentmihalyi and Hermanson, museum learning should rely principally on intrinsic rewards due to its learning nature. Intrinsic motivation makes a person act for the sake of intrinsic rewards when the action is worth doing for them, even in the absence of the external rewards.

Dean (1994) emphasizes the importance of comfort in informal science settings in order to motivate visitors toward learning. According to him, comfort is the state of being at ease in one’s surroundings and with the demands of the environment, and comfortable exhibits are the ones that do not require too high a level of education or extreme effort to grasp (Dean, 1994). He states that comfort and a good learning environment for the visitors are when they raise their own questions without hesitation and show the excitement of knowing and understanding new things. Allen (2004) supports Dean by saying that visitors only engage in a challenge if they are comfortable and oriented. Therefore, Dean goes on to say that comfort is an essential criterion for motivating people to visit museums, and if one feels uncomfortable then exit-oriented behavior or avoidance is probable.

Learning Style and Visitor Behavior

Learning is a conceptual change that occurs in people’s minds (Dierking, Ellenbogen, &
Falk, 2004). In other words, learning is equivalent to “meaning-making” (Falk & Dierking, 2000, p.1) by an individual. Proliferating museum activities in the 1920s attracted the attention of behavioral psychologists, who assessed the learning experiences of museum visitors and examined the relationships between exhibitions and learning. McCarthy (1987, cited from Serrell, 1996, p.52) classified learners in informal science institutions into four types:

1. Imaginative learners learn by listening and sharing ideas and prefer interpretation that encourages social interaction;
2. Analytical learners prefer interpretation that provides facts and sequential ideas;
3. Common-sense learners like to try out theories and discover things for themselves; and
4. Experiential learners learn by imaginative trial and error.

Serrell (1996) notes that all learners use and need many kinds of learning experiences. Falk and Dierking (2000) state that learning is not an abstract experience that takes place in a sterilized environment, rather, it is “an organic, integrated experience that takes place in the real world” (p. 10). In learning processes, people meaningfully connect incoming knowledge to their new knowledge, as Falk (2001) notes that what is learned today depends greatly upon individual motivations and identity, which in turn are determined by what was learned yesterday. Anderson, Lucas, Ginns, and Dierking (2000) see learning as construction of knowledge, deeply related to prior knowledge and ongoing experience. Anderson et al. point out the importance of memory saying that it becomes a basis not only on knowledge construction and understanding on learning in-gallery, but also on subsequent life experiences on continuing the transformation of individual’s knowledge beyond the museum setting.

Learning is contextualized in each individual and it takes time for the visitors to contextualize the learning outcomes (Dierking et al., 2004). Therefore, learning experiences must be designed to be responsive to the needs, aspirations, interests, abilities, casts of mind individual participants
(Beetlestone, Johnson, Quin, & White, 1998). In doing so, the informal science staff must understand the nature of learning and affect of memory holistically and explicitly. Honeyman (1996) supports this idea, saying that informal science staff must also understand the nature of personal learning to effectively help each individual visitor identify the present ideas and modify or extend the ideas, not trying to get the visitors to some predetermined knowledge goal, but of nudging their thinking as far as possible so that they can make better sense of their world. 

Visitors decide their own behaviors based on their prior experiences or knowledge, and choose what and how long to see and take actions according to their curiosity and motivation (Falk et al., 1986). Visitors personalize the museum’s message to conform to their own understandings and experiences (Falk & Dierking, 1992), and a high degree of visitor autonomy is retained throughout the activity. As a result, the nature of the experience and any outcomes are determined as much by the participants as by the designer of the activity (Beetlestone et al., 1998). Furthermore, Falk and Dierking (1992) state that the extent of visitor behavior varies according to their experiences in informal science settings: experienced visitors are able to take in much more of the contents of an activity than are inexperienced visitors because they can chunk the contents in higher-order categories. Therefore, relevance between visitors’ behavior, based on their novelty and knowledge level, and museum attempt, need to be considered when designing activities (Silverman, 1995; Thier & Linn, 1976).

In order to accommodate a variety of learners, informal science staff must take account in the three aspects: personal context, social context and physical context (Falk & Dierking, 1992, 2000, 2002). Since there are strong interrelationships between cognition and affect, cognition and the physical context, and cognition and social context (Falk & Dierking, 1997), the informal science staff must recognize each context and produce a special strategy to maximize the educational potential of their own institution. According to Falk and Dierking (1992, 2000, 2002), personal
context refers to the heart of every visitor’s preconceptions and expectations and takes into account motivation; interest, affect and flow; and the construction of knowledge.

Social context is based upon the notion that knowledge is socioculturally constructed within a community of learners such as family groups, school groups, or other groups. Modeling, which is learning through observation and imitation, is one of the critical factors in learning in the sociocultural context. This context is considered a powerful tool for childhood and adult socialization as well as attitude and emotions. Falk and Dierking (1992) refer to the physical context to as visitor pathways and exhibit and labels, saying that spatial learning influences all types of learning. To them learning appears to be not just “enveloped” with a physical context but rather “situated” within the physical context.

The literature offers two primary suggestions for creating effective learning environments. The first suggestion deals with the depth of science learning and the role of staff. The informal science staff should be effective guides to conduct scientific inquiry, promoting visitor knowledge construction. The second suggestion for effective learning environments calls for breadth in informal science settings. In order to deal with a broad age range of visitors, Falk and Dierking (2002) call for strategies to offer activities to visitors according to their developmental stages. For younger ages, they suggest exploration and discovery and nurturing the autonomy and ownership. Older children respond to nurturing their minds and learning skills in real world contexts, and need help to have meaningful communication with adults. For adolescents, they seek to nurture independence and responsibility, helping them master skills, interests, and sense of self. Young adults need free-time and new experiences to improve them personally and professionally. Middle aged adults can continue learning and achieve personal mastery, while older adults share their vast store of information.
Family Learning

Teaching occurs as a fundamental aspect of interactions of family members in informal science settings (Ellenbogen, Luke, & Dierking, 2004). Parents know their children well and they can offer interpretation of the activities in the most effective way to their children. Since family learning should be co-construction of knowledge by more mature and less mature participants engaged in activity together (Ash, 2003), playing with exhibits with the parents is significant in terms of not only providing information about the exhibits, but by influencing the attitudes of people as they interact with and ultimately learn from the objects and phenomena.

Sandifer (1997) found that families spend more time than nonfamilies in a particular exhibit and in a whole institution in informal science settings. A typical pattern of family visits includes orientation, intensive looking, exhibit cruising, and leave taking (Falk, Martin & Balling, 1978). Lakota (1975, cited from Falk & Dierking, 1992) found that adults tend to select an exhibit to be viewed, and children determine the level of interaction: for families, attracting power determines exhibit preference and holding power did not have significance. Diamond (1979, cited from Falk & Dierking, 1992) found that children were significantly more likely than parents to manipulate exhibits; parents are much more likely to look at graphics and read labels. She also found that novelty and curiosity were more likely to be factors in the behavior of children than in that of adults because adults were often already familiar with many of the stimuli children found novel.

Borun and Dritsas (1997) developed a list of characteristics of a successful exhibit for family learning:

1. Multi-sided: accessible from various angles of an exhibit
2. Multi-user: offers multiple activities and opportunities for cooperation in a family
3. Accessible: physical comfort for children and adults to manipulate the exhibit
4. Multi-outcome: observation and interactions are sufficiently complex to foster group discussion
and brings a range of appeals to different learning styles and levels of knowledge

5. Multi-modal: appeals to different learning styles and levels of knowledge

6. Readable: text is arranged in easily understood segments

7. Relevant: provides cognitive links to visitors’ existing knowledge and experience.

Families are the smallest social components of museum visitors that always include the widest age range and thus the widest knowledge level of any group of visitors. Families also possess a closer human relationship than any other group types. Thus, families have the greatest potential and difficulty to learn together. Therefore, these characteristics must be considered for family visitors to make exhibits easy, pleasant, and rewarding for them.

**Partnerships with Schools**

Students are stimulated by going to a new place, meeting new people, experiencing new approaches to gathering information and encountering real things (Hooper-Greenhill, 1991). Griffin (2004) states that the value of the field trips is that apparently context-specific settings of informal science institutions offer more chances of learning, especially if the settings integrate the school and museum learning and provide effective opportunities for student involvement.

For school kids the museum environment may be a confusing place (Sakofs, 1984) and teachers need to learn about how to use the museum as an informal learning resource (Griffin & Symington, 1997). Learning in informal science settings requires two strategies: the reciprocal commerce of ideas between formal and informal environments, and enhancing the role of teachers during the field trip (Rennes, 1978).

Bybee (2001) emphasizes that classroom science teachers must carefully refer to the *National Science Education Standards (NSES, NRC, 1996)* to facilitate successful school field trips. A critical strength of the *NSES* is that it presents a comprehensive and coordinated set of policies designed to improve science education in K-12 schools as well as how to develop effective partnerships.
between external resources including informal science institutions. However, Bybee (2001) warns that the classroom teachers must understand the assumptions upon which the *NSES* was developed. If the partnerships work well, he continues, the teachers can achieve higher levels of learning outcomes of their students. Hofstein, Bybee, and Legro (1997) agree, saying that in order to link formal and informal science education, the content standards in the *NSES* guide both the teachers in establishing learning outcomes for field trips and the exhibit designer or educator in creating exhibits and programs.

For more effective novelty reduction, teachers have several significant roles to take during the field trip. Ramey-Gassert et al. (1994) point out the two differences between in- and out-of-school learning environments. They say that informal science institutions are: (1) more motivational, engaging, enjoyable and non-threatening; and (2) more hands-on, experimental and personal. It depends on the teacher’s knowledge of informal science environment and the ability to maximally effectively coordinate the informal science environment and what the students learn in the classroom to determine to what extent the teacher can develop exciting and fruitful learning on the student enjoyment.

Rennes (1978) compared the students’ understanding of the program under four conditions: teacher-led inquiry program (label available); written-inquiry program with written feedback from the teacher (label available); written-inquiry program without feedback from the teacher (label available); and label only. In written inquiry, the students followed a written procedure in an inquiry activity. Both teacher-led inquiry and written inquiry included the same procedures. Teachers were allowed to support the student’s learning by asking helpful questions for the students to reach the conclusion and that increased the score of the final criterion test given to them. In this experimental survey, Rennes found that the teacher-led method was the most effective among the four.
The Role of the Staff in Visitor Learning

Museums are rapidly moving toward becoming ever more significant institutions for education and a new generation of science museums represents a paradigm shift from the “objects in glass cases” to an emphasis on involvement, activity, and ideas (Falk, 1999; Pedretti, 2004). For most institutions, real excitement and thrill in science learning is getting a focus of their daily operation as well as being equivocal, contested, and questioned and knowledge of science-in-the-making and of essential for the future citizen (Osborne, Collins, Ratcliffe, Millar, & Duscl, 2003). Therefore, the staff must consider how they can meet a variety of human needs and learn how best to do so (Silverman, 1995) in order to shift to this new focus.

Learning in a science museum does not occur only as a result of interactions between individual visitors and the exhibits. Professionals must be a bridge between the contents and the visitors (Falk and Dierking, 1992). Informal science institutions design displays exhibits and programs in order to convey their own messages. Staff members are responsible for determining topics for the new activities, collecting and interpreting resources, collaborating in the activity design using knowledge in science and education, and implementing and modifying them if needed. This process requires a keen connection by researchers, curators, educators and the administrator. The educators are ultimately responsible for creating opportunities for visitor learning that may arise from the experience of the visit (Heimlich, Diem, & Farrel, 1996). In addition to close study of visitor knowledge level, curiosity and learning styles, Rennes (1978) suggests introducing mentoring systems for deeper visitor learning in informal science institutions. Yet, informal science staff must create engaging, personal experiences for all visitors without creating shallow, mass-market, generic experiences (Roberts, 2001).

Rennie and Williams (2002) also state that informal science institutions provide an array of resources that help people learn not only science but also, more broadly, to develop long-term
relationships with the content, phenomena, and issues of science. To achieve these, a firm educational philosophy and a keen visitor study become a basis to represent the educational philosophy. Homeyman (1996) stresses that identifying the learner’s present ideas and interacting with the learners to help them modify or extend their ideas and make better sense of their world, not trying to get them to some predetermined knowledge goal, but of nudging their thinking as far as possible.

Knowledge about the visitor’s prior knowledge and experience, curiosity, and learning style provides a direct insight of effective activity design. Science centers should present science as a unified whole to be discovered and classified by visitor (Beetlestone et al., 1998). Informal science educators must consider the relationship between staff, activities, and visitor understanding as well as relationships between each activity and science as a whole.

For informal science educators to perform at their maximum educational potentials, they must maintain their creative independence and stay current with their knowledge (Katz & McGinnis, 1999). For example, Rix and McSorley (1999) point out that while the informal science staff think of the term “discover,” they do not specify “discover what,” “discover how” or “discover why.” The answers to these discover questions provide informal science institutions suggestions in making messages to be included in activities. And the messages made through these questions give visitors options of learning behaviors: agreeing with the ideas, disagreeing, using them as building blocks in making conclusions, or making discoveries of their own (Serrell, 1996).

*Exhibits*

*Characteristics of Ideal Exhibits*

Exhibits are environments in which complex interactions occur among visitors, objects, environment and meaning (Hennes, 2002), and, in that sense, exhibits have to be user-centered and reduce cognitive overload (Allen, 2004). Thus, creating exhibits is no longer just a process of
putting specimens on display and having a curator write informal labels (Diamond, 2000). The quality of exhibits determines visitor behavior. Exhibits must help visitors recognize the concepts, construct new understandings and be interactive (Feher, 1990, 1993). Based on the wish that visitors become curious, emotionally stimulated, and gain confidence and competence, Walter (2002) points out six requirements of exhibits:

1. The exhibit should clearly respect the visitor by having many connecting points to their personal lives, does not speak down to them, and clearly is a valuable use of their leisure time;
2. The exhibit should have integrity and solid connections;
3. The exhibit should be warm, friendly, and accessible;
4. The exhibit should work for families and children;
5. The majority of the visitors should be able to articulate the exhibit’s big idea and several of its main messages; and
6. The exhibit should not really be an exhibit at all, rather, it should be a stimulating, multi-dimensional, immersion place where visitors have the opportunity to hear real stories, interact with cool stuff, construct their own knowledge, and be transformed.

In order to make exhibits attractive and educationally effective, collaboration with graphic designers, science educators, and museum staff is important in designing exhibits (Kanel & Tamir, 1991).

**Clear Messages and Concreteness**

Alt and Shaw (1984) conducted an experimental study to investigate a gap between the actual and ideal states of exhibits. A group of 20 visitors rated 45 exhibits in the Natural History Museum in London on the extent to which real exhibits and a supposed ideal exhibit possessed desired characteristics. Visitors preferred exhibits that impart a short clear message and are displayed in a vivid manner. They also found that characteristics of ideal static exhibits are shown as being eye-catching and dramatic, whereas ideal participatory exhibits should be inviting.
MacFarlan (2001) and Nicholson (1991) support the importance of clear messages, saying that the clear messages help visitors comprehend exhibits, and, thus, exhibits need to be arranged carefully and contain attributable, inherent data as well as appropriate labels so that they can convey a message effectively.

While the importance of the clear messages is emphasized, Hennes (2002) and Pyle (1997) mention that exhibits should cover broadly in order to avoid bias. Especially, Pyle says, if a goal of science education is to promote scientific literacy for all, it is important for exhibit developers to include as much information as possible for the audience to make informed decisions on scientific issues. Korn (1995) points out that messages must be presented in several different ways, using a variety of modalities. Visitors are diverse and they bring with them a variety of background, curiosity, expectation and prior knowledge. An exhibit must have various outputs to deal with broad needs of the visitors, but if an exhibit is not focused enough, the exhibit seems ambiguous to the visitors. Therefore, an exhibit with various outputs must still converge into the main idea of the exhibit. In addition, in order to be consistent with institutional goals, exhibits should reflect the collection and research strengths of the institution and be the foundation upon which many public programs are built (MaFadden, 2000).

Concreteness is another “must” (Falk & Dierking, 1992) to be considered in designing an exhibit. Boizvert and Slez (1995) and Peart (1984) state that more concrete exhibits attract and hold more people and promote more knowledge gain for each visitor. Beetlestone et al. (1998) point out that one way that labels become concrete is designing them in the contexts of every day life so that the visitors can make connections easily. They state that an interactive exhibit needs a human scale so that the exhibit can engage by being meaningful to the visitor. Furthermore, the extent of concreteness must be appropriate for the general public who do not have special background of science. When visitors see an exhibit, they have to understand the concepts only from the exhibit.
and the label, with the absence of interpreters.

Csikszentmihalyi and Hermanson (1995) state that exhibits must achieve “mindfulness” (p.37), which E. J. Langer termed as meaning the state of mind that results from drawing novel distinctions, examining information from new perspectives, and being intensive to the context. In other words, mindfulness is differentiating incoming knowledge from the visitor’s prior knowledge and constructing knowledge according to personal circumstances and philosophy. In that sense, too, exhibits that are designed close to the visitor’s everyday life and bring the deeper understanding with concrete messages promote knowledge development of the visitors. Therefore, exhibit design is important so that visitors make tight and broad connections, both in a context that they can operate (Feher, 1993) and between past visits and future events (Sandifer, 1997).

In order to design concrete exhibits that achieve mindfulness, Chermayeff et al. (2001) and Ramberg et al. (2002) point out that exhibit developers have to know how they can help visitors understand things before designing exhibits. For that, Ramberg, Rand, and Timulonis (2002) recommend an inductive approach in which exhibit developers start from mission statements (Why do we want to do this exhibition?), messages (What do we want to communicate?), and audience (Who are we doing this for?), before tackling the strategy (How are we going to do it?).

**Learning Effects of Hands-On Exhibits**

Direct learning from objects, stimulation of curiosity and interest and promotion of sensory awareness occur through interactive, manipulative, or hands-on exhibits (Beer, 1987, 1990; Boizvert & Slez, 1995; Hennes, 2002; Honeyman, 1996; Koran, Jr., Morrison, Lehman, Koran, & Gandara 1984; Pedretti, 2004). Falk et al. (1986) state that informal science education draws heavily on the psychomotor domain with the presence of gadgets and technology that develop skills in manipulating equipment, manual dexterity, and hand-to-eye coordination. Since hands-on learning is often experimental, exploratory, and explanatory (Feher, 1990, 1993), it enhances consideration
of visitors (King, 1984). Self-conducted learning through hands-on activities results in meaningful learning so that the learners can assimilate and apply complex concepts and foster scientific reasoning skills (Hofstein, et al., 1997; MacFarlan, 2001; Thier & Linn, 1976; Wright, 1980). Hennes (2002) believes that by shifting focus from knowledge taxonomies to problem-solving situations, museum could increase their exhibition’s potential for providing engaging educational experiences to visitors.

Alt and Shaw (1984) point out that to be successful hands-on exhibits need to be understood without taking too much time and effort. Therefore, cleanness is needed for hands-on exhibits as well as concreteness, and the initial attraction is an essential ingredient of each exhibit. But, attracting a visitor’s initial attention and motivation are not enough. An effective exhibit calls for deeper learning, moving from just enjoying or manipulating the exhibits to developing personal knowledge. Feher (1990) identifies four stages of visitor learning during the museum visit:

1. Experiencing. At this fundamental stage, the exhibit shows the visitors that certain phenomena occur in nature. Visitor curiosity is cultivated.

2. Exploring. The visitors discover new features of the phenomenon by manipulating the exhibit, integrating and internalizing sensory and perceptual discoveries.

3. Explaining. This conceptual stage deals more directly with cognitive issues and is the one most easily interpretable by educators or researchers.

4. Expanding. The generalization of ideas through the involvement of other related exhibits.

An exhibit by itself cannot carry out the whole conceptual change, but a set of multiple exhibits on a topic is likely to extend or expand the visitor’s worldview. For that, Feher (1993) points out that networks of exhibits are needed that enable visitors to make more and better connections among related concepts, images, and experiencing.
**Effects of Labeling**

Although labels play a significant role in effective exhibits, they are often ignored or skipped by visitors (Beer, 1987; Kanel & Tamir, 1991). Kanel and Tamir (1991) point out that a good label makes the visitor read it and helps make the exhibit understandable and meaningful. The extent of information included in a label is left for the exhibit developer’s decision: some labels can represent the facts and a further question or two; and some other labels can provide the detailed information to deepen the visitor understanding. Ramberg et al. (2002), suggest six requirements for labels: (1) attract the reader’s interest and draw them in; (2) anticipate and answer their questions; (3) use a reader-relevant approach; (4) address the reader directly; (5) write in language that is easy to understand; and (6) use a friendly, conversational tone, active voice, and vivid language.

Resonance among labels, images and exhibits is critical for visitor understanding and curiosity (Serrell, 1996). Labels should also be interpretive (Peart, 1984); in other words, labels should address visitor’s unspoken concerns such as: What is in it for me; Why should I care; and How will knowing this improve my life? (Serrell, 1996).

Labels for interactive exhibits need to be designed so that visitors respond to the exhibits and engage in them better. Serrell (1996) introduced a format for interactive exhibits with four sections, telling visitors “What to do” and “What to notice,” and asking the questions “What’s going on?” and “So what?” She points out that this organization of information “is logical, linear, and systematic, … and provides an easy “off-the-shelf design format” (pp.167).

**Spatial and Visual Effects**

Allen (2004) points out that learning is enhanced in quieter, smaller, and better-differentiated spaces. Koran, Jr., Koran, and Longino (1986) state that visitors are more attracted to and spent a longer period of time at an open and more accessible exhibit. Falk and Dierking (1992, 2000), Peart (1984), and Beer (1987) mention that exhibit type and spatial arrangement determines visitor traffic.
patterns. In a crowd, visitors feel the pressure to move quickly from one exhibit to another to allow other visitors their turn to interact with exhibits (Sandifer, 1997).

Assessment of Educational Operations

Roles and Values of Assessment

There are two major purposes of assessment of educational operations in informal science institutions. One is to study visitors, including the study of visitor behavior, motivation, and discourse among the members in a group. The other is to study the effectiveness of the activities, including the impact of activities on the visitor’s attitudinal reinforcement, learning, the effectiveness of the activities, and the long-term impact of the activities. Each of these components consist of more than a single aspect, thus the assessment usually requires multiple methodologies.

Evaluation is an explicit decision-making tool, and it has an impact on the museum (Korn, 1999; Yalow & Strossen, 1980), when related to mission statements. According to Friedman, changing visitors by helping them to question, to learn, and to be curious are usually demanded by mission statements. For that, the evaluation should be to provide information that decision makers would like to know so they can understand progress and success at a glance (Friedman, 1999; Yalow & Strossen, 1980).

The degree of uncertainty regarding a question, the extent to which it can be answered given enough time, financial resources of the evaluation, and the extent to which answering a particular question are likely to have an effect on the decision-making process (Yalow & Strossen, 1980). Museums are encouraged to endorse the premise that all exhibits should effectively communicate their messages to visitors who attend to them (Shettel, 2001). This requires excellent questions and assessments.

Shettel (2001) points out the five weaknesses of current assessments:

1. Weakness of behavior versus outcomes studies: Too many studies make little or no effort to
directly link visitor behavior in the exhibit area itself to exhibit outcome or impact findings. Looking only at one or two of these elements fails to make a connection with the remaining elements.

2. Behavioral benchmarks: When such measures are associated with arbitrary target values in an effort to define effectiveness, they restrict the potential usefulness of the methodology.

3. Pre- and post-visit testing: Without pre- post- designs it is not possible to determine why visitors gave incorrect answers.

4. Experimental testing: Circumstances of visitors vary, with some in a hurry, some not, some tired, some not. They also choose the exhibits that they want to see. Therefore, when we test casual visitors at the exhibit, we are unavoidably mixing the relative influence of the three- exhibit effectiveness variables—attraction, holding and communicating.

5. Longitudinal studies: They tend to justify the viability and validity of museum in general as important and productive organizations in the community on the basis of what people can say about their earlier museum experiences.

In order to design maximally useful evaluations, cooperation of experienced exhibition designers, scientists, and educators is important by drawing on shared skills, knowledge, and experienced institutions (Friedman, 1993). Evaluation keeps staff concentrating on how museums affect visitors rather than on the myriad of other priorities competing for their time. Also, evaluation keeps staff actively using scientific methodology and values, not just talking about them (Friedman, 1993). Evaluation helps visitors feel that they can have a hand in creating the museum, rather than simply passively viewing the work of scholars (Friedman, 1999). As visitor studies become more accepted and practiced, everyone working in museums will benefit from sharing a common understanding of the terminology and procedures used in these studies (Korn, 1999). Sheppard (2000), reporting at a conference held by the Institute of Museum and Library in 1998, said that (1)
museums and similar organizations must institutionalize evaluation methodologies and work together to develop and share data collection strategies and models for gathering both quantitative and qualitative information; and (2) data collection and evaluation methodology must become an institutionalized professional habit in the day-to-day business of museum management.

Hood (1999) suggests four steps in conducting an assessment: (1) identify the issue, (2) discuss the whole process to make sure what you want to know; how you plan to apply what you will find, (3) outline the entire project: intent of study, methodology, evaluator, data analyses, time people, outside experts and budget, and (4) administer the assessment. She emphasizes the importance of clarifying what you want to know and why during the whole procedure. She also points out that while the assessment planner can frame the questions in research articles to go beyond stereotypical demographic and participation data, the procedure must be followed exactly even if the staff has their own creative ideas to assess the operations in the institution, shortcuts and changes will undermine the ability to achieve worthwhile, substantial results.

The Ad-Hoc Committee of the National Association for Research in Science Teaching (NARST) (Dierking, et al., 2003) listed six goals for such research:

1. Examine the precursors to the actual engagement in learning
2. Take into account the physical settings where learning takes place
3. Explore the social and cultural mediating factors in the learning experience
4. Promote longitudinal research designs that recognize learning is cumulative
5. Investigate the process of learning
6. Expand the variety of methods used to carry out our research.

Dierking et al. (2003) suggest that much more work needs to be done to determine what characteristics of an exhibit best enhances visitor learning and that little work has been done on the conceptual design of interactive exhibits at the level of cognitive engineering.
Methodological issues for research on informal science education abound with little opportunity to measure unexpected or additional learning outcomes and the research findings remain narrow with limited generalizability. Also, early quantitative research was often limited by the statistical methods. Therefore, using a variety of methodologies needs to be considered as one of the goals. As a result, Dierking et al. (2003) calls for enhancing research understanding through multivariate statistical methods and naturalistic approaches such as observation of the subjects, clinical interviews and documenting, to give a detailed, fine-grained picture of leaning.

Assessment and Evaluation Types

Assessment is a measure while evaluation usually involves a judgment, often based on an assessment. These terms are routinely used somewhat interchangeably. This review follows that convention. Currently, three types of assessments or evaluations are widely used in informal settings: front-end, formative, and summative. Front-end evaluation tests concept ideas during the initial planning stages of an exhibit, helping planners understand how visitors comprehend and think about the ideas that will be displayed in the exhibit. Korn (1994) states that the front-end evaluation only works if the planning team has a vested interest in developing an exhibit that is both audience and institutionally driven.

Formative evaluation tests program components during the design stages to isolate problems such as the placement of exhibit components or the content of a label. According to Friedman (1993), formative evaluation is expensive and time-consuming but “the cheapest way to build effective exhibitions” (p.1).

Summative is the most formal evaluation, typically with larger sample size and a variety of instruments, usually at the end of a program or after the installation of an exhibit. Summative evaluation determines the overall effectiveness of the exhibit as well as the effectiveness of individual components. In summative evaluation, visitor behavior and experience in the exhibit are
compared to the exhibit’s goals and objectives; in other words, successes and shortcomings of the activities and general satisfaction of the visitors are assessed.

With both formative and summative assessments or evaluations, the effectiveness of the educational operation in informal science settings can be judged not only by the quality of the data collected, but also on the basis of the evaluation’s impact on the institution. Therefore, evidence of impact is a powerful tool for developing and changing the community and policy environment (Yalow & Strossen, 1980; Sheppard, 2000). In responding to this need, evaluation has shifted toward outcomes asking, “What are you measuring?” “Did you make a difference?” “Have you evoked a change?” (Sheppard, 2000) or “What has changed?” rather than “What have we done?” Many have been especially concerned that museums assert leadership in developing outcomes-based models that measure both qualitative and quantitative impact (Sheppard, 2000).

**Assessment Methods**

Assessment deals with both impact on visitors and effectiveness of operations. The informal science staff usually wish to know the effectiveness in terms of visitor understanding, long-term effect of activities, attitudinal reinforcement, discourse among visitors, and so on. In evaluating, tracking the visitors on a map, recording behavior and discourses, questioning through on-site questionnaires and face-to-face interviews are the current major methodologies (Stevenson, 1991; Korenic, 1991; Falk, 1993). Korenic (1991) investigated the long-term impact of interactive exhibits by tracking a member in a group, questioning all members in a group, sending a written questionnaire afterwards, and interviewing six months later. Comparison of the visitors using treatment and control groups (Falk, 1997; Flexner & Borun, 1984) or pre-post questionnaires (Falk & Adelman, 2003; Adelman, Falk, & James 2000) is often used in order to investigate the effectiveness of activities and the visitor understanding.

In assessing the effectiveness of exhibits, two measures, attracting power and holding power,
are often used (for example, Boizvert & Slez, 1995; Sandifer, 2003; Shettel, 1997; Peart, 1984; Koran et al., 1986). Attracting power shows the number of visitors who stop at the exhibit and holding power is expressed as the average amount of time spent by visitors at the exhibit. These measures are useful in assessment because exhibits have to attract the initial attention of visitors (Nein, 1993), and learning is significantly related to time spent at an exhibit (Sandifer, 1997; Cone, 1978). Since attracting power and holding power do not show the degree of visitor learning, Boizvert and Slez (1995) set another variable, engagement level, to show the visitor interaction with an exhibit. They found out in their research that high interaction, concrete, and complex exhibits have the highest engagement level.

In informal science institutions, a combination of multiple survey methods is usually used instead of an individual method. The survey methods include tracking visitors, unobtrusive observations at specific elements, face-to-face interviews with visitors, and paper and pencil responses to questions (Falk, 1993). Comparison of survey results between treatment and control groups, and between pre- and post-tests are often used as well and analyzed statistically (Falk, 1997; Falk & Adelman, 2003; Flexner & Boran, 1984).

Personal Meaning Mapping (PMM) is a counterpart of visitor studies that focuses on an individual’s learning. PMM is a method to quantifiably measure how an educational experience, such as a museum visit, uniquely affects each individual’s personal conceptual, attitudinal, and emotional understanding (Adelman et al, 2000; Falk, 1997; Falk et al, 1998). It is based on a Relativist-Constructivist approach (Falk, Moussouri, & Coulson, 1998) that starts from an individual’s own ideas and perceptions about a concept or experience. PMM emphasizes providing an individual's vocabulary, the breadth of understanding, and the depth of a person’s understanding since it does not assume that all learners enter with comparable knowledge and experience, nor does it require that an individual produce a "right" answer in order to demonstrate learning. According to
Falk and Dierking (2000), the scoring follows prescribed valid and reliable rubrics for each of the dimensions.

In Alt and Shaw’s research (1984), survey instruments consist of two phases and were developed in a more psychological way. In the first phase, a group of volunteer respondents individually make statements of their understanding and impression to the sample exhibits. After compiling the statements, in the second phase, another group of respondents are selected and assess the same sample exhibits using the statement list compiled in the first phase.

Professional Development of the Informal Science Education Staff

Roles of Informal Science Education Staff

Assistance by museum professionals, both educators and scientists, has a tremendous impact on the museum experiences of the visitors (Bailey & Hein, 2002; Falk & Dierking, 1992; Thier, 1984). Bailey (2002) suggests that both museum educators and scientists in museums should know each other’s cultures; scientists should know the culture of schools and museum education in order to give support museum educators offer scientific concepts effectively, and educators should know science in order to convey the nature of science and scientific methods to their visitors. He also emphasized that museum educators provide a bridge between the two cultures of formal and informal science settings since museum educators have more freedom in implementing programs than do classroom teachers.

Heimlich (1993) and Butterfield (2001) point out that the educator has the responsibility of holistically considering the outcome, the methods, the setting, and the learner’s behavior in constructing learning opportunities. Heimlich (1993) and Heimlich et al. (1996) state that visitors to informal science institutions bring with them their own objectives and a strong willingness to learn, and construction of suitable learning experiences according to their needs and preparation of opportunities for effective learning of diverse visitors are primary roles of informal science
educators. Therefore, staff must have broad knowledge of visitor behavior, needs, curiosity, and learning styles. Bailey (2002) points out that museum educators need to learn vocabulary used by classroom teachers to teach things in the students’ contexts when preparing activities for school groups. Bybee (2001) stresses the importance of the National Science Education Standards (NSES, NRC, 1996), saying that museum practitioners should read, interpret, and use all dimensions of the NSES.

Offering Lessons in Informal Settings

Sachatello-Sawyer et al. (2002) divided museum educators who offer lessons into two types, program planners and instructors, and gave a detailed suggestion on what to do to pursue excellence in museum lessons. For program planners, they provide the following guidelines to make the planner’s task focused:

1. Define the mission, vision, and core values of each lesson, and articulate them to staff, funders, and program participants.
2. Train the instructors so they can articulate the core values, mission and vision.
3. Make sure the instructors have access to teaching collections, exhibits, and key places behind the scenes.
4. Find out what the participants in the community care about and want to know more about.
5. Develop collaborative programs with community members to serve museum program participants.
6. Continually experiment with new programs.
7. Broaden your circle of program advisors and collaborate with new community groups frequently.
8. Strive to create the conditions under which life-changing experiences can take place.

Role of the Staff in Small Museums

According to Mead (1985), in a small museum, “how-to” courses of professional
development for museum staff should take precedence over more intellectual concerns such as museum development, philosophy, or field research methods. While a high degree of museum intellectualism is a desirable attribute of anyone long in the museum field, one might reasonably question its primacy in the initial museum-training curriculum. Therefore, she proposes several needs for proper training of museum personnel:

1. A small-museum employee needs basic, practical training in the care, management of collections, and in presenting materials in pleasing, educationally significant exhibits.
2. The greatest need for trained individuals is in small museums.
3. Regardless of official position, no staff member is exempt from additional duties, and preparatory training should consider a variety of assignments.
4. Museum training should consist of a basic academic education, general museum training, and an internship for practical experience.
5. Universities and museums must work together to provide a total learning experience for the student.

*Role of Docents and Volunteers*

Diamond, St. John, Cleary, and Libero (1987) reported on a docent training program at the Exploratorium in San Francisco, the Explainer Program, initiated in 1969. This Explainer Program teaches high school students to interpret exhibits to visitors. The Explainer’s Program formed a learning community among the docents where they:

1. Cultivated their own interests toward science.
2. Acquired self-confidence from the job.
3. Helped each other with colleague docents enhanced their effectiveness as docents.
4. Learned how to touch, manipulate and visualize phenomena in the exhibits.

The American Association for the Advancement of Science (AAAS) implemented a project
using professional scientists as volunteers in informal science institutions (AAAS, 1983) using 16 institutions and more than 500 scientist-volunteers across the United States. Grinell and Curtin (1990) compiled a report and developed a set of guideline so that the other informal science institutions could introduce the system to their institutions. According to them, the institutions regard scientist-volunteers as (1) teacher/mentor for school children; (2) special event interpreter; (3) regular docent; and (4) behind-the-scene advisor which means members of advisory committees, subject area specialists for exhibit development or educational program design, or lecturers of background material for staff. Grinell and Curtin point out that the key to developing and operating the programs lies in carefully matching volunteer roles to the scientists’ capabilities and interests so that volunteering provides intrinsic rewards.

Functional System for Informal Science Education Staff

Many have offered ideas for professional development; three stand out: (1) enhance communications among departments within an institution (Busque, 1991; Danilov, 1990; Kanel & Tamir, 1991); (2) go beyond the walls of the institution and share information with colleagues of other institutions (Baily & Hein, 2002; Genoways, 1996); and (3) ask external consultants for professional advice (Busque, 1991; Fischer, 2001; Grinell & Curtin, 1990).

A systematic approach involving various departments makes use of the staff in seeking excellence for the institution. Busque (1991) and Danilov (1990) state that museums should coordinate internal departments and engage in internal conversation in their organizations to make operations more educative. Conaway (1978) agrees, saying that research and education are jointly helpful to the working of a museum.

Local, regional, and national conferences (Busque, 1991; Fisher, 2001), allow colleagues to share information about what worked and what did not. Fisher (2001) also discusses the importance of using consultants for the professional development of museum educators. According to him,
consulting can bring a benefit of professional development, and value-added consulting occurs when consultants work hand-in-hand with museum staff members, providing on-the-job professional development opportunities. Consultation provides a direct insight and suggestions to the educational activities of the client institutions, and the suggestions fit the institution’s circumstances. They are not hired to train the staff; rather they provide a wide variety of services ranging from evaluation of visitor behavior to determining the best way to raise money (Fisher, 2001). Working with consultants provides the opportunity for the museum staff to do rather than simply to know.

Standards Scheme- An Example of an Attempt at Change

Museum strategic planning is discussed broadly in Kotler and Kotler (1998) and Danilov (1992). They offered a detailed rationale for the importance of developing guidelines and how to do it. Danilov especially focused on corporate museums that are owned and managed by a company, based on his experience of visiting a number of those facilities all over the world. In 2002, the Museum of New Zealand Te Papa Tongarewa completed a standards scheme (Museum of New Zealand Te Papa Tongarewa, 1999). The New Zealand National Services of the Museum (the National Services) started working on the scheme in 1997, and a total of twenty-four institutions in New Zealand engaged in the regional trial using the scheme by 2002.

The Standard Scheme consists of five components: governance, management and planning; care of collections and Taonga (a treasured thing of Maori); public programs (including exhibitions); customer service; and relationships with communities. The National Services (Museum of New Zealand Te Papa Tongarewa, 1999) define standards in three ways:

1. Performance indicators

2. Benchmarking
   a) internal benchmarking among departments of an institution
b) competitive benchmarking with other institutions

c) functional benchmarking to compare with the best operations in the world, and

d) generic benchmarking to compare universal standards.

3. Standards and regulations

In the process of developing the Standards Scheme based on these definitions, the National Services began with four goals.

1. To establish basic standards for the New Zealand museum sector, together with a means of assessment, as a tool for gauging the organizational health of individual museums,

2. To inform other National Services activities, such as the training programme, to enable museums to meet, maintain and exceed the standards,

3. To raise awareness of good museum practice throughout the sector and provide a range of responses to bicultural expectations, and

4. To provide a focus for strategic planning within individual museums (Museum of New Zealand Te Papa Tongarewa, 1999, p. 13)

They also note that standards should be measurable or describable in sufficient detail to make comparison possible, and regulations should be a document which lays down product, process or service characteristics, including the applicable administrative provisions, with which compliance is mandatory.

Procedures of the Pilot Project

The pilot project was undertaken in 1997 in four phases: (1) Research on museum standards schemes operating overseas such as the United States, United Kingdom, Canada, and Australia; (2) Consultation meetings with museums and external stakeholders; (3) Pilot trial of the concept of a museum standards program using the draft documentation. The documents and process were later evaluated and revised accordingly; and (4) Consideration of issues and options for implementing
the standards (Museum of New Zealand Te Papa Tongarewa, 1999). In addition to the Standards Scheme and related publications, the Museum published a set of resource guides that provide principles for operation of informal institutions on their website. Their focus is on visitor survey, exhibits, collection, security, and marketing. The Scheme has been disseminated throughout New Zealand in order to promote more effective museum management.

**Characteristics of the Standards Scheme**

The New Zealand National Services identified 11 characteristics of the standards:

1. voluntary and inclusive,
2. operated by a sector-based organization, and not through a government agency,
3. contain elements of both self-assessment and external review,
4. provide a choice of routes for attaining the standards,
5. give guidelines on how to reach standards,
6. user-friendly and affordable,
7. sustainable,
8. attainable levels of basic standards. 9. formal recognition of achievement,
9. give formal recognition of achievement,
10. certify compliance with standards for a limited period, and
11. devised and endorsed by the sector. (Museum of New Zealand Te Papa Tongarewa, 1999, p. 27)

In this pilot project, The National Services found the need of the museums “to share a common language and common understanding of the museum sector’s role, functions and constituencies (Museum of New Zealand Te Papa Tongarewa, 1999, pp. 38).” This is one of the most notable outcomes of the pilot project. They point out that fundamentally differing interpretations of questions and guidelines that derives from difference of operation system showed a lack of shared understanding, and the adoption of a formal museum standards program to set basic
standards would greatly assist the development of a common language and communication of key concepts of policy and practice. The pilot project was successful as well in terms of achieving the need to develop professional contacts with other museums and museum workers, and identifying the need for policy manuals.

The Trial of the Standards Scheme

The regional trial was set up by Te Papa National Services in 1998 (Museum of New Zealand Te Papa Tongarewa, 2000) to proceed with the next stage of development. Fourteen institutions from northern and southern parts of New Zealand participated in the regional trial, including a range of museums with a variety of administrative structures, size and focus; both paid and volunteer sectors to be presented in a museum; several museums to include bicultural collections and governing body with Maori; and museums with willingness and capability to commit to a twelve month program. The 14 institutions were divided into two groups; one group having active assistance and the other being largely self-managed.

The trial was evaluated based on diaries completed by participant museums, interviews with key informants in the museums and their community, observation of and participation in briefing and progress workshops with actively assisted museums, observation of and participation in Assessment Sector Reference Group meetings established for the trial, debriefing workshops with the participating museums and peer reviewers, and a survey for participants museums. Based on the feedback, the National Services revised the standards to be more user-friendly by rewording them to fit the conception of the museum staff, separating a standard into two where needed, and filling in the gap between the standards and actual settings. Table 2 summarizes the benefits of the Standard Scheme identified from feedback of participant museums and peer reviewers (Museum of New Zealand Te Papa Tongarewa, 2000).

Several future implications arose from the Standards Scheme trial. Documentation needs to
be edited into more user-friendly format and language. Consultation with key advisors within the sector is needed to refine definitions of a mission statement and best practice for levels within revised format. The revised documentation needs to be released to museums that are interested in using it as a self-review tool. To develop and facilitate common understandings of the museums’ roles, regional networking and peer review for museums using the revised documentation supported by contestable partnership projects with the National Services or other sources is also of necessity (Museum of New Zealand Te Papa Tongarewa, 2000).

Research Methodologies

*Project Synthesis*

An emphasis on improvement of K-12 science education followed the launching of the Russian Sputnik in 1957. During the 22 years following Sputnik, five billion dollars were expended to improve K-12 education in the United States (Harms & Yager, 1981). These efforts were designed to produce superior scientists and engineers, to exemplify the ways scientists do research and to produce well-educated citizens.

In the late 1970s, the US Congress essentially asked, “What was the impact of spending such a large sum on educational improvement?” To answer this question, in 1976 NSF awarded contracts to assemble information that would provide a picture of K-12 science education. An attempt was made to assess the impact of public support for science education during past twenty years: Were the improved courses and the support for teacher education successful and had science education kept pace with science, society, knowledge and schooling? Three major studies were funded.

Helgeson (1977) summarized the published and unpublished literature concerned with science education during the 1957-75 period. The literature surveyed included practices in schools, instructional materials, teacher education, administrative and financial control and needs in K-12 science. Weiss (1978) did a nationwide, deep-stratified, random survey of all science teachers,
administrators, supervisors and other school personnel. Questions addressed curricula, course offerings, teaching methods, enrollments, individualized materials, teaching assignments, support services and demographic information about teaching practices. Stake and Easley (1978) conducted eleven case studies and an in-depth analysis of the reports prepared by extended on-site visits to the schools.

At about the same time, the National Assessment of Educational Progress (NAEP) (1976) was instituted. NAEP assessed science instruction across the United States, and included items that revealed the affective outcomes of science education for nine-, thirteen-, and seventeen-year-olds. In 1981 Harms and Yager led a large national team of science education experts in a two-year effort to synthesize the information found in the three NSF status studies (Helgeson, 1977; Stake & Easley, 1978; Weiss, 1978) and the reports from the NAEP (1976). They called this “Project Synthesis.”

The primary purpose of Project Synthesis was to examine the actual state of science education as it existed then at the precollege level and to make basic recommendations regarding future activities in science education. Harms and Yager, seeing a unique opportunity with the assembling of these talented and expert science educators, developed a secondary goal; they asked their experts to go beyond the present state of affairs to design and describe a desired future state for science education; a prospective synthesis, based on data, expertise, and an image of where trends and future events might take our society and educational practices.

Methodology used for Project Synthesis

In this project, Harms and Yager used a discrepancy model evaluation design. Developed by Provus (1971), the model emphasized the search for discrepancies, a rational basis on which to take adjustments in the program, between the objectives of a program and students’ actual achievement of the objectives. In Project Synthesis, Harms and Yager applied this model to compare and contrast a desired state (objectives) and descriptions of the actual state, and to point the way to the critical
third step, identification of the discrepancies between the two states. Recommendations for future actions are also noted.

While information for defining the current state consisted primarily of the NSF studies and NAEP assessment, the desired state was drawn from a wide variety of writings and reports concerned with current projects, viewpoints and research. In the project, five focus groups were formed; Biology Education, Physical Science Education, Inquiry in School Science, Science Education in the Elementary School, and The Interaction of Science Technology, and Society in Secondary Schools. Each group independently worked in the same framework of four goal clusters, namely, Personal Needs, Societal Issues, Academic Preparation, and Career Education/Awareness (Harms & Kahl, 1981).

Phase I of Project Synthesis set the perspective for the desired states in science education, as the Project Synthesis team developed operational definitions of effective science education, going from the goal clusters to descriptions of the expected conditions if those broad goals were actually being achieved. Phase II determined the actual state of science education by reviewing the science education database, establishing what was known, and suggesting potential educational implications. A major task of Phase III was to ascertain causal factors that appear to perpetuate problems in science education and to consider alternative modes of attack on those problems. Phase III created further recommendations to fill in the discrepancies between desired and actual states identified in Phases I and II.

Project Synthesis includes a general report part that represents a synthesis of the results of the individual reports. It is a general summary of the desired and actual states of science education as well as recommendations derived from them. This methodology enables one to view the data from different perspectives, both in terms of group focus and of different experiences and philosophies of individuals involved, and ultimately achieves a set of general and comprehensive suggestions that
contribute to fill in the gap between the desired and actual states.

Project Synthesis became one of the major reports in science education research not only in the United States but also in many other collaborating countries. This report gave direction to science education for some time, leading to major themes such as Science, Technology and Society (STS), and projects such as Scope, Sequence, and Coordination (SS&C), (NSTA, 1990), and the Search for Excellence in Science Education (SESE) (Penick & Yager, 1983)

Findings from Project Synthesis

Project Synthesis recommended actions for improving science education, including:
1. Determination of new goals for science education,
2. Identification of actual and desired student outcomes,
3. Identification of course offerings, textbook characteristics, classroom practices and testing procedures that might help students achieve desired outcomes,
4. Comparison of the ideal curriculum with the current curriculum, and
5. Deciding on a course of action, such as developing new teacher competencies to deal with changing needs and accepting the responsibility of educational leadership.

Application of Findings and Methodology of Project Synthesis

The ideas of Project Synthesis, its goal clusters, and methodology are all consistent with general ideas of the often expressed goals of informal science education. Kotler and Kotler (1998) state that the challenge for museums is to create a coherent mission that coordinates the conflicting goals (maximize audiences and provide high-quality visual, aesthetic, and learning experiences for those audiences) and identifies goals and activities around which the museum’s values and resources can be effectively organized, communicated, and deployed. Informal education institutions without clear goal statements result in vague learning. Such a challenge might be better met with creation of a desired state, a scheme for looking at, organizing, and planning informal
science education initiatives.

The methodology adopted in Project Synthesis is applicable in informal science education as the discrepancy model enlightens what has been achieved and what needs to be achieved further. The insight into each individual component, both in desired and actual states, gives a micro spectrum of informal science education improvement. Thinking about improvement broadly, captures important, generally accepted goals, bringing a macro spectrum. The combination of both micro and macro spectrums brings practical strategies of improvement that do not ruin the broad goals of informal science education. A direct comparison of components in desired and actual states can bring a clear and concrete strategy to fill the observed discrepancy. As Yager (1981) states, the identification of specific discrepancies provides both a direction and a framework for immediate action, resulting in professional recommendations. This format enables the readers, mainly informal science educators from administrators to program planners and exhibit developers, to clearly figure out where they are, where they are heading, and where they would like to go in order to achieve more effective educational settings.

Use of Surveys as Data Sources

Role of Surveys

Whitney (1972) defines a data source as “a scientific instrument for gathering reliable and valid information for some purpose”(s) (p.1). Surveys are such a source. Surveys include self-administered instruments (Dillman, 2000; Biemer & Lyberg, 2003; Gorard, 2003) that take a form of questionnaire that is completed privately by the respondents. Whitney (1972) points out that surveys yield many separate pieces of information, unlike a test that yields only a total score, in which each item is interpreted as a part of a scale or a group of items. Interviews can satisfy richness of response, the ability to clear up misconceptions, and opportunities to follow up responses. Surveys provide an insight from a wide range of respondents, enabling generalizations
beyond the circumstance investigated.

Survey studies exist in two basic forms, descriptive and analytical (Whitney, 1972). Descriptive studies estimate population facts for certain characteristics or current practices of a given population or in some field. Analytical studies, on the other hand, compare characteristics among multiple populations. Surveys include two types of questions: open- and closed-ended (Whitney, 1972; Converse & Traugott, 1986; Gorard, 2003). Open-ended questions include long essays, short answers, and simple fill-in-the-blank questions, while closed-ended questions consist of checklists, rankings, ratings, multiple-choice questions, and dichotomous questions. Whitney (1972) lists advantages of both types of questions

Open questions:

1. are subject to little influence of the investigator,
2. elicit a wide variety of responses,
3. are useful for introducing subjects or new parts of questionnaires,
4. provide background for interpreting results,
5. give respondents a chance to “have their say,”
6. are more “courteous,”
7. can aid in drafting questions and coding responses (when used in pilot quark), and
8. give “sparkle” and credibility to your final report.

Closed questions:

1. are interpreted more uniformly by respondents,
2. produce easily tabulated responses,
3. are unaffected by the respondent’s verbosity,
4. eliminate some problems of vocabulary and definitions, and
5. allow more questions to be asked. (p.10).
Sources of Survey Error

To many users of survey data, data quality is purely a function of the amount of error in the data (Biemer & Lyberg, 2003). That is, if the data are perfectly accurate, the data are of high quality, and vise versa. The estimate of the data quality, called total survey error, includes components of error that arise solely as a result of drawing a sample rather than conducting a complete census, called sampling error components, and other components that are related to mistakes of the data collection and processing procedures called nonsampling error components. Biemer and Lyberg (2003), Converse and Traugott (1986) and Dillman (2000) point out several sources of nonsampling errors:

1. Specification Error: When the concept implied by the survey question and the concept that should be measured in the survey differ. When it occurs, the wrong parameter is being estimated in the survey and thus inferences based on the estimate may be erroneous.

2. Frame Error: Arises from construction of the sampling frame for the survey. The error occurs when the construction of the sampling frame does not represent the target population.

3. Nonresponse Error: Results from refusal to participate in the entire survey and nonresponse on an item or a unit.

4. Measurement Error: Either respondents, investigator, or the instrument can cause Measurement Error. Respondents may have provided incorrect data deliberately or unintentionally, the investigators may inappropriately influence responses, record the responses incorrectly, or the instrument can have wording that leads the respondents to misunderstandings.

5. Processing Error: Caused by error in data entry, coding, or tabulation.

Converse and Traugott (1986) point out the wording of the questions and the context in which the questions are lodged need to be considered.

Biemer and Lyberg (2003) state that common reasons for nonresponse, especially refusal, are
that the respondents are not motivated, lack time, are approached at the wrong time, or the survey is too difficult, has low priority, has sensitive or even bad questions, and has a short data collection period. To avoid refusal, Biemer and Lyberg (2003) and Dillman (2000) suggest that a survey should be tailored to the needs of the specific sample population. Dillman (2000) calls tailored design “the development of survey procedures of increased rewards and reduced costs for being a respondent, that take into account features of the survey situation, and that have as their goal the overall reduction of survey error” (p.4). He continues saying that some technical requirements must be satisfied: avoiding inconvenience or embarrassment, making the questionnaire short and easy, and minimizing requests to obtain personal information. In addition to these technical requirements, the tailored survey must make the task appear important and interesting so that the respondents regard it as worth completing.

Sampling and data collection methods also need to be considered. Whitney (1972) states that two requirements must be present: (1) each person in the sampling unit must have an equal likelihood of being chosen; and (2) the choice of one subject in no way influences the choice of any other subject. To achieve these, random and stratified samplings are commonly used in descriptive studies. Surveys on the Internet have the potential of reaching large numbers (even entire populations) with effectiveness comparable to self-administered questionnaires (Dillman, 2000; Bethlehem, 1997). Dillman (2000) points out that online surveys also offer the potential for dramatically reducing the close correspondence between sample size and survey costs. Online instruments can be designed with high visibility, promoting high response rates (Dillman, 2000). Using the Internet as a data collection method, some errors are avoidable. For example, by surveying entire populations rather than only a sample, we reduce sampling and frame error. Also, the nature of an online survey provides for responses to be sent directly to the investigator, eliminating processing error.
Reliability and Validity of Surveys

Reliability and validity of the survey instruments must be considered. Reliability is usually defined as the accuracy or consistency with which measurements are taken. Validity, on the other hand, refers to the degree to which an instrument measures what it is supposed to measure. People tend to answer factual questions more accurately (reliably) than opinion items. Whitney (1972) states that one method for estimating the accuracy of responses is to ask the same question or a related question in another part of the questionnaire. If the questions are being coded, having another coder is also effective to demonstrate the reliability. In opinion questions, showing reliability is rather difficult since attitude and opinion items depend on the wording of the respondents. In this case, Whitney (1972) states, the pilot work should play a crucial role in determining groupings of attitude items as well as eliminating unnecessary items. The validity for factual questions depends on both the respondent’s engagement level and the clarity of wording. In this case, cross checking, either for individuals or for the group as a whole, is said to be effective (Whitney, 1972). There is no definite way to gauge the validity of opinion questions. Researchers often use the literature to find research results against which their own results can be checked.
CHAPTER 3 METHODOLOGY

This study examined the educational operations of informal science institutions and the circumstances of visitor understanding and preference toward the operation through two sets of surveys: Survey Set #1 and Survey Set #2.

Survey Set #1 examined the actual state of educational operations of 42 informal science institutions from the perspectives of administrators, exhibit developers, and program planners. Institutions were surveyed about the effectiveness of ongoing operations in terms of goals/roles, contents, assessment, and professional development, as well as the staff’s perceptions of further needs. Within each institution administrators, exhibit developers, and program planners were questioned about daily operations and exhibits.

In Survey Set #2, visitors were surveyed to determine the effectiveness of the main idea of exhibits, activities, label designs, lesson expectations, and daily operations. Together, these visitor surveys provided an indirect measure of exhibit effectiveness.

Survey Set #1 Survey of Informal Science Institutions

Institutional surveys were administered to determine the actual status of operations in informal science institutions and their perceived staff needs in terms of assessment, professional development, partnerships, and adequacy of their operations manuals. Data from this survey provided answers for Research Question 1 and (a) through (f) of Research Question 2.

Instruments

Three web-based instruments were developed: one for administrators, one for exhibit developers, and the other for program planners. A website was created on the North Carolina State University server so that the respondents could access the instruments and fill in the surveys easily. While a web-based survey allows for a larger sample size, can be set up with less cost than a mailed
survey, and makes replying easier, a web-based format tends to have lower response rates than do mailed surveys.

In order to create the on-line survey, the html files were designed with consideration of appearance such as font, font size, coloration of the font, and the background for the convenience of the respondents. Implementation of the on-line survey was announced after checking that the web pages worked properly. After respondents accessed the cover page, they moved to the appropriate page within the site (based on their roles in the institution) to answer the questions.

All instruments included a common core of questions related to (1) their setting of goal and roles; (2) the actual state of assessment and perceived needs; (3) the effectiveness of existing professional development programs, the desired style of professional development sessions, and components to be included in the training; (4) the effectiveness of partnerships and the types of institutions with which they would like to have partnerships; and (5) the use of an operations manual and the necessary components to be included in the manual.

Each targeted group of respondents had some questions unique to that group. Administrators were asked the general goals and roles of the institutions, in addition to the type of their institution. Program planners were asked about the actual and desired states of docent/volunteer training and the use and the needs of resources when developing activities. Exhibit developers were asked about the actual state of exhibits.

The instrument for the administrators had 13 items, the one for the exhibit developers included 15 items, and the one for the program planners included 17 items. All items have 4-21 sub-questions to ask about their operations and further needs. Most of the questions are to be answered on a 5-point Likert scale, and a space for comments is provided at the bottom of each item.

Face validity of the instruments was first provided by a critical review by two informal
science educators, one with long experience in museum programs as well as administration, and the other an expert on exhibits. After the first revision, the instruments were reviewed by three additional experts, none of whom were current museum employees. The final revision reflected all expert commentary and was deemed by the experts to be consistent with the desired views of informal science.

**Data Collection and the Sample**

The population to be sampled included 456 informal science education institutions in the U.S. that are included in MUSEUMSTUFF.COM, a website created by Discovery Media that provides a variety of resources of museums, including a museum directory. The instruments were posted on the NCSU-based website in November, 2004. Adding to the database, in November 2004 the survey was advertised in the listserv of the Association of Science-Technology Centers (ASTC). A cover letter was then sent to each institution through an email, stating the purpose, timing, and organizer of the research and the survey. A second request, also via email, was done three weeks later, and no more requests to participate in the on-line survey were made (see Appendix B). During the posted time, 42 administrators ($\alpha=0.89$), 21 exhibit developers ($\alpha=0.91$), and 36 program planners ($\alpha=0.60$) responded by completing one or more surveys.

The data were analyzed by summary statistics and compared using a Wilcoxon Two-sample test. The comparison demonstrated differences between the actual and desired state in each of administration, exhibits, and programs. The comparison was also done between administration, exhibits, and programs regarding the same questions to examine differences in viewpoints.

**Survey Set #2 Survey of Visitor Understanding**

Four surveys were administered to examine effectiveness of operations in terms of visitor understanding. The surveys examined the effectiveness of the main ideas of exhibits for visitor understanding, of label types, of visitor expectations toward on-site lessons, and effectiveness of the
assessments system for evaluating daily operations. Visitor surveys were all conducted at the North Carolina Museum of Natural Sciences in Raleigh. The largest museum of natural sciences in the southeastern U.S., it focuses on natural features in geology, paleontology, biology, and ecology in North Carolina, from the deep ocean to the mountains. The Museum also has a set of exhibits, called Tropical Connections Hall, that encourages visitors to look outside of North Carolina. Tropical Connections Hall introduces common features such as natural habitats, imported items, and ecological destruction that North Carolina and tropical forests in Central America share. In addition to the general exhibits, the Museum offers a variety of interactive activities in public and interactive areas based on these topics. As a large, public, free museum it draws more than 700,000 visitors each year, providing a large visitor population for sampling.

Survey 1: Effectiveness of Exhibits for Visitor Understanding

The visitor survey provided data to determine how the main idea of an exhibit enhances visitor understanding. Research Question 2-g sought answers to the question, “If visitors are provided the main idea, do they learn better than visitors without the main idea? Although the visitor surveys were done individually, leading to a small sample size (N=68), this technique provided opportunity to meet visitors and better understand their interests and needs.

Tropical Connections Hall was chosen as the interview site. This Hall has clear and very specific messages to visitors, conveying that North Carolina does not exist independently and that we are connected by sharing lots of species and products with the tropics. Tropical Connections Hall is different from other exhibits in the Museum because visitors are invited to look both inside and outside of North Carolina, while many other exhibits in the Museum focus solely on natural features of North Carolina. With a clear message and a different perspective than the rest of the Museum, visitors probably view the exhibits in Tropical Connections in new ways, enhancing the potential for understanding.
Instruments

Two survey instruments were developed (see Appendix C).

Instrument 1: Tropical Connections Hall Questionnaire without the Main Idea

Administered before entering the hall, this instrument asked questions to determine visitors’ prior knowledge about the Hall, the messages they took from their visit to the Hall, and the relationships between North Carolina and the tropical forest. These three questions were arranged on one page for ease and completeness of responding.

Instrument 2: Tropical Connections Hall Questionnaire with the Main Idea

Visitors were presented with a sheet with the main idea on one side and the three survey questions on the other. They were asked to read the main idea before starting the exploration and answer the survey questions after their visit. In this way, potential threats to respondents were reduced by reading the questions before the main idea was made. The questions asked about their prior knowledge of the Hall, their perspectives of the main ideas, the relationships between North Carolina and the tropical forest, and the effectiveness of the main ideas.

The instruments were reviewed by various Museum staff for insights from an internal point of view. In addition, two professional informal science education researchers from outside the Museum reviewed the instruments, providing face validity of the instrument. The main idea used in Instrument 2 was created from descriptions on the official website of the Museum and checked for accuracy by the Museum staff. Each visitor provided age and gender information as a final set of questions.

Data Collection and the Sample

The visitor instruments were administered on two Saturdays, the day of a week when the most diverse range of visitors come to the Museum. Instruments 1 and 2 were handed out on different days so that the visitors surveyed with Instrument 1 could not see the main idea labels. The
collection site, Tropical Connections Hall, consists of an introductory exhibit (a big globe) and a set of the main exhibits. An informal observation of the Hall prior to the survey indicated that some visitors left the Hall after looking at no more than the big globe. Therefore, visitors were surveyed only if they entered the main exhibit. Visitors accompanied by more than three children were not selected. A survey station was set next to Tropical Connections Hall with a box to collect the responses. The person conducting the survey wore a name tag and the official Museum apron for identification. The survey instrument, a pencil with an eraser, and a piece of candy as a reward, were bound on a clipboard.

When visitors entered the Hall, they were approached by the researcher and asked, “Would you mind taking a few minutes to take a survey? We are inquiring about what messages you take from your visit to Tropical Connections Hall. You will be asked three questions. There is no incorrect answer, so please write whatever you felt from the exhibit.” When doing Instrument 2, the same thing was told to the visitors, and respondents were encouraged to read the main idea before answering the questions by saying, “Please read these paragraphs first, which give you the main idea of Tropical Connections Hall, and answer the questions on the back of the sheet.” As soon as one visitor was sampled, the next in the main exhibit was chosen. In this way, data were collected from a sample of 68 persons for each instrument. With both Instruments 1 and 2, the surveys started at 10:00 am and continued until all responses were obtained. On the day of Instrument 1, the survey finished at 2:00 pm, and the day of surveying with Instrument 2 ended at 2:30 pm.

Data Analyses

The scores of the respondents were analyzed by summary statistics and compared in terms of the number of prior visits to the Hall and the nature of their prior knowledge of the Hall. From the prior visit data, respondents were categorized into two groups: first or second visit and more than three visits. From the prior knowledge data, respondents were divided into two groups: no
knowledge or not much and more than some knowledge. Because the sample size was too small to assume a normal distribution, a Wilcoxon Two-sample Test (nonparametric analysis) was used in order to compare the scores.

Survey 2: Effectiveness of Labels

Data for Research Question 2- (h) came from a survey administered to determine effective designs of labels for visitor understanding of an exhibit. A unique exhibit, a *Thescelosaurus* fossil with a clearly visible heart, was chosen as a setting for this survey. This specimen, named “Willo,” had three benefits for an investigation of effective labeling. First, Willo has a clear message that it is the first and only discovery of evidence of a dinosaur heart; therefore it is easy for almost any type of label to convey the main message to visitors. Secondly, while Willo is a part of the Prehistoric North Carolina exhibits, it can also be studied independently because of its special features. Third, the Museum introduces the history of paleontological research on Willo, enabling visitors not only to learn knowledge about Willo but also to gain a broad perspective of paleontology, resulting in deeper understanding.

**Instruments**

Four different label models were developed: Title, Caption, Exploratorium Model, and Modified Exploratorium Model (see Appendix D). The first three labels, Title, Caption, and the Exploratorium Model were designed based on Serrell (1996). Another interactive label, Modified Exploratorium Model label, was developed based on the Exploratorium Model label. Each of these models is described and illustrated below.

*Title*: An interpretive label that identifies the exhibit, the Title label provides the phylogeny, age, location and the collector of the item.

*Caption*: A traditional label in museum settings, Captions are the “frontline” form of interpretive labels because many visitors wander around in exhibits, without attending to the linear or
hierarchical organization of information. Serrell (1996) states the appropriate number of words in a Caption label is 20-150 words; therefore, the length at this level was limited to 147 words in this survey.

*Exploratorium Model:* Based on the interactive label used at the Exploratorium in San Francisco, these labels contain four sections, telling visitors “What to do” and “What to notice,” and asking the questions “What’s going on?” and “So what?” Serrell (1996) points out that this organization of information is logical, linear, and systematic, and is able to include the scientific or technological background, thus “fulfilling the exhibit developer’s desire to present knowledge (Serrell, 1996, p. 166).” This type of label has three problems in attempting to achieve visitor understanding: (1) It is typically not responsive to the different physical layouts, components, and conceptual challenges specific to every individual interactive exhibit; (2) It assumes that visitors do not have any prior knowledge about the topic; thus visitors are told what to do before they are given any reason to perform the action; and (3) The design format (the four sections) dominates the label content and denies the opportunity to emphasize graphically the information it is meant to convey. The lead-in words, “What to do,” are too prominent, according to Serrell (1996).

*Modified Exploratorium Model:* In addition to the three problems of the Exploratorium Model label that Serrell (1996) mentioned, labels in general have two additional problems that prevent visitors from broader and deeper learning. One is that the information included in labels is usually limited to explicit aspects of the exhibit. For example, few labels tell the back-of-the-scene information; usually they just tell what it is and what it is trying to say. Therefore, visitors have little chance to broaden their perspectives. Another problem is that the main idea is hard to convey because visitors usually do not read the label, as Beer (1987), Kanel and Tamir (1991), and Falk and Dierking (1992) point out.

In order to solve all these problems, the Modified Exploratorium Model label was developed
as part of this research. It solves the problems in the following ways:

1. The format of this label is like a book, consisting of four pages, and a question is posted at the bottom of each page. That gives readers freedom, whether they keep reading it without thinking of the answers or try to think about the answers before moving on to the next page.

2. The essential question of the exhibit is shown on the first page and sub questions are arranged at the bottom of each page. The answer of the sub question is on the next page. By the end of all the pages, visitors are able to think of the answer to the essential question. In this way, visitors can learn the content of the exhibit in a systematic way. By asking a series of questions of the visitors, learning is supported.

3. The book format enables the inclusion of more information than the Exploratorium Model since it does not take much space. Therefore, this label is able to include important or behind-the-scene information as well as provide supplementary pictures. This allows visitors to sample broad and deep information about the object.

4. The lead-in words (“What to do”) were left. Visitors usually look at, or even see exhibits without keen attention and do not know what part of the exhibit is important or why. It may not be appropriate to assume that visitors do not have any prior knowledge, but more knowledge may be needed for them to find the essential elements and messages of the exhibit. Therefore, guiding them to the remark(s) by the lead-in words is considered necessary as an initial step of understanding the main idea.

5. The level of prior knowledge is diverse; for example, visitors know about Willo itself, know about paleontology in general, or do not know much about fossils or dinosaurs. The Modified Exploratorium Model label was designed so that it explains the anticipated questions visitors have about Willo and paleontology. The features include the explanation of the low possibility of fossilization of a soft tissue, and the evidence for it to be considered as a heart.
Information about Willo was collected from the Museum’s official website, and used in developing the labels. The accuracy of information included in the labels was double-checked by a Museum staff member who works for the paleontology research department. All labels except the Title label were designed to include the same basic information, but due to the different goals of each label, the information is not exactly the same. Table 2 compares the information included on each label.

A short questionnaire was developed (see Appendix D) to ask the respondents to choose their most “favorite” labels and provide reasons for their choices. The questions were arranged on a half page. A measure of effectiveness of a label depends upon a range of criteria, from whether or not they like it intuitively to how much they learned from the label. Thus, the word “favorite” was used in the question so that the respondents could choose a label without being limited to one sense. The questionnaires were reviewed by two professional, informal science education researchers to ensure the validity of the questions.

Table 2
Comparison of the labels

<table>
<thead>
<tr>
<th></th>
<th>Caption label</th>
<th>Title label</th>
<th>Modified Exploratorium Model label</th>
<th>Exploratorium Model label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific name (Thescelosaurus)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phylogeny</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location where collected</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>This dinosaur would have been herbivore.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Willo is the first discovery of fossilized heart.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal organs are not usually preserved.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location of the heart in the fossil (picture provided).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A 3-D imaging technology was used.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A picture from the 3-D analysis provided in the label.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The structure is like a heart with ventricles and aorta.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart structure of Willo is similar to birds and mammals.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron-stained concretion was found.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some dinosaurs would have had high metabolic rate.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some dinosaurs would have been warm-blooded.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The actual size of Willo was not provided.
** The actual size of Willo was provided.
Data Collection and the Sample

Prehistoric North Carolina exhibits, including Willo, are arranged on both sides of an aisle. The survey was administered on a Saturday when a sufficient number of people can be expected to visit the Museum. A survey station was set up arranging the four labels, Caption, Title, Modified Exploratorium Model, and Exploratorium model, from left to right, and the numbers (#1 through #4) on each label so that the respondents could circle the number of their favorite label. The name of each label was not provided to the respondents in order to avoid preconception. The survey instrument, a pencil with an eraser, and a piece of candy as a reward, were bound on a clipboard. The survey started at 10:30 am continuing through 3:30 pm, until 70 responses were obtained. From informal observation of the visitors walking through the Prehistoric North Carolina section, most visitors kept walking the aisle without making any stops at exhibits. For example, during the first two hours of the survey period (10:30 am- 12:30 pm), 23 groups of visitors (averaging 2.6 persons per group) passed by the survey station and 15 groups out of 23 did not make any stop at Prehistoric North Carolina exhibits. Survey data were obtained from the visitors who did make a stop in front of Willo. The researcher, wearing a name tag and the Museum official apron for identification, approached and asked the visitors,

“Would you mind taking a few minutes to fill in this survey? We are inquiring about the effect of various types of exhibit labels. Here are four types of labels, please circle the number of your favorite label on the sheet and provide the reason of your choice. If you have any prior knowledge about Willo, please briefly describe it as well.”

At most, seven people participated in the survey at a time, primarily because of a lack of clipboards with the instruments. In some cases, people wanted to participate in the survey and waited for the clipboard to become available.

Visitors accompanied by more than three children were not sampled. Although a total of 70 responses were collected, only 68 responses were used since two were judged invalid.
Data Analysis

The data were analyzed by summary statistics, percentage and the number of responses for each type of label. In order to compare the preferences for each label, a Wilcoxon Two-sample Test was used because the sample size was too small to assume a normal distribution.

Survey 3: Visitor Expectation about Museum On-Site Lessons

This survey provided data for Research Question 2- (i), to examine special features of on-site lessons offered by the museum through investigating the expectations of teachers and students, using “Curiosity Class” as an example.

Curiosity Class offers various one-hour long lessons to visiting elementary school groups, and many teachers are routine visitors to Curiosity Class. All of the lessons correlated to the Science Standard Course of Study of the North Carolina Department of Public Instruction. Curiosity Class has two classrooms and a sufficient number of staff members and docents who give lessons and help the instructor, so that up to two groups of students can participate simultaneously in separate classrooms.

A regular problem, due to traffic conditions, is that many school groups do not arrive at the Museum on time. This results in a tight schedule with little time for the program and making filling in a survey difficult. Thus, this survey was mailed to the teachers in advance and completed by both teachers and students prior to their visit.

Instruments

A set of two instruments, one for teachers and another for the students, was developed for this survey. The teacher’s instrument consisted of five Likert-type questions on a 5-point scale and a short-answer question, all on a single page (Appendix E). The multiple-choice items asked about their expectations in terms of hands-on activities, knowledge of the staff, the main idea of the lesson, teaching style, and participating in lessons that are not graded. These choices were developed from
a review of journal articles in informal science education. The teachers provided additional specific expectations in the short answer section (Appendix E).

The student instrument consisted of seven questions on a half page (Appendix E). The items focused on student expectations related to hands-on activities, communication with the staff, participating in a learning atmosphere that is different from classroom science, and learning something new. The multiple choices were selected from common notions about special characteristics of informal science education that were mentioned in journal articles, and validity and appropriateness of the choices and wording in terms of focus toward the research questions and feasibility for fourth graders were carefully checked. All of the instruments were checked for validity by two Museum staff members and three professional researchers on informal science education.

Data Collection and the Sample

Fourth grade groups were selected, since fourth graders are capable of understanding the questions and filling in the survey in a short period of time. In choosing the sample, the teachers who signed up for the “Animal Detectives” class for October and November 2004 were contacted prior to their visit in order to ask if they would participate in the survey (sample letter in Appendix E). Two teachers volunteered and the instruments were mailed to them at school. The teachers and the students completed the surveys in advance and brought them when they came to the Museum. An additional question was submitted to the teachers through mail asking them what they told their students about the lesson before visiting the Museum. School Group A included a teacher and 22 students and School Group B included a teacher and 65 students. Thus, the overall sample size was two teachers and 87 students.

Data Analyses

The scores of the students were analyzed by summary statistics overall and by school groups
and the scores of each school group were compared with a Wilcoxon Two-sample Test (nonparametric), because the sample size was too small to assume a normal distribution. The student scores of each school group were also compared with each teacher. In comparing the results between the students and the teachers, students’ and teacher’s multiple-choice responses were scored (Table 3).

Table 3

Scores of the responses to the survey

<table>
<thead>
<tr>
<th>Answer</th>
<th>3 points</th>
<th>2 points</th>
<th>1 point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>Yes</td>
<td>Maybe</td>
<td>No</td>
</tr>
<tr>
<td>Teachers</td>
<td>Very much</td>
<td>I'm neutral</td>
<td>Not much</td>
</tr>
<tr>
<td></td>
<td>Moderately</td>
<td></td>
<td>Not at all</td>
</tr>
</tbody>
</table>

Survey 4: Assessment of Daily Operations

Data for Research Question 2- (j) were provided by an assessment of daily operations. Daily operations include the jobs, roles, and management of an activity (Discovery Room, in this case). In informal science education this usually refers to any attempts that let visitors see, listen, smell, manipulate, compare, think, and so on in order for them to reach an understanding of scientific concepts and natural phenomena or the displays themselves.

This survey consisted of two parts, an assessment instrument based on perceived staff needs, and another to investigate visitor suggestions for exhibit or activity improvement. An interactive area, the Discovery Room of the North Carolina Museum of Natural Sciences, was chosen as a setting for this survey. A hands-on room primarily for family groups, it has many real specimens and at least several staff or docents in the Room every day. Docents and staff talk with the visitors, answer questions about the exhibits, provide explanations, and suggest other exhibits to visit. Designed for preschool and kindergarteners through second graders, Discovery Room does not have an age limit; instead it prepares a variety of activities that are often suitable for older elementary school students as well. Groups of middle school students and adults often visit the Room to play
with hands-on natural specimens and see the living beehive.

Attendance has large seasonal and daily variation, and usually 30 to 70 people visit each school day, about 170 per day during the summer, and 200 to 300 people each day on the weekends. A number of repeaters can be expected in these numbers. The goals of the Room are to nurture the rich emotions of children through activities that require them to use their senses, to promote intimacy toward nature through real nature objects, and to facilitate interaction within a family. For those goals, the staff and the docents behave as guides, encouraging visitors to take initiative with the activities, as well as answering their questions and supporting the learning experiences of the visitors.

*Development of the Assessment Instrument*

The coordinator of Discovery Room wanted to develop an assessment system to evaluate the daily operation of the Room on a regular basis. Especially, she wanted to know about the effectiveness of activities and what activities need to be improved to promote more visitor interaction. Therefore, clarity of the information collected and feasibility of the instrument were the critical requirements for the assessment. Based on these needs, the instrument was designed to (1) investigate the effectiveness and popularity of activities in the Room in terms of visitor learning and curiosity; (2) determine what visitors perceive they are learning from their experiences; (3) determine the quality of staff interactions; and (4) determine the effectiveness of the exhibit and visitor experience in presenting and developing a positive attitude toward the natural world.

The assessment instrument for Discovery Room was developed as a visitor survey (see Appendix F). The instrument includes three parts: (1) 12 Likert-type questions with a five-point scale, (2) a map on which the respondents indicate their favorite exhibits, and (3) visitor comments. The Likert-type questions are categorized into three groups seeking to learn to what extent: (1) the visitor could learn in the Room, (2) visitors developed intimacy toward nature and a positive
attitude toward learning, and (3) the staff helped them learn. The instrument was revised until the items met the coordinator’s needs. Revision led to an easy format so that the staff could interpret the results, whether or not the items show clear meanings for both the staff and respondents, and whether or not the respondents participate in the survey without too much burden. Appendix F shows the instrument used.

The visitor survey was designed to be short with explicit and easy to answer items. At first, the instrument was designed for a half page, with three-point scale Likert-type items and a space for a short comment. When the first version was developed, it was found that the half size paper was too small to include the necessary questions and the paper size was shifted to be full letter size. After staff review, the number of Likert-type items was reduced from 16 to 12, by omitting ambiguous and complex items. At the same time, the Likert-type items shifted to a five-point scale, with five for strongly agree and one for strongly disagree. A map was provided on the instrument so that visitors could choose their three favorite activities in the Room.

Through the four revisions and meetings with the coordinator, the visitor survey started in July 2004. The evaluation with the visitor survey was done on Friday since the room has a large number of visitors on these days. However, when the Room was so busy that the docents and staff could not manage efficiently or keep safety, the survey was canceled for the day.

Instrument Format

A questionnaire to investigate the use of the results of the visitor survey was developed for the coordinator of Discovery Room. It consisted of four questions, asking goals of this visitor survey, to what extent they survey results are helpful for her, how she will use the survey results to improve the Room, and the satisfaction of individual questions in the visitor survey. The first three questions were short-answer questions, and satisfaction was rated on a 5-point Likert-scale.
Data Collection and the Sample

The Discovery Room survey was administered for 24 Fridays between July 2004 and March 2005 (Table 4). Adults were asked to fill in the survey, because the children visiting the Room are almost always too young to answer the questions. Groups with less than three children were asked to participate in the survey. Five clipboards with a survey instrument, a pencil with an eraser, and an Acroanthosaurus sticker (the Museum’s official sticker) as a reward were prepared on the staff’s desk of the Room.

When visitors came to the entrance door, either a docent or a staff member met them, providing an overview of the Room and the safety rules. For safety, the door opens exclusively from the inside and visitors were advised to use the exit, not the entrance, when leaving the Room. A survey conductor waited until the visitors got familiar with the Room and activities, which usually took 5-10 minutes. Then the conductor asked the adult visitors about the survey, saying “Would you mind taking a few minutes to take a survey if you are not too busy? We are checking the effectiveness of Discovery Room. You can fill it in anytime while being in the Room, but don’t spend so much time concentrating on the survey; enjoy the Room, too.”

Visitors were cooperative, and only six adults declined to participate between July 2004 and March 2005. To control for repeating visitors, the survey conductor asked if they had ever taken the survey before and the decision whether or not to participate in the survey again was left to the visitors. Since this visitor survey was designed to examine the improvement of the daily operations of Discovery Room from time to time, it does not cause any problem if the same person takes the survey multiple times on different days.

The Table below shows the sample sizes on Fridays each month. For December 2004 and January 2005, the sample size was only 9 in total, thus the data for these two months were merged.
Table 4
Sample sizes for the Discovery Room visitor survey

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>July</td>
<td>August</td>
</tr>
<tr>
<td>Responses</td>
<td>84</td>
<td>89</td>
</tr>
<tr>
<td>Survey dates</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Data Analyses

The Likert-type items were analyzed by summary statistics and the overall mean score for each category was calculated and plotted on a compass chart in order to see the balance of the educational operation of the Room. For the map question, the circles that visitors put on their favorite activities were counted for each activity and plotted on a bar graph. The comments were categorized into two groups: general comments and suggestions for improvement.

The questionnaire for the coordinator of Discovery Room was analyzed qualitatively to examine the use of results of the assessment for improvement of the Room.
CHAPTER 4  RESULTS

Chapter 4 provides data from the five surveys. The first section is a report of the on-line survey administered to administrators, exhibit developers, and program planners of informal science institutions seeking information about actual and desired state for informal science education. This report provides a basic overview of the educational operations and the perceived needs of informal science institutions and staff. The second through fifth sections report the results of visitor surveys in terms of the effectiveness of the main ideas in understanding exhibits, visitor preference of labels, visitor expectations of on-site lessons of the informal science institutions, and the overall visitor assessment of daily operations.

A Survey for Informal Science Institutions

Survey of the Actual and Desired State of Informal Science Education

Data and results are organized according to the domains of educational operation of informal science institutions discussed in the research questions 1 and 2-a through f. The first part (description of the operations and the further needs) includes responses to questions about daily operations as reported by administrators, exhibit developers, and program planners in terms of goals/roles, activities, assessments, and professional development. The next part presents pairwise and 3-pairwise comparisons among the groups that examine the perceived effectiveness and further needs of the educational operations, and among administrators, exhibit developers, and planners.

The questions were designed with a 5-point Likert scale, indicating 1 as the most negative or the strongest disagreement through 5 as the most positive or the strongest agreement.

Administrators

Item 1 asked the respondent to identify the type of institution where she or he was employed. The institution sample of 42 included five science centers, two nature centers, a children’s museum,
three science museums, seven natural history museums, three science and technology museums, and 21 other informal science education institutions.

Item 2 asked for goals of the institution, and no special feature was found as a consistent goal of informal science institutions. One option, “introducing the way in which professional scientists do research,” received rather negative responses. Item 3, roles of the institutions, obtained relatively low scores for scientific research and visitor studies research ($\mu=2.54$, and $\mu=2.61$, respectively). This indicates that the institutions do not see scientific or visitor research as significant in their roles.

The results are summarized in Tables 5 and 6.

Table 5
The administrator’s responses for the goals of educational operation

<table>
<thead>
<tr>
<th>Item 2. How well does each of the following statements describe the goals of educational operation? (n=42)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guiding the science learning of visitors</td>
<td>3.73</td>
<td>1.04</td>
</tr>
<tr>
<td>Helping visitors construct scientific knowledge</td>
<td>3.49</td>
<td>1.08</td>
</tr>
<tr>
<td>Providing resources for visitors to learn science</td>
<td>3.88</td>
<td>1.00</td>
</tr>
<tr>
<td>Providing hands-on activities for visitors</td>
<td>3.88</td>
<td>1.25</td>
</tr>
<tr>
<td>Bringing a broad perspective of science to the visitors</td>
<td>3.48</td>
<td>1.14</td>
</tr>
<tr>
<td>Teaching scientific knowledge</td>
<td>3.46</td>
<td>1.12</td>
</tr>
<tr>
<td>Introducing the way in which professional scientists do research</td>
<td>2.98</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Scale: 5: Very well; 4: Well; 3: Neutral; 2: Not much; 1: Not at all

Table 6
The administrator’s responses for the role of the institution

<table>
<thead>
<tr>
<th>Item 3. How well does each of the following statements describe the roles of educational operation? (n=42)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preserving collections</td>
<td>3.24</td>
<td>1.62</td>
</tr>
<tr>
<td>Scientific research</td>
<td>2.53</td>
<td>1.47</td>
</tr>
<tr>
<td>Visitor studies research</td>
<td>2.60</td>
<td>1.05</td>
</tr>
<tr>
<td>Public understanding of science</td>
<td>3.90</td>
<td>1.00</td>
</tr>
<tr>
<td>Partnerships with classroom science</td>
<td>4.07</td>
<td>1.17</td>
</tr>
<tr>
<td>Entertainment</td>
<td>3.32</td>
<td>1.27</td>
</tr>
</tbody>
</table>

Scale: 5: Very well; 4: Well; 3: Neutral; 2: Not much; 1: Not at all

Item 4 asked about the actual state of assessments for daily operations. Visitor curiosity ($\mu=2.89$), visitor understanding of science concepts ($\mu=2.61$) and long-term impact of the effort on visitors ($\mu=2.68$) all received quite low mean scores. Visitor enjoyment ($\mu=3.89$), on the other hand, received a relatively higher mean score than the others. Item 5 shows that the assessment
instruments of the respondent institutions are most frequently short-term and in-house developed.

Item 5 also shows that 16 out of 42 institutions assess individual programs, while only 18 assess the whole institution. Item 6 asked about further needs for assessment. Responses indicate a perceived need for assessing visitor enjoyment ($\mu=4.17$), cost-benefit analysis ($\mu=3.44$), and popularity ($\mu=3.84$), while not as strong a response as for enjoyment, this does indicate that they are more or less concerned with it. Tables 7 and 8 below show the results.

Table 7
*The administrator’s responses for the actual state of assessment*

<table>
<thead>
<tr>
<th>Item 4. To what extent do you assess the following outcomes? (n=42)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitor curiosity</td>
<td>2.88</td>
<td>1.12</td>
</tr>
<tr>
<td>Visitor understanding of science concepts</td>
<td>2.61</td>
<td>1.07</td>
</tr>
<tr>
<td>Long-term impact of your effort on visitors</td>
<td>2.68</td>
<td>1.23</td>
</tr>
<tr>
<td>Visitor enjoyment of their visit</td>
<td>3.88</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Table 8
*The administrator’s responses for the desired state of assessment*

<table>
<thead>
<tr>
<th>Item 6. To what extent do you want to assess the following outcomes? (n=42)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitor curiosity</td>
<td>3.51</td>
<td>0.98</td>
</tr>
<tr>
<td>Visitor understanding</td>
<td>3.56</td>
<td>0.98</td>
</tr>
<tr>
<td>Long-term impact on the visitors</td>
<td>3.27</td>
<td>1.10</td>
</tr>
<tr>
<td>Cost-benefit analysis</td>
<td>3.44</td>
<td>1.16</td>
</tr>
<tr>
<td>Popularity</td>
<td>3.80</td>
<td>1.03</td>
</tr>
<tr>
<td>Visitor enjoyment of their visit</td>
<td>4.17</td>
<td>0.89</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Items 7 and 8 asked for the actual and desired states of professional development of staff (see Tables 9 and 10). The data indicate that the most popular resource for professional development is professional meetings ($\mu=4.10$). Item 8, desired state of professional development scored lower than Item 7, the actual state, indicating the surveyed institutions are either satisfied by the current state or are not looking to the future. Interestingly publishing journal articles is not regarded as a means of professional development ($\mu=3.47$).
Items 9 and 10, which asked about the actual and desired states of partnerships, shows that the administrators wish to have partnerships with K-12 schools ($\mu=4.34$), and they feel they achieve it ($\mu=4.42$). In addition, they desire a close relationship with other divisions within the institution ($\mu=4.12$) (see Tables 11 and 12).

Item 11 provided opportunity for the respondents to indicate their interest in traditional versus...
more formal educational settings (Table 13). The results show three remarkable findings: (1) The respondent administrators feel hands-on activities they offer are successful (µ=4.34); (2) They avoid traditional lectures for on-site classes (µ=1.94, reverse question); and (3) The administrators think that the activities are consistent with the goals of the institution (µ=4.31).

Table 13
Results of other miscellaneous questions asked to the administrators

<table>
<thead>
<tr>
<th>Item 11. Please indicate what you think about the following statements.</th>
<th>n</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>We include take-home messages in our activities.</td>
<td>39</td>
<td>4.05</td>
<td>0.79</td>
</tr>
<tr>
<td>We use techniques to inquire about visitor needs and understanding.</td>
<td>39</td>
<td>3.74</td>
<td>0.88</td>
</tr>
<tr>
<td>Our visitors make use of hands-on instructional aids in the classes.</td>
<td>38</td>
<td>4.34</td>
<td>0.58</td>
</tr>
<tr>
<td>A class period primarily consists of traditional lectures presented by the instructor.</td>
<td>36</td>
<td>1.94</td>
<td>0.83</td>
</tr>
<tr>
<td>Our strategies provide high levels of visitor engagement such as analysis and/or synthesis.</td>
<td>36</td>
<td>3.50</td>
<td>0.91</td>
</tr>
<tr>
<td>We would like to have an operations manual for daily operation.</td>
<td>34</td>
<td>3.50</td>
<td>1.13</td>
</tr>
<tr>
<td>We are able to represent the goals of the institution in our activities.</td>
<td>39</td>
<td>4.31</td>
<td>0.69</td>
</tr>
<tr>
<td>We need professional development sessions on a regular basis to acquire knowledge in science education.</td>
<td>36</td>
<td>3.56</td>
<td>1.05</td>
</tr>
<tr>
<td>We need professional development sessions on a regular basis to acquire knowledge in natural sciences.</td>
<td>37</td>
<td>3.54</td>
<td>0.90</td>
</tr>
<tr>
<td>We need docent or other volunteer training sessions on a regular basis.</td>
<td>37</td>
<td>4.05</td>
<td>1.13</td>
</tr>
<tr>
<td>We need assessment skills so that we can assess the activities by ourselves.</td>
<td>37</td>
<td>4.19</td>
<td>0.62</td>
</tr>
<tr>
<td>The activities in our institution are logically structured.</td>
<td>39</td>
<td>4.13</td>
<td>0.62</td>
</tr>
<tr>
<td>We update the strategic plan as a need arises.</td>
<td>38</td>
<td>3.92</td>
<td>1.00</td>
</tr>
<tr>
<td>We would like to have more partnerships with broader institutions.</td>
<td>40</td>
<td>3.95</td>
<td>0.93</td>
</tr>
<tr>
<td>The assessment instruments we use are effective.</td>
<td>37</td>
<td>3.22</td>
<td>0.82</td>
</tr>
<tr>
<td>We tie the design of assessment instruments to our goals.</td>
<td>34</td>
<td>3.71</td>
<td>0.83</td>
</tr>
<tr>
<td>The assessment outcomes are correlated with the goals and missions of our institution.</td>
<td>36</td>
<td>3.75</td>
<td>0.91</td>
</tr>
<tr>
<td>We revise our instructional strategies to incorporate findings from assessments.</td>
<td>36</td>
<td>3.78</td>
<td>0.87</td>
</tr>
<tr>
<td>We revise assessment strategies to incorporate recent research about how people learn.</td>
<td>37</td>
<td>3.65</td>
<td>0.92</td>
</tr>
<tr>
<td>We do visitor surveys at times to determine their needs about understanding of scientific concepts.</td>
<td>35</td>
<td>3.29</td>
<td>1.07</td>
</tr>
<tr>
<td>We do visitor surveys at times to determine their needs about curiosity and interest in science and nature.</td>
<td>34</td>
<td>3.42</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Scale: 5: Strongly agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly disagree

Item 12 asked about the actual state of an operations manual. Twenty-one respondent institutions out of 42 answered that they did not have an operations manual. The respondents with such a manual answered that the operations manuals typically includes strategic planning (µ=4.15), visitor behavior and understanding (µ=4.14), and partnerships (µ=4.09). Item 13 asked about the need for an operations manual. The mean scores of all options are around 3, providing an
ambiguous answer as to need. This suggests that the administrators’ perceived needs for having an operations manual are low. Tables 14 and 15 show the results.

Table 14
*The administrator’s responses for the actual state of operations manual*

<table>
<thead>
<tr>
<th>Item 12. To what extent have you found the following helpful in your operations manual?</th>
<th>n</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity design</td>
<td>20</td>
<td>3.85</td>
<td>0.88</td>
</tr>
<tr>
<td>Professional development</td>
<td>21</td>
<td>3.86</td>
<td>0.73</td>
</tr>
<tr>
<td>Evaluation</td>
<td>22</td>
<td>3.77</td>
<td>0.68</td>
</tr>
<tr>
<td>Strategic planning</td>
<td>20</td>
<td>4.15</td>
<td>0.67</td>
</tr>
<tr>
<td>Visitor behavior and understanding</td>
<td>22</td>
<td>4.14</td>
<td>0.71</td>
</tr>
<tr>
<td>Partnerships</td>
<td>22</td>
<td>4.09</td>
<td>0.81</td>
</tr>
<tr>
<td>Research and conservation</td>
<td>20</td>
<td>3.90</td>
<td>0.79</td>
</tr>
</tbody>
</table>

Scale: 5: Very helpful; 4: Helpful; 3: Neutral; 2: Not helpful; 1: Not helpful at all; N/A: Not applicable

Table 15
*The administrator’s responses for the desired state of operations manual*

<table>
<thead>
<tr>
<th>Item 13. To what extent would specific revisions and additions to your operations manual help you? (n=42)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity design</td>
<td>2.80</td>
<td>1.50</td>
</tr>
<tr>
<td>Professional development</td>
<td>2.85</td>
<td>1.56</td>
</tr>
<tr>
<td>Evaluation</td>
<td>2.98</td>
<td>1.59</td>
</tr>
<tr>
<td>Strategic planning</td>
<td>3.07</td>
<td>1.56</td>
</tr>
<tr>
<td>Visitor behavior and understanding</td>
<td>3.05</td>
<td>1.53</td>
</tr>
<tr>
<td>Partnerships</td>
<td>3.07</td>
<td>1.56</td>
</tr>
<tr>
<td>Research and conservation</td>
<td>2.76</td>
<td>1.50</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

*Exhibit Developers*

Item 1, goals of exhibit developers, provided high mean scores for all options, indicating that many of them include these options in their goals (see Table 16). The majority of responses favored providing hands-on activities for the visitors ($\mu=4.33$). Providing hands-on activities resulted in the most frequent response. Introducing the ways in which professional scientists do research ranked relatively lower than other options ($\mu=3.48$).
Table 16
The exhibit developer’s responses for the goals of the institution

<table>
<thead>
<tr>
<th>Item 1. How well does each of the following statements describe the goals of exhibit program? (n=21)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guiding the science learning of visitors</td>
<td>4.19</td>
<td>1.17</td>
</tr>
<tr>
<td>Helping visitors construct knowledge</td>
<td>4.00</td>
<td>1.26</td>
</tr>
<tr>
<td>Providing resources for visitors to learn science</td>
<td>4.19</td>
<td>1.17</td>
</tr>
<tr>
<td>Providing hands-on activities for the visitors</td>
<td>4.33</td>
<td>1.28</td>
</tr>
<tr>
<td>Teaching scientific knowledge</td>
<td>4.10</td>
<td>1.22</td>
</tr>
<tr>
<td>Introducing the ways in which professional scientists do research</td>
<td>3.48</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Scale: 5: Very well; 4: Well; 3: Neutral; 2: Not much; 1: Not at all

Items 2 and 4, the actual and desired states of assessment, gave mean scores that indicate their attempts at assessment are not achieved though they wish to assess these areas (see Tables 17 and 18). Concern with long-term impact was among the least emphasized for both actual and desired assessment needs ($\mu=2.00$ for the actual state and $\mu=3.67$ for the desired state). Item 4 does show that exhibit developers feel the need to assess the attracting and holding power of the exhibit ($\mu=4.43$). Item 3, format of assessments, showed that half of the respondents use both of in-house assessment instrument and ones prepared by a third party. Fifteen respondents out of 21 (71.4%) answered that they assess short-term impact of exhibits on their visitors. Nine respondents answered that they are responsible for assessing individual exhibits, and 10 respondents assess individual exhibits as well as the whole institution.

Table 17
The exhibit developer’s responses for the actual state of assessment

<table>
<thead>
<tr>
<th>Item 2. To what extent do you assess the following outcomes? (n=21)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attracting and holding power of the exhibit</td>
<td>3.48</td>
<td>1.12</td>
</tr>
<tr>
<td>Visitor curiosity</td>
<td>3.33</td>
<td>1.02</td>
</tr>
<tr>
<td>Visitor understanding of science concepts</td>
<td>3.43</td>
<td>1.12</td>
</tr>
<tr>
<td>Long-term impact of your efforts on the visitors</td>
<td>2.00</td>
<td>1.04</td>
</tr>
<tr>
<td>Visitor enjoyment of their visit</td>
<td>3.67</td>
<td>1.24</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Table 18
The exhibit developer’s responses for the desired state of assessment

<table>
<thead>
<tr>
<th>Item 4. To what extent do you want to assess the following outcomes? (n=21)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attracting and holding power of the exhibit</td>
<td>4.42</td>
<td>1.03</td>
</tr>
<tr>
<td>Visitor curiosity</td>
<td>4.00</td>
<td>1.26</td>
</tr>
<tr>
<td>Visitor understanding of science concepts</td>
<td>3.95</td>
<td>1.36</td>
</tr>
<tr>
<td>Long-term impact of your effort on the visitors</td>
<td>3.67</td>
<td>1.15</td>
</tr>
<tr>
<td>Visitor enjoyment of their visit</td>
<td>4.43</td>
<td>1.03</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never
Items 5 and 6 asked about the use and need of resources in designing exhibits and. Exhibit developers use ideas from their colleagues ($\mu=4.32$) and the results of internal evaluation ($\mu=4.12$) more than ideas from journal articles in natural science ($\mu=3.63$) or in informal science education ($\mu=3.12$). The desired state was defined by them in the same manner, with mean scores of the desired state favoring using ideas from colleagues being 4.14, in-house evaluation 4.05, journal articles in natural sciences 3.52, and journal articles in informal science education 3.10. Tables 19 and 20 show the results.

Table 19

<table>
<thead>
<tr>
<th>Item 5. To what extent have you found the following resources effective in designing exhibits?</th>
<th>n</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideas from journal articles and/or experts in sciences</td>
<td>19</td>
<td>3.63</td>
<td>0.76</td>
</tr>
<tr>
<td>Ideas from journal articles and/or experts in formal science education</td>
<td>17</td>
<td>3.12</td>
<td>0.70</td>
</tr>
<tr>
<td>Ideas from journal articles and/or experts in informal science education</td>
<td>18</td>
<td>3.67</td>
<td>0.84</td>
</tr>
<tr>
<td>Ideas from colleagues/staff</td>
<td>19</td>
<td>4.32</td>
<td>0.58</td>
</tr>
<tr>
<td>Ideas from professional conferences</td>
<td>18</td>
<td>3.83</td>
<td>0.62</td>
</tr>
<tr>
<td>Ideas from in-house evaluation on programs</td>
<td>17</td>
<td>4.12</td>
<td>0.78</td>
</tr>
<tr>
<td>Ideas from third-party independent evaluation on programs</td>
<td>17</td>
<td>3.71</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Scale: 5: Very effective; 4: Effective; 3: Neutral; 2: Not effective; 1: Not at all effective; N/A: Not applicable

Table 20

<table>
<thead>
<tr>
<th>Item 6. To what extent would you use these resources if they were available? (n=21)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideas from journal articles and/or experts in natural sciences</td>
<td>3.52</td>
<td>1.12</td>
</tr>
<tr>
<td>Ideas from journal articles and/or experts in formal science education</td>
<td>3.10</td>
<td>1.04</td>
</tr>
<tr>
<td>Ideas from journal articles and/or experts in informal science education</td>
<td>3.57</td>
<td>1.16</td>
</tr>
<tr>
<td>Ideas from colleagues/staff</td>
<td>4.14</td>
<td>1.06</td>
</tr>
<tr>
<td>Ideas from professional conferences</td>
<td>3.43</td>
<td>1.25</td>
</tr>
<tr>
<td>Ideas from in-house evaluation on programs</td>
<td>4.05</td>
<td>1.28</td>
</tr>
<tr>
<td>Ideas from third-party independent evaluation on programs</td>
<td>3.67</td>
<td>1.39</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Item 7 asked about how exhibit developers organize informal seminars for professional development within and outside of the institution. Sharing information by publishing journal articles was the least popular method ($\mu=3.21$). Item 8, the desired state of professional development for exhibit developers, received mean scores for all options were around 3, which means they are neutral in their perceived needs for the features represented in each option in
enhancing professional development. In this sense, this item did not clarify their needs. Tables 21 and 22 show the results.

Table 21
The exhibit developer’s responses for the actual state of professional development sessions

<table>
<thead>
<tr>
<th>Item 7. To what extent have you found the following effective for professional development?</th>
<th>n</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informal seminars with staff members within your institution</td>
<td>15</td>
<td>4.20</td>
<td>0.77</td>
</tr>
<tr>
<td>Informal seminars with the staff from other institutions</td>
<td>18</td>
<td>4.00</td>
<td>0.59</td>
</tr>
<tr>
<td>Professional meetings</td>
<td>19</td>
<td>3.84</td>
<td>0.51</td>
</tr>
<tr>
<td>Publishing journal articles</td>
<td>14</td>
<td>3.21</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Scale: 5: Very effective; 4: Effective; 3: Neutral; 2: Not effective; 1: Not at all effective; N/A: Not applicable

Table 22
The exhibit developer’s responses for the desired state of professional development sessions

<table>
<thead>
<tr>
<th>Item 8. To what extent would you use these resources if they were available? (n=21)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informal seminars with staff members within your institution</td>
<td>3.67</td>
<td>1.43</td>
</tr>
<tr>
<td>Informal seminars with the staff from other institutions</td>
<td>3.62</td>
<td>1.24</td>
</tr>
<tr>
<td>Professional meetings</td>
<td>3.62</td>
<td>1.16</td>
</tr>
<tr>
<td>Publishing journal articles</td>
<td>3.00</td>
<td>1.26</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Item 9 showed that the highest mean score of the exhibit developers was for having partnerships with other institutions (μ=4.05). However, in Item 10, the desired state of having partnerships, the perceived needs were found to be for partnerships with other divisions within the same institution (μ=4.05), and with K-12 schools (μ=4.05) rather than with other institutions (μ=3.86). In addition, their needs to have partnerships with universities and industries are relatively low (μ=3.43). See tables 23 and 24 for the results.

Table 23
The exhibit developer’s responses for the actual state of partnerships

<table>
<thead>
<tr>
<th>Item 9. To what extent have you found the following partnerships effective at promoting your goals and missions?</th>
<th>n</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other divisions in your institution</td>
<td>18</td>
<td>3.83</td>
<td>0.71</td>
</tr>
<tr>
<td>K-12 schools</td>
<td>19</td>
<td>3.74</td>
<td>0.81</td>
</tr>
<tr>
<td>University researchers</td>
<td>16</td>
<td>3.63</td>
<td>1.09</td>
</tr>
<tr>
<td>Other informal science institutions</td>
<td>19</td>
<td>4.05</td>
<td>0.52</td>
</tr>
<tr>
<td>Industries (excluding sponsorships)</td>
<td>13</td>
<td>3.62</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Scale: 5: Very effective; 4: Effective; 3: Neutral; 2: Not effective; 1: Not at all effective; N/A: Not applicable
Table 24

*The exhibit developer's responses for the desired state of partnerships*

<table>
<thead>
<tr>
<th>Item 10. To what extent do you want to promote partnerships with? (n=21)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>other divisions in your institution</td>
<td>4.05</td>
<td>1.43</td>
</tr>
<tr>
<td>K-12 schools</td>
<td>4.05</td>
<td>1.20</td>
</tr>
<tr>
<td>university researchers</td>
<td>3.43</td>
<td>1.21</td>
</tr>
<tr>
<td>other informal science institutions</td>
<td>3.86</td>
<td>1.24</td>
</tr>
<tr>
<td>industries (excluding sponsorships)</td>
<td>3.10</td>
<td>1.26</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Item 11, the actual state of professional development, provided low mean scores for all items. The lowest scores for Item 11 indicated that exhibit developers spend the least time on acquiring knowledge in natural sciences ($\mu=2.71$) or science education ($\mu=2.67$) for their professional development. Item 12, the desired state of professional development using the same options, had a mean score for all options higher than the options in Item 11. Mean scores related to acquiring instructional skills and strategies ($\mu=3.90$) and knowledge of exhibit design ($\mu=4.10$) were clearly positive. This indicates that they perceive the need to acquire skills to develop exhibits so that they can convey messages more precisely. Tables 25 and 26 show the results.

Table 25

*The exhibit developer's responses for the actual state of contents in professional development sessions*

<table>
<thead>
<tr>
<th>Item 11. To what extent do you include the following in professional for the permanent staff of your institution? (n=21)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>General knowledge in science education</td>
<td>2.67</td>
<td>1.02</td>
</tr>
<tr>
<td>General knowledge in sciences</td>
<td>2.71</td>
<td>1.10</td>
</tr>
<tr>
<td>Instructional skills and strategies</td>
<td>3.14</td>
<td>1.01</td>
</tr>
<tr>
<td>Communication and interaction skills</td>
<td>3.24</td>
<td>1.22</td>
</tr>
<tr>
<td>Assessment methods</td>
<td>3.00</td>
<td>1.18</td>
</tr>
<tr>
<td>Exhibit design</td>
<td>3.48</td>
<td>1.29</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Table 26

*The exhibit developer's responses for the desired state of contents in professional development sessions*

<table>
<thead>
<tr>
<th>Item 12. To what extent do you want the following aspects in professional development sessions for the permanent staff of your institution? (n=21)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>General knowledge in science education</td>
<td>3.71</td>
<td>1.45</td>
</tr>
<tr>
<td>General knowledge in sciences</td>
<td>3.71</td>
<td>1.35</td>
</tr>
<tr>
<td>Instructional skills and strategies</td>
<td>3.90</td>
<td>1.22</td>
</tr>
<tr>
<td>Communication and interaction skills</td>
<td>3.86</td>
<td>1.46</td>
</tr>
<tr>
<td>Assessment methods</td>
<td>3.81</td>
<td>1.54</td>
</tr>
<tr>
<td>Exhibit design</td>
<td>4.10</td>
<td>1.22</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never
Item 13 (see Table 27) asked miscellaneous questions that were not categorized in the other items. Three of these questions received high mean scores from respondent exhibit developers: (1) The permanent exhibits closely match the goals of the institution ($\mu=4.11$); (2) The visitors make use of hands-on exhibits throughout the visit ($\mu=4.05$); and (3) They would like to have an operations manual for daily operation ($\mu=4.18$).

Table 27

Results of other miscellaneous questions asked to the exhibit developers

<table>
<thead>
<tr>
<th>Item 13. Please indicate what you think about the following statements.</th>
<th>n</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our exhibits are logically structured.</td>
<td>19</td>
<td>3.84</td>
<td>0.76</td>
</tr>
<tr>
<td>The permanent exhibits closely match the goals of our institution.</td>
<td>19</td>
<td>4.11</td>
<td>0.88</td>
</tr>
<tr>
<td>The traveling exhibits closely match the goals of our institution.</td>
<td>17</td>
<td>3.82</td>
<td>0.64</td>
</tr>
<tr>
<td>We update our exhibits at regular intervals.</td>
<td>20</td>
<td>3.45</td>
<td>0.89</td>
</tr>
<tr>
<td>Each individual exhibit has a clear message for the visitors.</td>
<td>20</td>
<td>3.80</td>
<td>1.11</td>
</tr>
<tr>
<td>The whole set of exhibits has a clear message for the visitors.</td>
<td>20</td>
<td>3.60</td>
<td>0.75</td>
</tr>
<tr>
<td>Our exhibits provide high levels of visitor engagement such as analysis and/or synthesis.</td>
<td>20</td>
<td>3.50</td>
<td>0.83</td>
</tr>
<tr>
<td>We emphasize a take-home message in the exhibits.</td>
<td>19</td>
<td>3.68</td>
<td>0.95</td>
</tr>
<tr>
<td>Our visitors make use of hands-on exhibits throughout the visit.</td>
<td>19</td>
<td>4.05</td>
<td>1.10</td>
</tr>
<tr>
<td>We would like to have an operations manual for daily operation.</td>
<td>17</td>
<td>4.18</td>
<td>1.08</td>
</tr>
<tr>
<td>We are able to represent the goals of the institution in our exhibits.</td>
<td>20</td>
<td>4.10</td>
<td>0.69</td>
</tr>
<tr>
<td>We need professional development sessions on a regular basis to acquire skills and viewpoints in designing better exhibits.</td>
<td>19</td>
<td>3.84</td>
<td>0.96</td>
</tr>
<tr>
<td>We need assessment skills so that we can assess the activities by ourselves.</td>
<td>19</td>
<td>3.68</td>
<td>1.00</td>
</tr>
<tr>
<td>The viewpoints in the assessment instruments are correlated with the goals and mission of our institution.</td>
<td>16</td>
<td>3.88</td>
<td>0.72</td>
</tr>
<tr>
<td>We update our exhibits and instructional strategies to incorporate findings from assessments.</td>
<td>19</td>
<td>3.68</td>
<td>0.82</td>
</tr>
<tr>
<td>We update assessment instruments to incorporate recent research about how people learn.</td>
<td>18</td>
<td>3.44</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Scale: 5: Strongly agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly disagree

Item 14 asked about the use of an operations manual. Fourteen respondents out of 21 answered that they do not have an operations manual. The seven respondents who did have a manual indicated that evaluation, strategic planning, and visitor behavior and understanding are the most important. Item 15, the need for an operations manual, had mean scores for all options below the 3-point level, indicating a neutral position. None of the options, including exhibit design, professional development, evaluation, strategic planning, visitor behavior and understanding or partnerships had high scores as needed aspects of a manual. These results are not consistent with the
result of the question asked about the operations manual in Item 3. This inconsistency indicates that the respondent exhibit developers do not need any of the components asked in Item 15. Further research is needed to investigate what components they need in the operations manual. See Tables 28 and 29 for the results.

Table 28
The exhibit developer’s response for the actual state of operations manual

<table>
<thead>
<tr>
<th>Item 14. To what extent have you found the following helpful in your operations manual?</th>
<th>n</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhibit design</td>
<td>7</td>
<td>3.57</td>
<td>1.27</td>
</tr>
<tr>
<td>Professional development</td>
<td>6</td>
<td>3.83</td>
<td>0.41</td>
</tr>
<tr>
<td>Evaluation</td>
<td>6</td>
<td>4.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Strategic planning</td>
<td>7</td>
<td>4.14</td>
<td>3.78</td>
</tr>
<tr>
<td>Visitor behavior and understanding</td>
<td>6</td>
<td>4.17</td>
<td>0.41</td>
</tr>
<tr>
<td>Partnerships</td>
<td>7</td>
<td>3.71</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Scale: 5: Very helpful; 4: Helpful; 3: Neutral; 2: Not helpful; 1: Not helpful at all; N/A: Not applicable

Table 29
The exhibit developer’s response for the desired state of operations manual

<table>
<thead>
<tr>
<th>Item 15. To what extent would specific revisions and additions to your operations manual help you? (n=21)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhibit design</td>
<td>2.67</td>
<td>1.62</td>
</tr>
<tr>
<td>Professional development</td>
<td>2.71</td>
<td>1.68</td>
</tr>
<tr>
<td>Evaluation</td>
<td>2.76</td>
<td>1.67</td>
</tr>
<tr>
<td>Strategic planning</td>
<td>2.90</td>
<td>1.77</td>
</tr>
<tr>
<td>Visitor behavior and understanding</td>
<td>2.95</td>
<td>1.80</td>
</tr>
<tr>
<td>Partnerships</td>
<td>2.67</td>
<td>1.68</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Program Planners

Item 1, the goal of educational programs, received high mean scores in providing resources for visitors to learn science (µ=4.54) and hands-on activities for the visitors (µ=4.60). Introducing the ways in which professional scientists do research, on the other hand, was not emphasized as a goal (µ=3.03). See Table 30 for the results.
Item 2, the actual state of assessment, found visitor enjoyment to be the most frequent answer ($\mu=4.00$). Meanwhile, visitor understanding of science concepts ($\mu=2.83$) and long-term impact of programs ($\mu=2.37$) were not emphasized. Item 4, the desired state of assessment, showed very positive responses. This suggests that program planners wish to have assessment instruments although they perhaps do not have suitable ones yet. A fact revealed in item 2 that they do not assess visitor understanding of science concepts or long-term impact of the activities on the visitors provides a further issue relating to the results in Item 1, asking about goals of their operation. Although they include enhancing visitor experience and learning in their goals, they do not have assessment tools to know the extent of effectiveness of the operation, and thus they feel a further necessity for assessment systems.

Item 3 asked about the format of assessment. Twenty-seven respondents out of 36 noted that they prepare assessment instruments by themselves. Eight respondents indicated that some or all of the instruments they use are prepared by the external agency. One respondent answered that he or she uses a locally developed assessment instrument as a form of a trading post where children bring in objects, earning points for their knowledge and object. Then they use the points to trade for interesting items. Twenty-six respondents assessed the short-term impact of programs, and 10 respondents used either longitudinal assessment or a combination of short and long term. Twenty-four respondents only assessed individual programs, as opposed to the overall institution.

Table 30

The program planner’s responses for the goals of the institution

<table>
<thead>
<tr>
<th>Item 1. How well does each of the following statements describe the goals of your educational programs? (n=35)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guiding the science learning of visitors</td>
<td>4.09</td>
<td>0.95</td>
</tr>
<tr>
<td>Helping visitors construct scientific knowledge</td>
<td>4.29</td>
<td>0.71</td>
</tr>
<tr>
<td>Providing resources for visitors to learn science</td>
<td>4.54</td>
<td>0.74</td>
</tr>
<tr>
<td>Providing hands-on activities for the visitors</td>
<td>4.60</td>
<td>0.82</td>
</tr>
<tr>
<td>Teaching scientific knowledge</td>
<td>3.86</td>
<td>0.81</td>
</tr>
<tr>
<td>Introducing the ways in which professional scientists do research</td>
<td>3.03</td>
<td>1.10</td>
</tr>
</tbody>
</table>

Scale: 5: Very well; 4: Well; 3: Neutral; 2: Not much; 1: Not at all
Tables 31 and 32 show the results.

Table 31  
*The program planner’s responses for the actual state of assessment*

<table>
<thead>
<tr>
<th>Item 2. To what extent do you assess the following outcomes? (n=35)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitor curiosity</td>
<td>3.31</td>
<td>1.08</td>
</tr>
<tr>
<td>Visitor understanding of science concepts</td>
<td>2.82</td>
<td>0.95</td>
</tr>
<tr>
<td>Long-term impact of your efforts on the visitors</td>
<td>2.37</td>
<td>1.06</td>
</tr>
<tr>
<td>Visitor enjoyment of their visit</td>
<td>4.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Table 32  
*The program planner’s responses for the desired state of assessment*

<table>
<thead>
<tr>
<th>Item 4. To what extent do you want to assess the following outcomes? (n=35)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitor curiosity</td>
<td>3.91</td>
<td>0.95</td>
</tr>
<tr>
<td>Visitor understanding of science concepts</td>
<td>3.80</td>
<td>0.87</td>
</tr>
<tr>
<td>Long-term impact of your effort on the visitors</td>
<td>3.80</td>
<td>1.05</td>
</tr>
<tr>
<td>Visitor enjoyment of their visit</td>
<td>4.49</td>
<td>0.66</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Item 5, the resources used in planning programs, indicated use of ideas from colleagues (μ=4.76) as having the highest score. Ideas from journal articles and experts in informal science education scored high (μ=4.20), with ideas from professional conferences (μ=4.12), and ideas from the assessment results (μ=4.00) showing scores in the same range. Item 6, asking about the desired state, had similar results. Tables 33 and 34 show the results.

Table 33  
*The program planner’s responses for the actual state of the use of resources in activity design*

<table>
<thead>
<tr>
<th>Item 5. To what extent have you found the following effective to plan activities?</th>
<th>n</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideas from journal articles and/or experts in sciences</td>
<td>31</td>
<td>3.41</td>
<td>0.89</td>
</tr>
<tr>
<td>Ideas from journal articles and/or experts in formal science education</td>
<td>34</td>
<td>3.47</td>
<td>0.79</td>
</tr>
<tr>
<td>Ideas from journal articles and/or experts in informal science education</td>
<td>35</td>
<td>4.20</td>
<td>0.53</td>
</tr>
<tr>
<td>Ideas from colleagues/staff</td>
<td>34</td>
<td>4.76</td>
<td>0.43</td>
</tr>
<tr>
<td>Ideas from professional conferences</td>
<td>34</td>
<td>4.12</td>
<td>0.77</td>
</tr>
<tr>
<td>Ideas from in-house evaluation on programs</td>
<td>33</td>
<td>4.00</td>
<td>0.90</td>
</tr>
<tr>
<td>Ideas from third-party independent evaluation on programs</td>
<td>21</td>
<td>3.57</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Scale: 5: Very effective; 4: Effective; 3: Neutral; 2: Not effective; 1: Not at all effective; N/A: Not applicable
Table 34
The program planner’s responses for the desired state of the use of resources in activity design

<table>
<thead>
<tr>
<th>Item 6. To what extent would you use these resources if they were available? (n=35)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideas from journal articles and/or experts in sciences</td>
<td>3.31</td>
<td>0.83</td>
</tr>
<tr>
<td>Ideas from journal articles and/or experts in formal science education</td>
<td>3.37</td>
<td>0.77</td>
</tr>
<tr>
<td>Ideas from journal articles and/or experts in informal science education</td>
<td>3.89</td>
<td>0.76</td>
</tr>
<tr>
<td>Ideas from colleagues/staff</td>
<td>4.34</td>
<td>0.73</td>
</tr>
<tr>
<td>Ideas from professional conferences</td>
<td>3.97</td>
<td>0.71</td>
</tr>
<tr>
<td>Ideas from in-house evaluation on programs</td>
<td>3.94</td>
<td>1.08</td>
</tr>
<tr>
<td>Ideas from third-party independent evaluation on programs</td>
<td>3.51</td>
<td>1.12</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Items 7 and 8 asked about the actual and desired states of professional development see Tables 35 and 36 for the results). The mean score of organizing informal seminars with the staff from other institutions ($\mu=4.32$) scored the highest, with informal seminars within the institution ($\mu=3.93$) and presenting at a professional conference ($\mu=3.97$) obtaining high mean scores as well. Interestingly, publishing journal articles scored higher in the actual state ($\mu=3.39$) than in the desired part of professional development ($\mu=2.94$).

Table 35
The program planner’s responses for the actual state of professional development sessions

<table>
<thead>
<tr>
<th>Item 7. To what extent have you found the following effective for professional development?</th>
<th>n</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informal seminars with staff members within your institution</td>
<td>30</td>
<td>3.93</td>
<td>0.87</td>
</tr>
<tr>
<td>Informal seminars with the staff from other institutions</td>
<td>28</td>
<td>4.32</td>
<td>0.61</td>
</tr>
<tr>
<td>Presenting at a professional meeting</td>
<td>30</td>
<td>3.97</td>
<td>0.72</td>
</tr>
<tr>
<td>Publishing journal articles</td>
<td>18</td>
<td>3.39</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Scale: 5: Very effective; 4: Effective; 3: Neutral; 2: Not effective; 1: Not at all effective; N/A: Not applicable

Table 36
The program planner’s responses for the desired state of professional development sessions

<table>
<thead>
<tr>
<th>Item 8. To what extent would you use these resources if they were available? (n=35)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informal seminars with staff members within your institution</td>
<td>3.89</td>
<td>0.72</td>
</tr>
<tr>
<td>Informal seminars with the staff from other institutions</td>
<td>3.94</td>
<td>0.68</td>
</tr>
<tr>
<td>Presenting at a professional meeting</td>
<td>3.51</td>
<td>0.82</td>
</tr>
<tr>
<td>Publishing journal articles</td>
<td>2.94</td>
<td>1.14</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Item 9 asked what actual state of partnerships the respondent program planners currently have. Partnerships with K-12 schools ($\mu=4.26$) and the other informal science institutions ($\mu=4.10$) were the most frequent responses. In Item 10, the desired state of partnerships, program planners
indicated they would like to have more partnerships with the other divisions within the institution ($\mu=4.23$), as well as closer partnerships with K-12 schools ($\mu=4.54$). Clearly, schools and peer institutions are an important part of these actual and desired operations. Tables 37 and 38 show the results.

Table 37

The program planner’s responses for the actual state of partnerships

<table>
<thead>
<tr>
<th>Item 9. To what extent have you found the following partnerships effective at promoting your goals and missions?</th>
<th>n</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other divisions in your institution</td>
<td>32</td>
<td>3.97</td>
<td>0.82</td>
</tr>
<tr>
<td>K-12 schools</td>
<td>34</td>
<td>4.26</td>
<td>0.57</td>
</tr>
<tr>
<td>University researchers</td>
<td>26</td>
<td>3.54</td>
<td>0.90</td>
</tr>
<tr>
<td>Other informal science institutions</td>
<td>33</td>
<td>4.09</td>
<td>0.77</td>
</tr>
<tr>
<td>Industries (excluding sponsorships)</td>
<td>28</td>
<td>3.14</td>
<td>0.97</td>
</tr>
</tbody>
</table>

Scale: 5: Very effective; 4: Effective; 3: Neutral; 2: Not effective; 1: Not at all effective; N/A: Not applicable

Table 38

The program planner’s responses for the desired state of partnerships

<table>
<thead>
<tr>
<th>Item 10. To what extent do you want to promote partnerships with? (n=35)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other divisions in your institution</td>
<td>4.23</td>
<td>1.06</td>
</tr>
<tr>
<td>K-12 schools</td>
<td>4.54</td>
<td>0.56</td>
</tr>
<tr>
<td>University researchers</td>
<td>3.74</td>
<td>1.04</td>
</tr>
<tr>
<td>Other informal science institutions</td>
<td>4.14</td>
<td>0.88</td>
</tr>
<tr>
<td>Industries (excluding sponsorships)</td>
<td>3.26</td>
<td>1.22</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Items 11 and 12 (Tables 39 and 40) asked the actual and desired states of professional development, respectively. The mean scores of Item 11 were around 3. This indicates that the respondent institutions do not see these aspects as important features of the actual state of professional development. Professional development in assessment methods ($\mu=2.49$) scored lowest in this area of actual professional development. The desired state of professional development was seen to be an inclusion of communication and interaction skills ($\mu=4.03$). Assessment methods, while receiving a higher rating ($\mu=3.51$) than in the actual state, still were not emphasized as a need for professional development.
Table 39
The program planner’s responses for the actual state of contents in professional development sessions

<table>
<thead>
<tr>
<th>Item 11. To what extent do you include the following in professional for the permanent staff of your institution? (n=35)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>General knowledge in science education</td>
<td>2.97</td>
<td>1.38</td>
</tr>
<tr>
<td>General knowledge in natural sciences</td>
<td>2.97</td>
<td>1.29</td>
</tr>
<tr>
<td>Instructional skills and strategies</td>
<td>3.37</td>
<td>1.21</td>
</tr>
<tr>
<td>Communication and interaction skills</td>
<td>3.54</td>
<td>1.27</td>
</tr>
<tr>
<td>Assessment methods</td>
<td>2.49</td>
<td>0.98</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Table 40
The program planner’s responses for the desired state of contents in professional development

<table>
<thead>
<tr>
<th>Item 12. To what extent do you want the following aspects in professional sessions for the permanent staff of your institution? (n=35)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>General knowledge in science education</td>
<td>3.74</td>
<td>1.07</td>
</tr>
<tr>
<td>General knowledge in sciences</td>
<td>3.54</td>
<td>1.22</td>
</tr>
<tr>
<td>Instructional skills and strategies</td>
<td>3.94</td>
<td>0.97</td>
</tr>
<tr>
<td>Communication and interaction skills</td>
<td>4.03</td>
<td>0.98</td>
</tr>
<tr>
<td>Assessment methods</td>
<td>3.51</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Items 13 and 14 (Tables 41 and 42), the actual and desired states of docent training sessions, revealed instructional skills and strategies (µ=4.14) and communication and interaction skills (µ=4.20) as the most emphasized features for both states. In Item 14 the mean scores of all options featuring docent training sessions were marked high. This suggests that they see needs for all features for their docent training sessions, perhaps because they do not achieve all features, as represented by the low mean scores reported for Item 13.

Table 41
The program planner’s responses for the actual state of contents in docent training sessions

<table>
<thead>
<tr>
<th>Item 13. To what extent do you emphasize the following in docent or other training sessions? (n=35)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>General knowledge in science education</td>
<td>3.60</td>
<td>1.03</td>
</tr>
<tr>
<td>General knowledge in sciences</td>
<td>3.74</td>
<td>1.09</td>
</tr>
<tr>
<td>Instructional skills and strategies</td>
<td>4.14</td>
<td>1.11</td>
</tr>
<tr>
<td>Communication and interaction skills</td>
<td>4.20</td>
<td>1.16</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Table 42
The program planner’s responses for the desired state of contents in docent training sessions

<table>
<thead>
<tr>
<th>Item 14. To what extent do you want the following in docent or other training sessions? (n=35)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>General knowledge in science education</td>
<td>3.89</td>
<td>0.99</td>
</tr>
<tr>
<td>General knowledge in sciences</td>
<td>3.97</td>
<td>1.01</td>
</tr>
<tr>
<td>Instructional skills and strategies</td>
<td>4.43</td>
<td>1.04</td>
</tr>
<tr>
<td>Communication and interaction skills</td>
<td>4.43</td>
<td>1.07</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never
Item 15 included miscellaneous questioned that could not be categorized in any other items (Table 43). Several questions indicated positive operations of the respondents’ institutions.

1. The respondent program planners incorporate a variety of teaching strategies in the classes ($\mu=4.56$),

2. They emphasize a take-home message in the activities ($\mu=4.24$),

3. Their visitors make use of hands-on instructional aids in the classes ($\mu=4.52$),

4. They do not design classes based on traditional lectures ($\mu=1.75$, reverse question),

5. They are successful at representing goals of the institution in the programs ($\mu=4.38$),

6. They feel a necessity to hold docent training sessions on a regular basis ($\mu=4.03$), and

7. They update program and instructional strategies as the need arises from assessment findings ($\mu=4.00$).

Table 43

<table>
<thead>
<tr>
<th>Item 15. Please indicate what you think about the following statements.</th>
<th>n</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>We incorporate a variety of teaching strategies in our classes.</td>
<td>34</td>
<td>4.56</td>
<td>0.50</td>
</tr>
<tr>
<td>We emphasize a take-home message in the activities.</td>
<td>34</td>
<td>4.24</td>
<td>0.65</td>
</tr>
<tr>
<td>We inquire about the prior knowledge of visitors before a new topic or program is presented.</td>
<td>33</td>
<td>3.91</td>
<td>1.07</td>
</tr>
<tr>
<td>Our visitors make use of hands-on instructional aids in the classes.</td>
<td>33</td>
<td>4.52</td>
<td>0.94</td>
</tr>
<tr>
<td>A class period primarily consists of traditional lectures presented by the instructor.</td>
<td>32</td>
<td>1.75</td>
<td>0.88</td>
</tr>
<tr>
<td>Our teaching strategies provide higher levels of visitor engagement such as analysis and/or synthesis.</td>
<td>33</td>
<td>3.91</td>
<td>0.84</td>
</tr>
<tr>
<td>We would like to have an operations manual for daily operation.</td>
<td>31</td>
<td>3.77</td>
<td>0.99</td>
</tr>
<tr>
<td>We are able to represent the goals of the institution in our programs.</td>
<td>34</td>
<td>4.38</td>
<td>0.74</td>
</tr>
<tr>
<td>We need professional development sessions on a regular basis to acquire knowledge in science education.</td>
<td>33</td>
<td>3.88</td>
<td>1.05</td>
</tr>
<tr>
<td>We need professional development sessions on a regular basis to acquire knowledge in natural sciences.</td>
<td>33</td>
<td>3.61</td>
<td>1.11</td>
</tr>
<tr>
<td>We need docent training sessions on a regular basis.</td>
<td>31</td>
<td>4.03</td>
<td>0.98</td>
</tr>
<tr>
<td>We need assessment skills so that we can assess the activities by ourselves.</td>
<td>34</td>
<td>3.74</td>
<td>0.86</td>
</tr>
<tr>
<td>The outcomes in the assessment instruments are correlated with the goals and mission of our institution.</td>
<td>32</td>
<td>3.91</td>
<td>0.89</td>
</tr>
<tr>
<td>We update our program and instructional strategies to incorporate findings from assessments.</td>
<td>34</td>
<td>4.00</td>
<td>0.92</td>
</tr>
<tr>
<td>We update assessment instruments to incorporate recent research about how people learn.</td>
<td>30</td>
<td>3.67</td>
<td>0.89</td>
</tr>
</tbody>
</table>

Scale: 5: Strongly agree; 4: Agree; 3: Neutral; 2: Disagree; 1: Strongly disagree
Items 16 and 17 focused on the actual and desired states of an operations manual (Tables 44 and 45). Twenty respondents out of 36 answered that they have an operations manual. A few respondents who answered that they have one remarked that their operations manual consists of more general features such as the mission, policies, and procedures, and does not include the features represented in the options in Item 16. None of the mean scores indicated current use of an operations manual. For the desired state, the mean scores of all options showed either neutral or negative results. This means that the respondents do not feel the necessity to have an operations manual for their educational operations.

Table 44
The program planner’s responses for the actual state of operations manual

<table>
<thead>
<tr>
<th>Item 16. To what extent have you found the following helpful in your operations manual?</th>
<th>n</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional development</td>
<td>20</td>
<td>3.40</td>
<td>0.99</td>
</tr>
<tr>
<td>Evaluation</td>
<td>20</td>
<td>3.40</td>
<td>0.94</td>
</tr>
<tr>
<td>Strategic planning</td>
<td>21</td>
<td>3.62</td>
<td>0.97</td>
</tr>
<tr>
<td>Visitor behavior and understanding</td>
<td>21</td>
<td>3.81</td>
<td>1.08</td>
</tr>
<tr>
<td>Partnerships</td>
<td>20</td>
<td>3.40</td>
<td>0.99</td>
</tr>
<tr>
<td>Program design</td>
<td>20</td>
<td>3.65</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Scale: 5: Very helpful; 4: Helpful; 3: Neutral; 2: Not helpful; 1: Not helpful at all; N/A: Not applicable

Table 45
The program planner’s responses for the desired state of operations manual

<table>
<thead>
<tr>
<th>Item 17. To what extent would specific revisions and additions to your operations manual help you? (n=35)</th>
<th>mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional development</td>
<td>2.91</td>
<td>1.44</td>
</tr>
<tr>
<td>Evaluation</td>
<td>3.00</td>
<td>1.41</td>
</tr>
<tr>
<td>Strategic planning</td>
<td>3.10</td>
<td>1.41</td>
</tr>
<tr>
<td>Visitor behavior and understanding</td>
<td>3.06</td>
<td>1.52</td>
</tr>
<tr>
<td>Partnerships</td>
<td>2.74</td>
<td>1.27</td>
</tr>
<tr>
<td>Program design</td>
<td>3.03</td>
<td>1.47</td>
</tr>
</tbody>
</table>

Scale: 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

Comparison of Actual and Desired States within the Groups

Administrators

For administrators, statistically significant differences were found in comparisons between the actual and desired states of all options about assessment (Items 4 and 6), and for three options out of four about professional development (Items 7 and 8). No statistically significant difference
was found related to partnerships and operations manual questions. In a comparison of Items 4 and 6 about assessment, the mean scores of all options for the desired state were higher than the mean scores of the actual states, indicating that the administrators wished to have more effective assessment tools. For Items 7 and 8, the responding administrators would like the staff to enhance professional development by communicating with staff from the other institutions, presenting at conferences, or publishing journal articles. Tables 46 through 49 show the results.

Table 46
Actual-desired comparisons of the responses for the administrators regarding assessment

<table>
<thead>
<tr>
<th>Viewpoint</th>
<th>Actual</th>
<th>Desired</th>
<th>Difference</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitor curiosity</td>
<td>2.88</td>
<td>3.51</td>
<td>-0.63</td>
<td>-3.08</td>
<td>0.002**</td>
</tr>
<tr>
<td>Visitor understanding</td>
<td>2.61</td>
<td>3.56</td>
<td>-0.95</td>
<td>-4.00</td>
<td>0.00**</td>
</tr>
<tr>
<td>Long-term impact on the visitors</td>
<td>2.68</td>
<td>3.27</td>
<td>-0.59</td>
<td>-2.48</td>
<td>0.01**</td>
</tr>
<tr>
<td>Cost-benefit analysis</td>
<td>3.88</td>
<td>4.17</td>
<td>-0.29</td>
<td>-1.99</td>
<td>0.05*</td>
</tr>
</tbody>
</table>

*Scale (Actual): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never
Scale (Desired): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never
*p<0.05. **p<0.01.

Table 47
Actual-desired comparisons of the responses for the administrators regarding professional development sessions

<table>
<thead>
<tr>
<th>Session type</th>
<th>Actual</th>
<th>Desired</th>
<th>Difference</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informal seminars with staff members within your institution</td>
<td>3.86</td>
<td>3.44</td>
<td>0.42</td>
<td>-1.33</td>
<td>0.19</td>
</tr>
<tr>
<td>Informal seminars with the staff from other institutions</td>
<td>3.97</td>
<td>3.56</td>
<td>0.41</td>
<td>-2.27</td>
<td>0.02*</td>
</tr>
<tr>
<td>Professional meetings</td>
<td>4.10</td>
<td>3.78</td>
<td>0.32</td>
<td>-2.36</td>
<td>0.02*</td>
</tr>
<tr>
<td>Publishing journal articles</td>
<td>3.47</td>
<td>2.88</td>
<td>0.59</td>
<td>-2.32</td>
<td>0.02*</td>
</tr>
</tbody>
</table>

*Scale (Actual): 5: Very effective; 4: Effective; 3: Neutral; 2: Not effective; 1: Not at all effective; N/A: Not applicable
Scale (Desired): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never
*p<0.05.

Table 48
Actual-desired comparisons of the responses for the administrators regarding partnerships

<table>
<thead>
<tr>
<th>Partner</th>
<th>Actual</th>
<th>Desired</th>
<th>Difference</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>With other divisions in your institution</td>
<td>4.17</td>
<td>3.66</td>
<td>0.51</td>
<td>-1.15</td>
<td>0.25</td>
</tr>
<tr>
<td>With K-12 schools</td>
<td>4.42</td>
<td>4.34</td>
<td>0.08</td>
<td>-1.73</td>
<td>0.08</td>
</tr>
<tr>
<td>With university researchers</td>
<td>3.65</td>
<td>3.56</td>
<td>0.09</td>
<td>-1.80</td>
<td>0.07</td>
</tr>
<tr>
<td>With other informal science institutions</td>
<td>3.81</td>
<td>3.71</td>
<td>0.10</td>
<td>3.34</td>
<td>0.74</td>
</tr>
<tr>
<td>With industries (excluding sponsorships)</td>
<td>3.28</td>
<td>3.22</td>
<td>0.06</td>
<td>-1.44</td>
<td>0.15</td>
</tr>
</tbody>
</table>

*Scale (Actual): 5: Very effective; 4: Effective; 3: Neutral; 2: Not effective; 1: Not at all effective; N/A: Not applicable
Scale (Desired): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never
Table 49

*Actual-desired comparisons of the responses for the administrators regarding operations manual*

<table>
<thead>
<tr>
<th>Content</th>
<th>Actual</th>
<th>Desired</th>
<th>Difference</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity design</td>
<td>3.85</td>
<td>2.80</td>
<td>1.05</td>
<td>-0.47</td>
<td>0.64</td>
</tr>
<tr>
<td>Professional development</td>
<td>3.86</td>
<td>2.85</td>
<td>1.00</td>
<td>-0.47</td>
<td>0.64</td>
</tr>
<tr>
<td>Evaluation</td>
<td>3.77</td>
<td>2.98</td>
<td>0.80</td>
<td>-0.25</td>
<td>0.81</td>
</tr>
<tr>
<td>Strategic planning</td>
<td>4.15</td>
<td>3.07</td>
<td>1.08</td>
<td>-1.63</td>
<td>0.10</td>
</tr>
<tr>
<td>Visitor behavior and understanding</td>
<td>4.14</td>
<td>3.05</td>
<td>1.09</td>
<td>-1.02</td>
<td>0.31</td>
</tr>
<tr>
<td>Partnerships</td>
<td>4.09</td>
<td>3.07</td>
<td>1.02</td>
<td>-0.58</td>
<td>0.56</td>
</tr>
<tr>
<td>Research and conservation</td>
<td>3.90</td>
<td>2.76</td>
<td>1.14</td>
<td>-1.27</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Scale (Actual): 5: Very helpful; 4: Helpful; 3: Neutral; 2: Not helpful; 1: Not helpful at all; N/A: Not applicable
Scale (Desired): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

*Exhibit Developers*

Exhibit developers gave scores with statistically significant differences between the actual and desired states. These included most options about assessment (between Items 2 and 4), developing keener relationships inside the institution and partnerships with K-12 schools (between Items 9 and 10), and all options about professional development (between Items 11 and 12).

In comparing the actual and desired states of assessment (Items 2 and 4), the mean scores of the desired state exceeded the ones of the actual state for options, attracting and holding power, visitor curiosity, and visitor enjoyment. In comparison of the difference of the partnerships Items (9 and 10), it is notable that exhibit developers wish to have keener relationships with other departments internally, while the statistically significant differences of the administrators were found in developing partnerships with staff outside of the institution. For the components of professional development of the staff (Items 11 and 12), all options showed statistically significant differences. All the mean scores of the desired state were higher than the ones of the actual state. Tables 50 through 55 show the results.
### Table 50
Actual-desired comparisons of the responses for the exhibit developers regarding assessment

<table>
<thead>
<tr>
<th>Viewpoint</th>
<th>Actual</th>
<th>Desired</th>
<th>Difference</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attracting and holding power of the exhibit</td>
<td>3.48</td>
<td>4.43</td>
<td>-0.95</td>
<td>-3.10</td>
<td>0.002**</td>
</tr>
<tr>
<td>Visitor curiosity</td>
<td>3.33</td>
<td>4.00</td>
<td>-0.67</td>
<td>-2.50</td>
<td>0.01**</td>
</tr>
<tr>
<td>Visitor understanding of science concepts</td>
<td>3.43</td>
<td>3.95</td>
<td>-0.52</td>
<td>-1.76</td>
<td>0.08</td>
</tr>
<tr>
<td>Long-term impact of your efforts on the visitors</td>
<td>2.00</td>
<td>3.67</td>
<td>-1.67</td>
<td>-3.27</td>
<td>0.001**</td>
</tr>
<tr>
<td>Visitor enjoyment of the visit</td>
<td>3.67</td>
<td>4.43</td>
<td>-0.76</td>
<td>-2.41</td>
<td>0.02**</td>
</tr>
</tbody>
</table>

Scale (Desired): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

*p<0.05. **p<0.01.

### Table 51
Actual-desired comparisons of the responses for the exhibit developers regarding use of resources in activity design

<table>
<thead>
<tr>
<th>Resource</th>
<th>Actual</th>
<th>Desired</th>
<th>Difference</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideas from journal articles and/or experts in sciences</td>
<td>3.63</td>
<td>3.52</td>
<td>0.11</td>
<td>-0.63</td>
<td>0.53</td>
</tr>
<tr>
<td>Ideas from journal articles and/or experts in formal science education</td>
<td>3.12</td>
<td>3.10</td>
<td>0.02</td>
<td>-1.52</td>
<td>0.13</td>
</tr>
<tr>
<td>Ideas from journal articles and/or experts in informal science education</td>
<td>3.67</td>
<td>3.57</td>
<td>0.10</td>
<td>-0.63</td>
<td>0.53</td>
</tr>
<tr>
<td>Ideas from colleagues/staff</td>
<td>4.32</td>
<td>4.14</td>
<td>0.17</td>
<td>0.66</td>
<td>0.66</td>
</tr>
<tr>
<td>Ideas from professional conferences</td>
<td>3.83</td>
<td>3.43</td>
<td>0.40</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Ideas from in-house evaluation on programs</td>
<td>4.12</td>
<td>4.05</td>
<td>0.07</td>
<td>0.34</td>
<td>0.34</td>
</tr>
<tr>
<td>Ideas from third-party independent evaluation on programs</td>
<td>3.71</td>
<td>3.67</td>
<td>0.04</td>
<td>0.96</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Scale (Actual): 5: Very effective; 4: Effective; 3: Neutral; 2: Not effective; 1: Not at all effective; N/A: Not applicable
Scale (Desired): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

### Table 52
Actual-desired comparisons of the responses for the exhibit developers regarding professional development sessions

<table>
<thead>
<tr>
<th>Session type</th>
<th>Actual</th>
<th>Desired</th>
<th>Difference</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informal seminars with staff members within your institution</td>
<td>4.20</td>
<td>3.67</td>
<td>0.53</td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td>Informal seminars with the staff from other institutions</td>
<td>4.00</td>
<td>3.62</td>
<td>0.38</td>
<td>-0.26</td>
<td>0.80</td>
</tr>
<tr>
<td>Professional meetings</td>
<td>3.84</td>
<td>3.62</td>
<td>0.22</td>
<td>-0.28</td>
<td>0.78</td>
</tr>
<tr>
<td>Publishing journal articles</td>
<td>3.21</td>
<td>3.00</td>
<td>0.21</td>
<td>-1.51</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Scale (Actual): 5: Very effective; 4: Effective; 3: Neutral; 2: Not effective; 1: Not at all effective; N/A: Not applicable
Scale (Desired): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

### Table 53
Actual-desired comparisons of the responses for the exhibit developers regarding partnerships

<table>
<thead>
<tr>
<th>Partner</th>
<th>Actual</th>
<th>Desired</th>
<th>Difference</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other divisions in your institution</td>
<td>3.83</td>
<td>4.05</td>
<td>-0.21</td>
<td>-2.34</td>
<td>0.02*</td>
</tr>
<tr>
<td>K-12 schools</td>
<td>3.74</td>
<td>4.05</td>
<td>-0.31</td>
<td>-2.04</td>
<td>0.04*</td>
</tr>
<tr>
<td>University researchers</td>
<td>3.63</td>
<td>3.43</td>
<td>0.20</td>
<td>-0.58</td>
<td>0.56</td>
</tr>
<tr>
<td>Other informal science institutions</td>
<td>4.05</td>
<td>3.86</td>
<td>0.20</td>
<td>-0.11</td>
<td>0.91</td>
</tr>
<tr>
<td>Industries (excluding sponsorships)</td>
<td>3.62</td>
<td>3.10</td>
<td>0.52</td>
<td>-0.44</td>
<td>0.66</td>
</tr>
</tbody>
</table>

Scale (Actual): 5: Very effective; 4: Effective; 3: Neutral; 2: Not effective; 1: Not at all effective; N/A: Not applicable
Scale (Desired): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

*p<0.05.
Program Planners

For program planners, all options in Items 2 and 4 about assessment and all options in Items 11 and 12 showed that the desired state exceeded the actual state. Several options showed statistically significant differences in comparison of the use of resources for activity design (between Items 5 and 6), professional development (between Items 7 and 8), partnerships (between Items 9 and 10), and docent and volunteer sessions (Items 13 and 14). No statistically significant differences were found in Items 16 and 17 about the operations manual.

In comparisons related to assessment (Items 2 and 4), all the mean scores of the desired state exceeded the actual state, indicating that the respondent program planners wished to have assessment methods of visitor curiosity, visitor understanding of science concepts, long-term impact of the efforts on the visitors, and visitor enjoyment although they are not currently employing such
assessments. See Table 56 for the results.

Table 56
Actual-desired comparisons of the responses for the program planners regarding assessment

<table>
<thead>
<tr>
<th>Viewpoint</th>
<th>Actual</th>
<th>Desired</th>
<th>Difference</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitor curiosity</td>
<td>3.31</td>
<td>3.91</td>
<td>-0.60</td>
<td>-2.88</td>
<td>0.004*</td>
</tr>
<tr>
<td>Visitor understanding of science concepts</td>
<td>2.83</td>
<td>3.80</td>
<td>-0.97</td>
<td>-4.29</td>
<td>0.00*</td>
</tr>
<tr>
<td>Long-term impact of your efforts on the visitors</td>
<td>2.37</td>
<td>3.80</td>
<td>-1.43</td>
<td>-4.29</td>
<td>0.00*</td>
</tr>
<tr>
<td>Visitor enjoyment of their visit</td>
<td>4.00</td>
<td>4.49</td>
<td>-0.49</td>
<td>-2.94</td>
<td>0.003*</td>
</tr>
</tbody>
</table>

Scale (Desired): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

*p<0.01.

Items 5 and 6, the use of resources in activity designs, found statistically significant differences in utilizing ideas from journal articles and/or experts in informal science education, and ideas from colleagues/staff. The mean scores of both options show that their needs exceed the actual state. Items 7 and 8, regarding how they hold professional development sessions, provided no statistically significant differences for the options about holding informal seminars with the staff from other institutions, and presenting at a professional meeting. Different than the result of the exhibit developers, this result matches those of the administrators who wished the staff to communicate with others. Tables 57 and 58 show the results.

Table 57
Actual-desired comparisons of the responses for the program planners regarding use of resources in activity design

<table>
<thead>
<tr>
<th>Resource</th>
<th>Actual</th>
<th>Desired</th>
<th>Difference</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideas from journal articles and/or experts in sciences</td>
<td>3.42</td>
<td>3.31</td>
<td>0.11</td>
<td>-0.23</td>
<td>0.82</td>
</tr>
<tr>
<td>Ideas from journal articles and/or experts in formal science education</td>
<td>3.47</td>
<td>3.37</td>
<td>0.10</td>
<td>-0.85</td>
<td>0.39</td>
</tr>
<tr>
<td>Ideas from journal articles and/or experts in informal science education</td>
<td>4.20</td>
<td>3.89</td>
<td>0.31</td>
<td>-3.05</td>
<td>0.002*</td>
</tr>
<tr>
<td>Ideas from colleagues/staff</td>
<td>4.76</td>
<td>4.34</td>
<td>0.42</td>
<td>-3.50</td>
<td>0.00*</td>
</tr>
<tr>
<td>Ideas from professional conferences</td>
<td>4.12</td>
<td>3.97</td>
<td>0.15</td>
<td>-1.21</td>
<td>0.23</td>
</tr>
<tr>
<td>Ideas from in-house evaluation on programs</td>
<td>4.00</td>
<td>3.94</td>
<td>0.06</td>
<td>-0.37</td>
<td>0.71</td>
</tr>
<tr>
<td>Ideas from third-party independent evaluation on programs</td>
<td>3.57</td>
<td>3.51</td>
<td>0.06</td>
<td>-2.11</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Scale (Actual): 5: Very effective; 4: Effective; 3: Neutral; 2: Not effective; 1: Not at all effective; N/A: Not applicable
Scale (Desired): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

*p<0.01.
Table 58

*Actual-desired comparisons of the responses for the program planners regarding professional development sessions*

<table>
<thead>
<tr>
<th>Session type</th>
<th>Actual</th>
<th>Desired</th>
<th>Difference</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informal seminars with staff members within your institution</td>
<td>3.93</td>
<td>3.89</td>
<td>0.05</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Informal seminars with the staff from other institutions</td>
<td>4.32</td>
<td>3.94</td>
<td>0.38</td>
<td>-2.32</td>
<td>0.02*</td>
</tr>
<tr>
<td>Presenting at a professional meeting</td>
<td>3.97</td>
<td>3.51</td>
<td>0.45</td>
<td>-2.52</td>
<td>0.01**</td>
</tr>
<tr>
<td>Publishing journal articles</td>
<td>3.39</td>
<td>2.94</td>
<td>0.45</td>
<td>-0.71</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Scale (Actual): 5: Very effective; 4: Effective; 3: Neutral; 2: Not effective; 1: Not at all effective; N/A: Not applicable

Scale (Desired): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

*p<0.05. **p<0.01.

Partnerships with K-12 schools, university researchers, other informal science institutions, and industries (excluding sponsorships) resulted in statistically significant differences in Items 9 and 10. The mean scores of all options in the desired state were higher than the actual state. See Table 59 for the results.

Table 59

*Actual-desired comparisons of the responses for the program planners regarding partnerships*

<table>
<thead>
<tr>
<th>Partner</th>
<th>Actual</th>
<th>Desired</th>
<th>Difference</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other divisions in your institution</td>
<td>3.97</td>
<td>4.23</td>
<td>-0.26</td>
<td>-2.98</td>
<td>0.003</td>
</tr>
<tr>
<td>K-12 schools</td>
<td>4.26</td>
<td>4.54</td>
<td>-0.28</td>
<td>-2.52</td>
<td>0.01**</td>
</tr>
<tr>
<td>University researchers</td>
<td>3.54</td>
<td>3.74</td>
<td>-0.20</td>
<td>-2.52</td>
<td>0.01**</td>
</tr>
<tr>
<td>Other informal science institutions</td>
<td>4.09</td>
<td>4.14</td>
<td>-0.05</td>
<td>-0.79</td>
<td>0.43</td>
</tr>
<tr>
<td>Industries (excluding sponsorships)</td>
<td>3.14</td>
<td>3.26</td>
<td>-0.11</td>
<td>-1.94</td>
<td>0.05*</td>
</tr>
</tbody>
</table>

Scale (Actual): 5: Very effective; 4: Effective; 3: Neutral; 2: Not effective; 1: Not at all effective; N/A: Not applicable

Scale (Desired): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never

*p<0.05. **p<0.01.

In Items 11 and 12, asking the actual and desired contents for professional development, showed all options as significantly different. The direct comparison of the mean scores indicate that they wish to enhance all options; acquiring general knowledge both in science education and natural science, instructional and communication skills and strategies, and assessment methods in professional development sessions and none are currently seen as ineffective. This result about learning assessment methods matches the results of the comparison between Items 2 and 4 above, indicating that the needs for effective assessment is urgent. For the docent and volunteer training
sessions (Items 13 and 14), on the other hand, statistically significant differences were found only in inclusion of instructional and communication skills in the session. The need to let the docents acquire knowledge in science or education is low, while the program planners wish to include instructional and communication skills in the sessions. Tables 60 and 61 show the results.

Table 60
Actual-desired comparisons of the responses for the program planners regarding contents of the professional development sessions

<table>
<thead>
<tr>
<th>Content</th>
<th>Actual</th>
<th>Desired</th>
<th>Difference</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>General knowledge in science education</td>
<td>2.97</td>
<td>3.74</td>
<td>-0.77</td>
<td>-3.28</td>
<td>0.001**</td>
</tr>
<tr>
<td>General knowledge in natural sciences</td>
<td>2.97</td>
<td>3.54</td>
<td>-0.57</td>
<td>-3.16</td>
<td>0.002**</td>
</tr>
<tr>
<td>Instructional skills and strategies</td>
<td>3.37</td>
<td>3.94</td>
<td>-0.57</td>
<td>-3.14</td>
<td>0.002**</td>
</tr>
<tr>
<td>Communication and interaction skills</td>
<td>3.54</td>
<td>4.03</td>
<td>-0.49</td>
<td>-2.45</td>
<td>0.02*</td>
</tr>
<tr>
<td>Assessment methods</td>
<td>2.49</td>
<td>3.51</td>
<td>-1.03</td>
<td>-4.34</td>
<td>0.00**</td>
</tr>
</tbody>
</table>

Scale (Desired): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never
*p<0.05. **p<0.01.

Table 61
Actual-desired comparisons of the responses for the program planners regarding contents of docent and other volunteer training sessions

<table>
<thead>
<tr>
<th>Content</th>
<th>Actual</th>
<th>Desired</th>
<th>Difference</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>General knowledge in science education</td>
<td>3.60</td>
<td>3.89</td>
<td>-0.29</td>
<td>-2.20</td>
<td>0.03</td>
</tr>
<tr>
<td>General knowledge in sciences</td>
<td>3.74</td>
<td>3.97</td>
<td>-0.23</td>
<td>-1.90</td>
<td>0.06</td>
</tr>
<tr>
<td>Instructional skills and strategies</td>
<td>4.14</td>
<td>4.43</td>
<td>-0.29</td>
<td>-2.67</td>
<td>0.008**</td>
</tr>
<tr>
<td>Communication and interaction skills</td>
<td>4.20</td>
<td>4.43</td>
<td>-0.23</td>
<td>-2.13</td>
<td>0.03*</td>
</tr>
</tbody>
</table>

Scale (Desired): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never
*p<0.05. **p<0.01.

No statistically significant difference was found in comparison of operations manual (Items 16 and 17) (Table 62).

Table 62
Actual-desired comparisons of the responses for the program planners regarding operations manual

<table>
<thead>
<tr>
<th>Content</th>
<th>Actual</th>
<th>Desired</th>
<th>Difference</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional development</td>
<td>3.40</td>
<td>2.91</td>
<td>0.49</td>
<td>-0.075</td>
<td>0.94</td>
</tr>
<tr>
<td>Evaluation</td>
<td>3.40</td>
<td>3.00</td>
<td>0.40</td>
<td>-0.41</td>
<td>0.68</td>
</tr>
<tr>
<td>Strategic planning</td>
<td>3.62</td>
<td>3.06</td>
<td>0.56</td>
<td>-0.62</td>
<td>0.62</td>
</tr>
<tr>
<td>Visitor behavior and understanding</td>
<td>3.81</td>
<td>3.14</td>
<td>0.67</td>
<td>-0.73</td>
<td>0.47</td>
</tr>
<tr>
<td>Partnerships</td>
<td>3.40</td>
<td>2.74</td>
<td>0.66</td>
<td>-0.89</td>
<td>0.37</td>
</tr>
<tr>
<td>Program design</td>
<td>3.65</td>
<td>3.03</td>
<td>0.62</td>
<td>-0.33</td>
<td>0.74</td>
</tr>
</tbody>
</table>

Scale (Actual): 5: Very helpful; 4: Helpful; 3: Neutral; 2: Not helpful; 1: Not helpful at all; N/A: Not applicable
Scale (Desired): 5: Always; 4: Often; 3: Sometimes; 2: Seldom; 1: Never
Comparison of the Actual and Desired States Among Administrators,

Exhibit Developers and Program Planners- Pairwise Analyses

Pairwise analyses were administered for the common items according to Table 63. The analyses consist of three pieces: a comparison between administrators and exhibit developers; a comparison between administrators and program planners; and a comparison between exhibit developers and program planners. The items with an asterisk in the table are commonly asked of all three responding groups, thus 3-pairwise comparisons were done. The following sections describe the items or questions that showed statistically significant differences between and among the groups.

Table 63
Consistency of Items for pairwise analyses

<table>
<thead>
<tr>
<th>Viewpoint</th>
<th>Administrators</th>
<th>Exhibit Developers</th>
<th>Program Planners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goals</td>
<td>Item 2</td>
<td>Item 1</td>
<td>Item 1</td>
</tr>
<tr>
<td>Assessment- Actual state</td>
<td>Item 4</td>
<td>Item 2</td>
<td>Item 2</td>
</tr>
<tr>
<td>Assessment- Desired state</td>
<td>Item 6</td>
<td>Item 4</td>
<td>Item 4</td>
</tr>
<tr>
<td>Use of resources in activity designs- Actual State</td>
<td>N/A</td>
<td>Item 5</td>
<td>Item 5</td>
</tr>
<tr>
<td>Use of resources in activity designs- Desired State</td>
<td>N/A</td>
<td>Item 6</td>
<td>Item 6</td>
</tr>
<tr>
<td>Style of professional development- Actual state</td>
<td>Item 7</td>
<td>Item 7</td>
<td>Item 7</td>
</tr>
<tr>
<td>Style of professional development- Desired state</td>
<td>Item 8</td>
<td>Item 8</td>
<td>Item 8</td>
</tr>
<tr>
<td>Partnerships- Actual state</td>
<td>Item 9</td>
<td>Item 9</td>
<td>Item 9</td>
</tr>
<tr>
<td>Partnerships- Desired state</td>
<td>Item 10</td>
<td>Item 10</td>
<td>Item 10</td>
</tr>
<tr>
<td>Contents of professional development- Actual state</td>
<td>N/A</td>
<td>Item 11</td>
<td>Item 11</td>
</tr>
<tr>
<td>Contents of professional development- Desired state</td>
<td>N/A</td>
<td>Item 12</td>
<td>Item 12</td>
</tr>
<tr>
<td>Operations manual- Actual state</td>
<td>Item 12</td>
<td>Item 14</td>
<td>Item 16</td>
</tr>
<tr>
<td>Operations manual- Desired state</td>
<td>Item 13</td>
<td>Item 15</td>
<td>Item 17</td>
</tr>
</tbody>
</table>

A Comparison between Administrators and Exhibit Developers

In comparing the common items between the administrators and exhibit developers, four questions showed statistically significant differences as mentioned in Table 64. In the options of the items about assessment, the exhibit developer has higher mean scores than the administrators. The administrators have rather negative impression toward the effectiveness of their assessment systems. Partnerships with other divisions inside the institution and K-12 schools had higher mean scores for the administrators than exhibit developers, indicating that the administrators feel more positive
toward those partnerships.

Table 64  
Results of pairwise comparisons that showed statistically significant differences between the administrators and exhibit developers

<table>
<thead>
<tr>
<th>Question</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A4.2-E2.2 We assess visitor understanding of science concepts.</td>
<td>-2.2</td>
<td>0.03*</td>
</tr>
<tr>
<td>A4.3-E2.3 We assess long-term impact of our effort on visitors.</td>
<td>-2.98</td>
<td>0.003**</td>
</tr>
<tr>
<td>A9.1-E9.1 Partnerships with other divisions in our institution is</td>
<td>-2.53</td>
<td>0.01**</td>
</tr>
<tr>
<td>A9.2-E9.2 Partnerships with K-12 schools is effective.</td>
<td>-3.31</td>
<td>0.001**</td>
</tr>
</tbody>
</table>

*: p<0.05. **: p<0.01.

A Comparison between Administrators and Program Planners

For the comparison between the administrators and program planners, statistically significant differences were found as shown in Table 65. For all questions in this table except a question that asked about the actual state of partnerships (Item 9-2), the mean scores of program planners were higher than the scores of administrators, indicating that program planners feel more confident with their actual operation in terms of these aspects than the administrators.

Table 65  
Results of pairwise comparisons that showed statistically significant differences between the administrators and program planners

<table>
<thead>
<tr>
<th>Question</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2.2-P1.2 Helping visitors construct scientific knowledge describes goals of our institution.</td>
<td>-2.93</td>
<td>0.003**</td>
</tr>
<tr>
<td>A2.3-P1.3 Providing resources for visitors to learn science describes goals of our institution.</td>
<td>-3.09</td>
<td>0.002**</td>
</tr>
<tr>
<td>A2.4-P1.4 Providing hands-on activities for visitors describes the goals of our institution.</td>
<td>-2.76</td>
<td>0.006**</td>
</tr>
<tr>
<td>A7.2-P7.2 Informal seminars with the staff from other institutions is effective for professional development.</td>
<td>-2.13</td>
<td>0.03*</td>
</tr>
<tr>
<td>A9.2-P9.2 Partnerships with K-12 schools are effective.</td>
<td>-2.32</td>
<td>0.02*</td>
</tr>
</tbody>
</table>

*: p<0.05. **: p<0.01.

A Comparison between Exhibit Developers and Program Planners

Seven options in the comparison between exhibit developers and program planners showed statistically significant differences as shown in Table 66. All the mean scores of program planners except one were higher than the ones of exhibit developers, indicating the program planners feel
that their operations are more functional in terms of providing resources for visitors to learn science, utilizing ideas from colleagues in activity designs, organizing or participating informal seminars with the staff from other institutions, having partnerships with K-12 schools, and preparing effective hands-on instructional skills, and they have a keener need to enhance partnerships with universities than the exhibit developers think. For the question that asked the actual state of inclusion of acquiring assessment methods in the professional development sessions, the exhibit developers marked higher mean score than program planners.

Table 66
*Results of pairwise comparisons that showed statistically significant differences between the exhibit developers and program planners*

<table>
<thead>
<tr>
<th>Question</th>
<th>Wilcoxon test statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1.3-P1.3 Providing resources for visitors to learn science describes goals of our institution.</td>
<td>-2.07</td>
<td>0.034*</td>
</tr>
<tr>
<td>E5.4-P5.4 Ideas from colleagues and the staff is effective in exhibits.</td>
<td>-2.14</td>
<td>0.03*</td>
</tr>
<tr>
<td>E7.2-P7.2 Informal seminars with the staff from other institutions is effective for professional development.</td>
<td>-2.45</td>
<td>0.01**</td>
</tr>
<tr>
<td>E9.2-P9.2 Partnerships with K-12 schools is effective.</td>
<td>-2.49</td>
<td>0.01**</td>
</tr>
<tr>
<td>E10.2-P10.2 We would like to promote partnerships with university researchers.</td>
<td>-2.07</td>
<td>0.04*</td>
</tr>
<tr>
<td>E11.1-P11.11 We include learning of assessment methods in the development sessions.</td>
<td>-2.01</td>
<td>0.05*</td>
</tr>
<tr>
<td>E13.9-P15.4 Our visitors make use of hands-on instructional aids in the classes.</td>
<td>-1.98</td>
<td>0.05*</td>
</tr>
</tbody>
</table>

*: p<0.05. **: p<0.01.

These results indicated that the responses to the question about the actual state of partnerships with K-12 schools showed a statistically significant difference (Item 9-2 for the administrators, Item 9-2 for the exhibit developers, and Item 9-2 for the program planners) as a result of 3-pairwise analysis.

Visitor Surveys at Informal Science Institutions

*Survey of the Effectiveness of the Main Idea of an Exhibit on Visitor Understanding*

This survey examined visitor understanding by comparing the scores of visitors who answered based on the main idea and those who answered without the main idea. Appendix C
shows the survey instruments. The scores of the respondents were analyzed by summary statistics and compared in terms of the frequency of their prior visits to the Hall and the extent of their prior knowledge of the Hall. For the prior visits to the Hall, respondents were categorized into two groups: first or second visit and more than three visits. For the prior knowledge about the Hall, the respondents were divided into two groups: no knowledge or not much and more than some knowledge. Since the number of responses in each group is not equal, a Wilcoxon Two-sample Test (nonparametric analysis) was used in order to compare the scores. Tables 67 and 68 below show the demographics of the respondents for both surveys.

Table 67
Demographics of the Tropical Connections Hall survey without the main idea

<table>
<thead>
<tr>
<th>Age</th>
<th>Male</th>
<th>Female</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 18</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>6 (8.8%)</td>
</tr>
<tr>
<td>18-30</td>
<td>9</td>
<td>10</td>
<td>1</td>
<td>20 (29.4%)</td>
</tr>
<tr>
<td>31-50</td>
<td>19</td>
<td>8</td>
<td>-</td>
<td>27 (39.7%)</td>
</tr>
<tr>
<td>Over 50</td>
<td>8</td>
<td>4</td>
<td>-</td>
<td>12 (17.7%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td>3 (4.4%)</td>
</tr>
<tr>
<td>Total</td>
<td>39 (57.3%)</td>
<td>25 (36.8%)</td>
<td>4 (5.9%)</td>
<td>68 (100.0%)</td>
</tr>
</tbody>
</table>

Table 68
Demographics of the Tropical Connections Hall survey with the main idea

<table>
<thead>
<tr>
<th>Age</th>
<th>Male</th>
<th>Female</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 18</td>
<td>1</td>
<td>5</td>
<td>-</td>
<td>6 (8.9%)</td>
</tr>
<tr>
<td>18-30</td>
<td>7</td>
<td>17</td>
<td>-</td>
<td>24 (35.3%)</td>
</tr>
<tr>
<td>31-50</td>
<td>17</td>
<td>12</td>
<td>-</td>
<td>29 (42.7%)</td>
</tr>
<tr>
<td>Over 50</td>
<td>3</td>
<td>4</td>
<td>-</td>
<td>7 (10.3%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>2 (2.8%)</td>
</tr>
<tr>
<td>Total</td>
<td>28 (41.2%)</td>
<td>39 (57.4%)</td>
<td>1 (1.4%)</td>
<td>68 (100.0%)</td>
</tr>
</tbody>
</table>

The comparison of mean scores was done in terms of the number of visits and the extent of prior knowledge of the respondents. For Item 2 (Table 69), the visitors who were not provided the main idea were asked to describe what idea they got from the exhibits. In this Item, the mean scores of the visitors were quite low. Since 28 people out of 68 scored 0 points, meaning “I don’t know” or blank answer, they clearly affected the mean score. A total of 17 respondents out of 68 described that North Carolina is connected to tropics, which is the main idea of the Hall. However, 10
respondents out of the 17 described it with some inaccuracy.

The visitors who were not given the main idea were asked to rate to what extent the main idea was effective for their understanding. Twenty-three visitors rated it as 5 points, meaning it was very helpful, and thirty-nine people rated 4 points, meaning it was moderately helpful. Six visitors showed neutral attitudes toward the decision. No negative response to the effectiveness of the main idea was found.

The scores of Items 2 and 3 were examined using Wilcoxon Two-sample test. The results are shown in Table 71. The examples of relationships between North Carolina and the tropics that were asked in Item 3 had no statistically significant difference (see Table 70). However, the mean scores between the visitors who were given the main idea (in Instrument 2 survey) are higher than the visitors without the main idea (in Instrument 1 survey) in terms of number of results and prior knowledge. Figure 1 shows the distribution of scores of Item 3, indicating that almost a half of the respondents scored 2 or 3 points, which means they listed the examples of the relationship between North Carolina and the tropics, at least with some accuracy.

Table 69

<table>
<thead>
<tr>
<th>Number of visits</th>
<th>Prior knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>once or twice</td>
<td>More than three times</td>
</tr>
<tr>
<td>n=56</td>
<td>mean=1.02</td>
</tr>
<tr>
<td>mean=1.04</td>
<td>SD=1.04</td>
</tr>
</tbody>
</table>

Table 70

<table>
<thead>
<tr>
<th>Number of visits</th>
<th>Prior knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>once or twice</td>
<td>More than three times</td>
</tr>
<tr>
<td>n=56</td>
<td>mean=1.13</td>
</tr>
<tr>
<td>mean=1.28</td>
<td>SD=1.00</td>
</tr>
<tr>
<td>n=9</td>
<td>mean=0.67</td>
</tr>
<tr>
<td>mean=0.70</td>
<td>SD=1.00</td>
</tr>
</tbody>
</table>
Table 71

*Effect of the main idea of the exhibits on visitor understanding (Wilcoxon Two-sample Test)*

<table>
<thead>
<tr>
<th>Item</th>
<th>Without the main idea</th>
<th>With the main idea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of visits</td>
<td>Statistic=224.0 p-value=0.07</td>
<td>Statistic=4.00.0 p-value=0.30</td>
</tr>
<tr>
<td>Number of visits</td>
<td>Statistic=255.5 p-value=0.19</td>
<td>Statistic=326.5 p-value=0.20</td>
</tr>
<tr>
<td>Prior knowledge</td>
<td>Statistic=501.0 p-value=0.10</td>
<td>Statistic=880.0 p-value=0.47</td>
</tr>
</tbody>
</table>

Figure 1

*Responses of Item 3: What kind of relationship do North Carolinians have with tropical forests?*

![Graph showing responses](image)

From a qualitative analysis of the responses, the following two features were found:

1. In the survey without the main idea, many people saw the main idea of Tropical Connections Hall as a warning about environmental issues. It is one of the content components in the Hall, but it is not the main idea. Their preconceptions might have acted as a bias in understanding the exhibits.

2. In the question that asked the relationship between North Carolina and the tropics, several people who took the survey without the main idea answered, “I don’t know because I’m not from North Carolina.” The examples of relationships are clearly mentioned in the exhibits, and visitors should have been able to find it even though they do not know anything about features of North Carolina. On the other hand, none answered in this way when provided the main idea. Therefore, it can be
suggested the main idea of an exhibit helped visitor understanding.

Survey for the Effective Types of Labeling

In this survey, visitors were asked to choose their favorite label from four provided samples. They were allowed to freely choose one for any reason such as appearance, easiness to understand, and so on. The labels and the instruments are shown in Appendix D. A total of 68 people participated in this survey. Table 72 shows the demographics of those responding.

Table 72
Demographics of Label survey

<table>
<thead>
<tr>
<th>Age</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 18</td>
<td>6</td>
<td>4</td>
<td>10 (14.7%)</td>
</tr>
<tr>
<td>18-30</td>
<td>5</td>
<td>14</td>
<td>19 (28.0%)</td>
</tr>
<tr>
<td>31-50</td>
<td>16</td>
<td>15</td>
<td>31 (45.5%)</td>
</tr>
<tr>
<td>Over 50</td>
<td>3</td>
<td>5</td>
<td>8 (11.8%)</td>
</tr>
<tr>
<td>Total</td>
<td>30 (44.1%)</td>
<td>38 (55.9%)</td>
<td>68 (100.0%)</td>
</tr>
</tbody>
</table>

Table 73 shows the overall label preferences. The Caption and Exploratorium Model labels were the most popular of the four. In a comparison by age (Figure 2), it is remarkable that among the respondents who are from 30 to 50 years old, 13 and 11 respondents chose the Caption label and Exploratorium Model label, respectively. Also comparison according to gender clarifies that 13 females chose the Modified Exploratorium Model label (Figure 3). According to the informal observation, female respondents tend to teach the facts of Willo to their children using the Modified Exploratorium Model label. Thus it might be said that those respondents liked the Modified Exploratorium Model label that includes the back-of-the-scene information.

Table 73
Label preferences of the respondents

<table>
<thead>
<tr>
<th>Label type</th>
<th>Preferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caption</td>
<td>23 (33.8%)</td>
</tr>
<tr>
<td>Title</td>
<td>7 (10.3%)</td>
</tr>
<tr>
<td>Modified Exploratorium Model</td>
<td>15 (22.1%)</td>
</tr>
<tr>
<td>Exploratorium Model</td>
<td>23 (33.8%)</td>
</tr>
<tr>
<td>Total</td>
<td>68 (100.0%)</td>
</tr>
</tbody>
</table>
The following four points were found through a qualitative analysis of the responses.

1. The major benefit of the Title label is to be precise. One respondent stated that he needs only definite findings.

2. Many respondents stated that the Caption label is conclusive with all needed information and an appropriate picture in one place. Many people were attracted to the appearance (balance of the picture and texts) of this label even though it has many words on a page. One respondent liked this label because it tells the facts without just reading, making her comfortable in understanding
the exhibit. Interestingly, a respondent pointed out that this label assumes that readers do not have any information about Willo prior to reading it. For some people, this label gave direct information better than the interactive labels (Exploratorium Model and Modified Exploratorium Model).

One respondent chose the Caption label because of its title. This label has the title “Willo- A Dinosaur with a Heart,” while the Exploratorium Model and Modified Exploratorium Model labels have titles questioning the readers (“What do you see?” and “What is it?”). More concise labels seemed to attract more people.

3. The respondents who chose the Exploratorium Model were more likely to compare it with the Modified Exploratorium Model than with the other labels. They chose the Exploratorium Model because of the ease of understanding it without taking too much time. This model attracts the initial attention of many visitors, perhaps because the amount of information in this model is appropriate for them. In this model, they found that they did not need to take more time to read the label or information about the detailed background of Willo. One respondent stated that this model was good for children, while the Caption label was good for adults.

4. The Modified Exploratorium Model was chosen by visitors who wanted to learn more. The major reason for the respondents to choose this model is that it is informative in a way they found easy to understand. For them, the format in which the information is divided into parts was a favorable way to learn. Another respondent pointed out that this model leads the readers to the importance of Willo, bringing them better understanding. However, no respondents took advantage of answering the question at the bottom of each page before moving on to the next page. Their viewpoint in choosing the favorable label was the contents of the label.

It is worthwhile to note that three respondents informally said they chose the Exploratorium Model as their own favorite label, but they preferred the Modified Exploratorium Model as the
best to learn about Willo. Also, several respondents suggested putting all information of this label on a sheet rather than using a book format. It is also worth noting that no respondent who chose interactive labels (Exploratorium Model and Modified Exploratorium Model) mentioned the benefit of “interactive” labels as a reason of their choice. It can be implied that whether a label is interactive or merely one-way communication is not obvious to them.

Survey for Visitor Expectations about On-Site Museum Lessons

A mailed survey was administered to the class participants (teachers and their 4th grade students) to inquire about their expectations about on-site lessons. The scores of the students were analyzed by summary statistics overall and by school groups. Scores of each school group were compared with a Wilcoxon Two-Sample Test (nonparametric) because the number of responses was not the same between the school groups. The student scores of each school group were also compared with each teacher. For the purpose of the statistical analyses of the student responses, the responses of each student were scored: three points were given to the responses marked as Yes, which means that they expect it; two points were given to the responses marked as Maybe, which means they are undecided; and one point was given to the responses marked as No, which means they do not expect it. The instruments are shown in Appendix E.

Table 74 shows a summary of the teachers’ responses. Neither teacher was trained in natural science, but Teacher B was more experienced in taking the students to informal science institutions. For the responses to the multiple-choice items (see the instrument in Appendix F), both teachers have great expectations about the museum visit in terms of exposing their students to hands-on experiences, instruction by the Museum staff, and learning which is free from grades. It is notable that they also expect to acquire new skills by applying scientific knowledge and teaching skills in their classrooms. The short answers imply that the teachers wish to give the students a chance to think of science beyond the classroom. From the responses to the multiple-choice items and short
answers, it can be said that their expectations especially focus on hands-on experiences.

Table 74  
*A summary of the teachers’ responses for Curiosity Class survey*

<table>
<thead>
<tr>
<th>Question</th>
<th>Teacher A</th>
<th>Teacher B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profile</td>
<td>Teaching experience</td>
<td>5 years</td>
</tr>
<tr>
<td>Trip to museums per year</td>
<td>Once or twice</td>
<td>10 times</td>
</tr>
<tr>
<td>Training in natural sciences</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Expectations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of museum's collections</td>
<td>Expect very much</td>
<td>Expect very much</td>
</tr>
<tr>
<td>Instruction by the staff</td>
<td>Expect very much</td>
<td>Expect very much</td>
</tr>
<tr>
<td>Clear messages to apply to class</td>
<td>Expect very much</td>
<td>Expect very much</td>
</tr>
<tr>
<td>Grade specific instruction</td>
<td>Expect very much</td>
<td>Expect very much</td>
</tr>
<tr>
<td>Learning without grades</td>
<td>Expect very much</td>
<td>Expect very much</td>
</tr>
<tr>
<td>Other expectations</td>
<td>Hands-on experience</td>
<td>Hands-on experience</td>
</tr>
<tr>
<td></td>
<td>Real-life experience</td>
<td>Different experience from</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bringing a vision why</td>
</tr>
<tr>
<td>Introduction of the lesson prior to the visit</td>
<td>Told the title and outline of the lesson</td>
<td>Told only the title of the lesson</td>
</tr>
</tbody>
</table>

Table 75 show the items asked of the respondent students, and a comparison of mean scores of the student answers, respectively. Overall, the students in School Group B had higher expectations than those of School Group A. The mean scores of Item 3 ($\mu=2.94$) and Item 6 ($\mu=2.92$) were the highest among all items for both school groups. In addition, the mean scores of Item 5 ($\mu=2.85$) were higher for School Group B. This suggests that the students in School Group A emphasize casual atmosphere the most, while those in School Group B expect learning new things as well as a casual atmosphere.

The overall scores of Items 2 and 4 are relatively low. The results of comparison of Items 2 and 4 (Table 75) show statistically significant differences. For both school groups, the relatively higher mean scores of Items 3 and 6 show that the students regard a casual atmosphere in learning as the most important.

For both school groups, the teacher told students about the details of the lesson they would take in the Museum (see the bottom line of Table 74). This suggests that the students’ expectations reflect the knowledge they have of the lesson, not the expectation of field trips to museums in
general.

Table 75  
Observed outcomes of student’s responses for Curiosity Class survey

<table>
<thead>
<tr>
<th>Measures</th>
<th>overall</th>
<th>School group A</th>
<th>School Group B</th>
<th>Wilcoxon test statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>To touch real objects</td>
<td>n=87</td>
<td>n=22</td>
<td>n=65</td>
<td>922.00</td>
<td>0.27</td>
</tr>
<tr>
<td>mean=2.76</td>
<td>SD=0.48</td>
<td>mean=2.73</td>
<td>mean=2.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To meet people at the Museum</td>
<td>n=87</td>
<td>n=22</td>
<td>n=65</td>
<td>1120.00</td>
<td>0.05*</td>
</tr>
<tr>
<td>mean=2.45</td>
<td>SD=0.59</td>
<td>mean=2.64</td>
<td>mean=2.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To have fun</td>
<td>n=86</td>
<td>n=22</td>
<td>n=64</td>
<td>957.00</td>
<td>0.50</td>
</tr>
<tr>
<td>mean=2.93</td>
<td>SD=0.34</td>
<td>mean=2.91</td>
<td>mean=2.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To learn things that Museum offers</td>
<td>n=87</td>
<td>n=22</td>
<td>n=65</td>
<td>670.00</td>
<td>0.0002**</td>
</tr>
<tr>
<td>mean=2.63</td>
<td>SD=0.55</td>
<td>mean=2.27</td>
<td>mean=2.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To learn new things</td>
<td>n=87</td>
<td>n=22</td>
<td>n=65</td>
<td>879.00</td>
<td>0.07</td>
</tr>
<tr>
<td>mean=2.85</td>
<td>SD=0.39</td>
<td>mean=2.73</td>
<td>mean=2.89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To be in a friendly atmosphere</td>
<td>n=87</td>
<td>n=22</td>
<td>n=65</td>
<td>955.50</td>
<td>0.40</td>
</tr>
<tr>
<td>mean=2.90</td>
<td>SD=0.33</td>
<td>mean=2.86</td>
<td>mean=2.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To learn things without grades</td>
<td>n=87</td>
<td>n=22</td>
<td>n=65</td>
<td>891.50</td>
<td>0.14</td>
</tr>
<tr>
<td>mean=2.78</td>
<td>SD=0.47</td>
<td>mean=2.68</td>
<td>mean=2.81</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scale: 3: Yes; 2: Maybe; 1: No  
*p<0.05. **p<0.01.

Survey for Effective Assessment

This section consists of two parts: Effectiveness of the visitor survey as an assessment instrument for daily operations; and The use of the survey results for improvement of the Discovery Room that is analyzed from the questionnaire to the staff. The process of the instrument design is described in Chapter 3, and the instrument is shown in Appendix F.

Effectiveness of the Visitor Survey as an Assessment of Daily Operations

In examining the effectiveness of the Discovery Room, summary statistics for each Likert-type item are reported. The results of the Likert-type items are also compared by being categorized in three viewpoints: (1) items that represent the extent of the visitors prompted a positive attitude toward learning; (2) items that represent the extent of visitor learning in the Room;
and (3) items that represent effectiveness of the staff for visitor activities (Table 76). In this process, the overall average was calculated for each of the three categories and compared on a compass chart in order to visualize the operation (Figure 4). In this example, the graph skews to the “staff” category in July, August and September, suggesting that the staff had a meaningful effect on the visitors. In October, the visitors felt that they were able to learn a lot, but they were less satisfied with their interactions with the staff. The graph shows a large triangle in September, meaning that the visitors that month were most satisfied with the Discovery Room itself. The results might be affected by a balance between the number of staff and the visitor attendance of the day. A further study is needed to investigate this relationship.

Table 76
Categorization of the likert-type items for Discovery Room survey

<table>
<thead>
<tr>
<th>Category</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive attitude toward</td>
<td>1. The Room was inviting.</td>
</tr>
<tr>
<td></td>
<td>8. The materials in the Room were interesting to our children.</td>
</tr>
<tr>
<td></td>
<td>11. The Room enhanced our appreciation of natural world.</td>
</tr>
<tr>
<td></td>
<td>12. We would come back again.</td>
</tr>
<tr>
<td>Visitor learning</td>
<td>4. The specimens and the boxes enhanced learning.</td>
</tr>
<tr>
<td></td>
<td>7. We learned something about science or nature in the Room.</td>
</tr>
<tr>
<td></td>
<td>9. Visiting this Room will enhance our next family nature experience.</td>
</tr>
<tr>
<td></td>
<td>10. The Room balanced learning and playing opportunities.</td>
</tr>
<tr>
<td>Effectiveness of the staff</td>
<td>2. The staff was friendly.</td>
</tr>
<tr>
<td></td>
<td>3. The staff was knowledgeable about the Room.</td>
</tr>
<tr>
<td></td>
<td>5. The staff was helpful in answering our science or nature questions.</td>
</tr>
<tr>
<td></td>
<td>6. The staff was available when we needed to talk.</td>
</tr>
</tbody>
</table>

Figure 4
Responses of the visitors to Discovery Room
A close and thorough reexamination of each item is needed to assure the clearness of the items. Every time the visitor survey was administered, the response of the visitors to Item 3 (The staff is knowledgeable about the Room) varied according to the circumstances. The score of that question was usually lower than the other items about the staff effectiveness. However, when the staff prepared animals to be touched, the score on this item increased. This tendency was especially true when visitors were able to touch a snake. An informal observation of visitor conversation supports this result. When available, the staff and volunteers check out various animals including snakes and show them to visitors in public area. Snakes are among the most popular animals, and the visitors who saw snakes in the public area before visiting Discovery Room were excited and expected to touch snakes in the Discovery Room as well. Even though the visitor’s excitement was lower, the same tendency appeared on the visitor survey when insects popular to Americans were present. When displaying sensitive animals they cannot touch, such as geckos, certain species of lizards and mammals, the score of this item stayed low. Even when a snake is displayed in the Discovery Room, the staff and docents do not announce that they have snakes for visitors; their behavior and conversation with the visitors are always the same; therefore, the relationship between the choice of the animals and the visitor’s impression is still unknown. It needs to be studied how visitors understood the notion “The staff is knowledgeable about the Room.”

The novelty, originality and handiness of the question that asked the visitors to indicate their preference of the exhibits on a map brought the respondents a new perspective on the activities. An informal observation of the respondents clarified that many of them started to walk around to examine each activity when indicating their favorite activities on the map. This tendency was more likely to be true for male respondents than for female respondents. People do not usually pay attention to every activity, but this question attracted their attention to the ones that had not been noticed until they saw the map on the survey instrument. In this sense, this question cultivated their
new curiosity that enabled them to complete the survey actively.

This design of the visitor survey also gave the staff a direct insight into exhibit preferences of visitors. For example, magnification, live animals, discovery boxes, and a beehive attracted a lot of visitors. When the Room displayed live animals such as snakes, turtles, and geckos in September and October, visitors’ responses regarding live animals increased remarkably. On the other hand, a smaller number of visitors enjoyed activities using Discovery Boxes in September and October. Overall, the exhibits in difficult places to find did not attract as many visitors. Difficult places include the places where many exhibits are arranged close together (Classroom Animals, Rocks, Insects and Bones—all are beside Toddler activities and Discovery drawers) or the place that has tiny exhibits (stuffed animals of Songbirds and live Spiders). Difficult places for the visitors to find included footprints (Footprints: It is placed on the floor); Turtles, and X-ray (They are placed at the exit) The toddler activity was popular when the Room had lots of family groups with small children.

The Marine species are arranged beside the Coastal/Evening exhibit where the visitors, especially small children, take a longer time to play in sand (Beach in a Box) or with puppets. The specimens might have been less attractive than sand or puppets for those visitors.

For the visitor comments, many respondents mentioned that they like the Discovery Room very much and would come back again. For improvement, many suggested opening the room more often, making it larger and preparing more hands-on exhibits including an area for children to do puppet shows.

*The Use of Results of the Visitor Survey for Improvement- the Questionnaire for the Discovery Room Staff Regarding Instrument*

The answers to the questionnaire for the staff were analyzed qualitatively. The coordinator is satisfied with the effectiveness of the visitor survey instrument overall. She values this survey instrument in three ways: the format of the instrument enables her to visualize the effectiveness of
the Room; the survey brings the objective evaluation of the operation from a visitor point of view; and the survey will help guide changes in the Room from staff training content to budget allocations. For the first point, the coordinator can grasp visitor learning and appreciation of the natural world, and effectiveness of the staff interactions through the compass chart. For the second point, she states, “The survey helps give a more balanced snap shot of the room from a visitor point of view without my personal basis.” For the third point, she confirmed through the survey results that the Discovery Room is achieving its mission as well as the mission of the Museum and NC Department of Environment and Natural Resources (DENR), with which the Museum is affiliated.

In improving the operation of the Room, a direct use of the results can be seen from the coordinator’s answer. The following statement shows an example of how she will use the results of the visitor survey:

For example, since the beehive is the most popular attraction- I could add more interpretation around the hive or new (Discovery) [B]oxes or (Discovery) [D]rawers available on bees or other social insects. … for exhibits that are less utilized, the staff will look at them carefully to determine if changes should be made. For example, the new foot print exhibit has gone almost unnoticed. Should we move the exhibit to a new location, should we add text and some props? … some comments such as extended hours are good documentation to pass onto management to request more staff to extend time in the room.

The value of the assessment is that it brings an intuitive view of effectiveness of the operation to the staff. The coordinator’s statement above shows that the instrument achieves this value. She tries to enhance popular exhibits, improve less popular ones, and use appropriate departments of the Museum if the change is reasonable and beyond her control. The most practical improvement is then to examine each individual exhibit to see if they need to change it. In this sense, this survey instrument is designed to be as user-friendly as possible, which means that it gives the staff a direct view to each exhibit.
Summary of the Results

The following is a summary of major results of the on-line and visitor surveys that were administered in this study.

1. For all responding groups, administrators, exhibit developers, and program planners, their goals of the operation focus more on providing resources and activities and less on guiding and helping visitor learning of science. This result implies that the institutions prepare lots of learning materials and activities and it is left to visitors what to choose in their museum visit. This well represents what Falk and Dierking (1992, 2000) describe as “free-choice learning.”

2. The current focus of informal science educators tends to be on visitor enjoyment and curiosity, as well as visitor understanding. Strong needs for enhancing assessment systems were seen by all the administrators, exhibit developers, and program planners, however, the needs still tend to focus on attitudinal reinforcement rather than visitor learning or knowledge construction.

3. The informal science staff tend to use ideas from colleagues and the results of internal evaluation when designing activities. This and the results of the actual state of assessment mentioned above implies that their activity design is based on attitudinal reinforcement and they do not emphasize visitor learning much.

4. The needs for professional development sessions are high among all responding groups. However, there exists a gap between the administrators and practitioners concerning the form of professional development sessions: the administrators attend professional meetings, while practitioners participate more in informal seminars. The need for publishing journal articles as a form of the professional development is the lowest among the options. As for the contents of professional development sessions, none of the options in the items showed any special characteristics. For both of the practitioners, their needs for inclusion of communication and instructional skills seem to be high, and the need for acquiring assessment skills resulted in low.
5. The most frequent partnerships existing among the administrators and program planners are with K-12 schools as well as relationships within and outside of the institution. For exhibit developers, however, they feel that partnerships with the other informal science institution are the most successful. It is worth mentioning that the respondents in all groups wish to have more partnerships with K-12 schools than they have now.

6. In regards to operations manuals, no special characteristics have not been found nor were further needs made explicit regarding operations manuals. For all responding groups, the number of responses that provided was few. Exhibit developers seem to be somewhat concerned about visitor understanding, and would include it in the manual. This result is supported by a result that they would like to have an operations manual for daily operation (Item 13-10).

7. Miscellaneous questions that were asked of the respondents indicated that they are very negative to traditional lectures (Item 11-4 for the administrators and Item 15-5 for the program planners, with the mean scores of 1.94, and 1.75, respectively). It is also explicit that all respondent groups marked high mean scores for the question that their operations well represent the goal of the institution. The question did not clarify how they knew that their operations achieve the goal of the institution.

8. In a pairwise analysis for the items asking about assessment, statistically significant differences were found among all responding groups in terms of all options of the item except the exhibit developers’ responses about assessment of long-term impact. The results support a strong need for more effective assessment systems.

9. Large gaps were found in the forms of professional development sessions. The administrator’s further needs for holding and/or participating professional development exceed the actual state. The practitioners’ responses also clarified the gap between the actual and desires states regarding the contents to be included in the professional development sessions.
10. The comparison between the administrators and exhibit developers clarified the gap about some characteristics of assessment (the actual states of assessment of visitor understanding and long-term impact) and partnerships (the actual state of partnerships with other institutions, and with K-12 schools). The administrators are more concerned about those characteristics.

11. The comparison between the administrators and program planners made it explicit that there exist gaps in terms of assessment as well as having a partnership with K-12 schools. The program planners are more confident on their current assessment systems than the administrators.

12. The comparison between the practitioners, it was revealed that the program planners’ actual state scored higher than the exhibit developers’ actual operation in several aspects: providing learning resources as a goal of the operation, use internal resources in activity design, having professional development sessions with other institutions, having K-12 partnerships, and providing hands-on resources. The exhibit developers have less focus on acquiring assessment methods than the program planners have.

13. Three-pairwise comparisons showed that there are a statistically significant difference among all the respondent groups in regard to the effectiveness of the partnerships with K-12 schools.

14. No statistically significant difference was found from the visitor survey about investigating the effectiveness of the main idea of exhibits. The qualitative analysis of visitor responses showed that they are strongly influenced by the concept of environmental destruction, by just seeing the term “tropics.” In both sample groups, very few respondents understood the main idea of the exhibit as that North Carolinians have many facets that shows relationship between tropics.

15. The visitor survey to investigate label preferences of visitors clarifies that their preferences are too diverse to reveal a specific type of favorite label. This survey also made it explicit that the definition of “diverse” varies remarkably according to individuals. In addition, the informal observation of the visitors clarified that most of them do not make any stop at any objects in the
The survey to investigate visitor expectations toward museum on-site lessons clarified that the science teachers who applied for the lesson expected their students to learn science more broadly beyond the wall of schools, and learn in a friendly atmosphere while working with museum staff. The expectation of the students who took lessons strongly reflects their teacher’s expectation.

An assessment instrument for daily operation was conducted as a form of visitor survey and proved to be successful in terms of providing the staff with direct information about whether or not the activities are effective. This is possibly because the survey instrument was completely customized through a number of revisions according to the staff’s needs. Respondents who filled in the survey were motivated because of the appearance and handiness of the instrument.
CHAPTER 5 DISCUSSION, IMPLICATIONS AND FUTURE RESEARCH

Overview of the Study

Traditionally, the major goals of informal science education institutions have been promoting visitor understanding by introducing scientific concepts and natural phenomena, explaining them, and displaying objects. Activity designs typically depend on artistic and psychological criteria related to motivation and whether or not visitors can understand the concepts. The criteria, however, often do not anticipate the broad age ranges, diverse curiosity and interests, knowledge levels, or background of visitors. Often, exhibits and activities emphasize explanation of each individual object or program rather than promoting broad goals and concepts through consistency among activities and designs. Thus, this study sought to assess various aspects of museum operation to determine some institutional baselines. These baselines were then used to suggest how museums can provide more educationally effective science education. These suggestions are referred to as the “desired state.”

From the data collected, an intense review of the relevant literature, and logical thinking, this study began to develop the desired state as an initial set of guidelines so that informal science institutions can demonstrate their maximal potentials in education. In doing so, past findings of informal science education research, the National Science Education Standards, goals of science education, and the nature of science were synthesized. Data from the five surveys of this study were synthesized to begin defining the actual and desired states of informal science education from the perspectives of institutions and visitors.

Discussion and Implications for Informal Science Institutions

Survey 1--The On-Line Survey for Informal Science Institutions

An on-line survey was administered to informal science education institutions in order to
inquire about the actual and desired states of internal operations. Surveys of administrators, exhibit
developers, and program planners provided data to begin answering two broad research questions
and a series of sub-questions:

1. What is the desired state of informal science education?
   a. What are the desired components of assessment?
   b. What resources do informal science educators wish to obtain in designing activities?
   c. What kinds of professional development do informal science educators need?
   d. What kinds of partnerships do informal science educators wish to have?
   e. What components do informal science educators need in an operations manual?
   f. What components do informal science educators wish to include in docent/volunteer training?

2. What is the actual state of informal science education?
   a. What outcomes do informal science educators assess?
   b. What resources do informal science educators use in designing activities?
   c. What kinds of professional development training are available for informal science educators?
   d. What kinds of partnerships do informal science educators have?
   e. What components do informal science educators include in an operations manual?
   f. What components do informal science educators include in docent/volunteer training?

Forty-two museum administrators, 21 exhibit developers, and 36 program planners provided
data for analysis. For discussion, findings related to research questions 1 and 2 are organized into
broad areas of assessment, professional development, partnerships, and the operations manual. Each
is phrased as a statement or argument and discussed further in the remainder of this section.

1. Assessment instruments must include evaluation of visitor learning.

   Actual assessments focus only on visitor enjoyment and curiosity, perhaps reflecting informal
   science staff feeling that assessment of visitor learning or effectiveness of activities requires special
skills (instrument design, sampling, data analysis skills) that they do not have. Assessment of a
long-term impact of activities on visitors resulted in the least positive response of the actual state of
assessment. As practitioners design activities using the results of in-house evaluations, activities can
fall into a vicious cycle that does not lead to designs evolving toward educational effectiveness;
toward helping visitors learn science.

Since expressed goals of museums include visitor learning, museums need guidelines on how
to conduct effective surveys, how to design an instrument that objectively measures the degree of
visitor learning without bias, and the staff need training in all of these aspects. Such guidelines, to
be implemented, must be a significant part of a formal operations manual.

Exhibit developers and program planners saw that internal information and ideas from
colleagues and internal evaluations as common features of resources used in activity design.
Program planners saw knowledge from journal articles in informal science education as helpful in
activity design. Clearly, the actual state is to seek ideas broadly. However, since the current
assessments rely greatly on attitudinal development, activity design tends to focus on whether or not
visitors enjoy the activity rather than whether they learn from it. In the desired state, as reported by
museum staff, attitudinal reinforcement such as visitor enjoyment remains the primary focus,
consistent with the actual state of informal science education. Perhaps the difficulty of evaluating
visitor learning is related to the fact that the literature includes few reports of long-term assessments,
with most being surveys mailed to the past visitors after a period of time (Falk & Dierking, 1997;
Falk, Koran, Jr., & Dierking, 1986; Stevenson, 1991). The viewpoints of these surveys tend to be a
matter of memory making it difficult to analyze the real degree of visitor learning. Though rarely
done, visitor learning can be assessed by tailoring an instrument based on their educational goals
and the main ideas of each activity. Also, a long-term impact of activities can be assessed by
administering a visitor survey at regular intervals (monthly, biweekly, or weekly). This method
samples different visitors each time, but provides a measure of the general effectiveness of the activity across a long period of time. This type of evaluation requires training of personnel and special treatment of the repeating respondents and probably formal procedures in the operations manual. However, designing and using instruments that measure visitor learning is possible enough, as reported in one of the visitor surveys in this study, if we focus on the specific visitor learning desired. In the on-line survey in this study respondents gave little support to longitudinal assessments, perhaps because they have seen but a few.

Museums would learn more about their goals and operations if assessment measures the degree of visitor learning and achievement of goals of the institution as well as of the activity itself. It would also provide objective, universal, and direct information of the degree without biases so that every one can interpret the identical data in the same way. The ideal assessment would also include clear and easy questions for the visitors to answer; this would enable the staff to assess the activity over a long period of time.

2. Professional development sessions provide a good opportunity for staff to acquire general knowledge in science education and natural science.

Data indicate administrators wish to use professional meetings for professional development, while practitioners (exhibit developers and program planners) prefer informal seminars within and outside of the institution. Both administrators and practitioners gave publishing in journals a low mean score, indicating that they do not see this activity as valuable professional development. Except for this item, the comparisons showed a clear gap between administrators and practitioners.

As Dierking et al. (2003) suggest, research articles that are based on a through literature review and research methodology provide more relevance to institutions broadly. Such studies require training that is usually beyond typical museum staff. Graduate schools are the usual place where students take courses in research design, qualitative and quantitative data analyses, and
fundamentals in (informal) science education, and the informal science staff who finished the formal education at the end of the undergraduate program usually do not have a chance to acquire those skills. This makes it difficult for them to publish journal articles or have presentations at professional meetings, especially when the meetings have a peer-review system.

Conference registration is another barrier, as it is almost always too expensive for the staff to pay for by themselves. Since institutions have limited budgets and can send only a small number of the employees, practitioners have less chance to attend the conference or utilize resources there than do the administrators.

This could be solved by holding local or regional meetings, as they have low cost. Although the current regional meetings do not fully function to grow research skills of the staff, the regional meeting would be a chance for novice staff researchers to learn how to conduct research as well as for the experienced staff to have presentations based on their research. University researchers can be advisors of the sessions to provide suggestions from a research professional point of view. This regional meeting generally would make the staff more familiar with formal research methodology as well as how to present research.

The practitioner’s strong focus on informal seminars for both the actual and desired states might go beyond low cost, as they can be held more frequently than conferences, require less professional skills in managing data, and fit circumstances of individual institutions or local areas. Presentations at conferences and journal articles provide visibility as well as generalizability in the sense that suggestions and information may be broad as to where they can be located, who the target audience is, and what area of science they deal with.

However, at conferences and with journal articles, the staff can acquire knowledge and skills of designing instruments and conducting assessments promoting visitor curiosity, and all presentations contain some generalized or universal conclusions. Generalizability is important so
that the informal science staff can share information broadly and adapt the educational disciplines, process, and procedures to their own circumstances. By building a variety of skills and knowledge through these resources, the informal science staff can improve ongoing activities and create new ones, which bring enhanced learning for visitors. Generalizability also has much to do with assessment of the activities, in the sense that it produces fair results without bias.

No respondent group rated knowledge in science education or natural science as important components for their current professional development, either in the actual or desired state or not. In the actual state, the administrators did not rate research on visitors or scientific research as useful components of the roles of operation. Further questions can be raised here: How do they expect to acquire knowledge in science and science education; how do they design scientifically valid and educationally effective approaches in activities; and how do they assess the validity of contents and educational effectiveness besides attitudinal reinforcement?

Starting with communication and instructional skills, as the results show, is essential as all activities are based on those skills. As the next step, it can be strongly recommended to include content knowledge and knowledge in science education in professional development sessions. More content knowledge provides a wider variety of activities, and knowledge in science education helps convey the content knowledge effectively and appropriately, as well as enhancing instructional skills. Knowledge in science education provides a view of how visitors think, understand, and make meaning of the objects and activities. Using this knowledge, the ongoing activities can be improved to achieve more complete knowledge construction of visitors based on their prior knowledge combined with experience in informal science settings. It is also good that they build partnerships with other institutions, because in the process they communicate their findings and problems as relationships are developed. If they start using resources of conference presentations and journal articles, this may lead them to be involved in a broader network of informal science institutions,
resulting in more active communication of their educational operations and acquisition of
generalized knowledge.

3. K-12 partnerships can be an initial step in bridging between institutions and their visitors.

In responding to the actual state, administrators answered that they have partnerships with
K-12 schools, with other partnership targets not being so common. Exhibit developers had more
partnerships with other informal science institutions while program planners tended to have
partnerships with other informal science institutions as well as K-12 schools.

All pairwise comparisons among administrators, exhibit developers, and program planners
showed statistically significant difference for the actual partnerships with K-12 schools. These
responses reflect the nature of their jobs; program planners work with K-12 schools by offering
lessons, while exhibit developers focus more on the public in general. It is worth noting that
administrators focus on K-12 schools, with much higher mean scores than for any other options.
Even though results showed K-12 partnerships as the most frequent actual state response, the
respondents answered that they desired more such partnerships.

Although no literature supports these results, the reason why K-12 partnerships are a larger
focus than any other partnerships can be explained as follows. Partnerships with K-12 schools are
different from the other partnerships. The informal science staff design partnerships with K-12
schools to offer museum experience to teachers and students. The partnerships with universities and
industries, however, imply that they take resources and expertise to design activities. This means the
K-12 partnerships are directly influenced by educational effectiveness of the institution; the
administrators can expect more attendance of school groups by offering educative activities, and
thus the program planners are concerned about the status of K-12 partnerships, since they are
responsible for and are the primary contacts with school group activities.

The answers to several other questions asked in the survey support a strong focus of
partnerships with K-12 schools. Practitioners aim at providing more easily understandable activities by enhancing communication and instructional skills. In addition, the exhibit developers are concerned with acquiring ideas about exhibit design. Results of the visitor survey that investigated expectations toward on-site lessons indicated that teachers wish to have their students exposed to science learning that gives broader perspective beyond the walls of classrooms. This means that they expect some learning and, thus, some measure of successful lessons becomes the extent to which the participants learned during the lesson. If this is true, there is an essential need for powerful assessment systems that evaluate educational effectiveness, visitor understanding, and the state of knowledge construction of students, all of which can and must be administered as summative and front-end evaluations.

K-12 partnerships have a great potential to develop effective activities. Four reasons support the notion that partnerships with K-12 schools can be an initial step in bridging between institutions and their visitors. First, making links with formal science education leads to structured museum activities. Formal science education has curriculum to follow and content knowledge is structured accordingly throughout the grades. As students progress through the grade levels, students deal with different natural phenomena and relate knowledge in the science learning, thus the content knowledge becomes broader. Therefore, activities with links to multiple grade levels add breadth to visitor learning. A second reason is that people’s cognition develops dramatically between grades K and 12. By covering all the developmental stages between these age levels, various outputs can be designed in an activity, providing depth of learning.

Third, since knowledge taught in K-12 schools is generally said to be our basic education, museums can play a significant role in building this base. And fourth, family groups usually are composed of young adults and school students, meaning that a focus on K-12 partnerships leads to designing effective activities for families, and thus, the general public.
One example promoting public understanding through K-12 partnerships is to use an activity that consists of several modules, all expressing the main idea. The modules can include exhibit components, hands-on material boxes, or lesson plans. Each module contains its own main idea as well. Such coordinated modules are designed to have a link to content knowledge of formal science education, covering both depth and breadth. Modules can be structured that way, but still give visitors freedom to try all modules or a module or two that attracted their interest. In this way, the principle of free-choice (Falk & Dierking, 1992, 2000, 2002) is left, yet depth and breadth are included so visitors can learn with clear ideas and see the full scope of a concept.

4. An Operations Manual must direct the informal science institutions to achieve better educational operation.

No respondent group answered positively to any options as being necessary components of an operations manual. This may result from respondents not having an operations manual or, perhaps they do not have a clear vision of one. Responses related to the actual inclusion of components showed a remarkable difference between administrators and practitioners. Administrators answered that their operations manual is currently effective in terms of strategic planning, visitor behavior and understanding, and partnerships. However, the practitioners did not find any of these effective. Obviously, administrators and practitioners view their current museum realities from vastly different perspectives or, the manual may not be effective for practitioners because of their emphasis on developing visitor attitude, as indicated by the other questions. Respondents did not currently assess science learning, so most of their focus on assessment is on attitudinal reinforcement; none sees learning of knowledge in science or science education as important for professional development. This, too, reflects satisfaction with the current state.

Data indicate the actual state of museum educational operations are based on the staff’s past experiences. Where operations manuals exist, they are rarely research-based and build on current
operations with little thought of future evolution. Yet, clearly, in the desired state an operations
manual for the next generation would provide a rationale or guide to achieve excellence. Such
excellence in an operations manual would clearly point out the importance of aiming at educational
assessment and lead to effectiveness of all facets of operation. A desired manual would promote
staff professional development that would lead to this effectiveness. In this model, assessment
becomes the basis of all educational operations, playing a significant role in all areas of the manual.

Survey results clarified that staff use assessment findings in activity design. But, since
evaluations are rarely done before design, much effort is wasted. This makes explicit that front-end
evaluations, done prior to design or implementation, need to be called for in the operations manual.
Front-end assessments would investigate states of mind (knowledge level, background, and
curiosity) of visitors, allowing for data-driven decision making rather than decisions based solely on
staff experience or intuition. By conducting front-end evaluations, museums would be one step
ahead of the normal pattern of activity evolution. By providing such details of operation, the desired
operations manual would represent ideal visions of components of educational operations so that a
given institution would have a guide to the future rather than just a manual for the present.

Stretching a bit further, one can envision a generalized operations manual, based on the
commonalities desired by all informal science education institutions, that would apply research
findings and best practice ideas to all kinds of informal science education, with all their diverse
topics and visitor profiles. If developed properly, all can refer to this generalized or universal
operations manual, selecting from it or modifying it to develop ideas and operations that fit their
circumstances.

Although we have some insight, further research is needed to closely examine the perceptions
of both administrators and practitioners toward informal science education. Further research might
reveal more immediate desired or actual visitor behaviors such as facial expressions or subjective
behaviors, and help us understand the attracting and holding power of particular variables, perhaps allowing us to track of visitors in terms of expected outcomes of informal science education.

The data for the surveys of this section would have been more compelling if the numbers of respondents had been greater. Additionally there are problems and threats of administering an on-line survey. These include: (1) While providing ID numbers or access code to the instrument is effective to reduce the possibility of the same respondents participating multiple times or inappropriate persons (not informal science staff) who might fill in it, setting ID takes time and some respondents feel that the investigator might identify who filled in the survey, reducing response rates; (2) The number of questions seems to relate to response rate, leading to attempts to create shorter surveys that might not provide adequate discrimination or validity.

Another issue with the on-line survey instrument was its inclusion of the response option “Not Applicable (N/A),” indicating that the question did not fit their actual operation. For example, in the instrument for the administrators, Item 12 asked, “To what extent have you found the following helpful in your operations manual?” In this item, the option N/A was supposed to be marked when they do not have an operations manual. However, some respondents wrote “Why do you assume we have an operations manual?” in the blank space at the end of this item. This implies that this and possibly other survey instructions were not clear about using the N/A option.

The next item, 13, asked “To what extent would specific revisions and additions to your operations manual help you?” In this item, the respondents were expected to rate their desired state on a 5-point Likert scale, whether they have a manual or not. Thus this item did not include N/A. Since the instrument asked the actual and desired states of the operations manual one after another, it is possible that the respondents who did not have an operations manual got confused about how they should answer. This kind of confusion was seen at some other places in all three instruments, again leading to some questions about validity of the responses.
Confusion might also have occurred as the instrument aimed at simplicity by reducing many potentially necessary words and phrases in an attempt to reduce the total length. In the future, there are some possible ways to reduce the confusion; (1) ask all of the questions about the actual state first, and then ask the questions of desired state; (2) clearly mention “if this question does not fit the operations of your institution, please mark it N/A”; and (3) rephrase the question such as, “This item asks you about the effectiveness of your operations manual. Please rate its effectiveness. The next item asks you for further or desired needs in an operations manual; please rate how much would you like to enhance the item as described.” In addition, additional pilot testing would have reduced such an issue if a draft instrument had been administered between the steps of validity check and implementation.

Survey 2--The Visitor Survey Regarding Effectiveness of the Main Idea of Exhibits

This survey sought answers for research question 2-g, How do the main ideas of exhibits enhance visitor understanding? No statistically significant differences between the various classes of respondents were found in this survey. While these data suggest that providing the main idea does not help visitors understand exhibits, three problems were identified that could have influenced the data, possibly causing the non-significant results.

1. A problem regarding the sample visitors

Many responding visitors failed to answer all questions, implying that many respondents had low motivation to complete the survey. Future research might avoid this problem by designing the instruments to avoid short-answer questions and provide rewards that encourage respondents to complete the survey. Multiple-choice or Likert-type questions, rather than short answer questions, makes it easier for the respondents to answer and may motivate respondents to participate in the survey. These types of questions would also reduce the threat derived from the scoring rubric.

The second solution, appropriate rewards to motivate visitors, might be achieved by
investigating other possibilities, such as providing them rewards that offer opportunities for science learning. These might include giving scientific toys rather than candy, literature that introduces interesting information about science or nature, opportunity to participate in an engaging class or workshop (possibly with a discount rate), or a chance to take a guided tour inside the institution (perhaps behind the scenes). Providing respondents with choices of rewards might also encourage participation. The key is visitor’s thinking it is worthwhile to participate in the survey. And, if the reward can achieve a relationship with science learning, it becomes educative to the respondents, doubling the educational effectiveness.

2. A problem regarding target exhibits

The target exhibit, Tropical Connections Hall, had a special intention or message for visitors. The Hall expresses the relationships between North Carolina and the tropics, while all the other exhibits display natural features within NC. Perhaps this transition in message is too abrupt or unexpected for the visitors to shift their view from the matters within NC to the matters between NC and the tropics. Many respondents wrote that the main idea of Tropical Connections Hall was protecting nature from destruction caused by human needs. This is a common issue everywhere, even outside of the Museum, and Tropical Connections Hall includes a few exhibits about the issue. However, as the official website of the Museum states, Tropical Connections Hall has a broader idea beyond environmental destruction. Visitor responses might often be led by their preconceptions. Using an exhibit that is more consistent with the museum’s main or more consistent messages might have led to different results.

3. A problem of survey design

This survey followed a standard procedure for demonstrating validity of the instruments and sampling method. However, many respondents marked 0 or 1 in scoring the responses and no statistically significant difference was found between groups. In analyzing these results, three
concerns can be mentioned: (1) a format of short-answer questions might have been difficult (in this sense, validity check was not complete); (2) the choice of the target exhibit might have been inappropriate, as mentioned above; and (3) the scoring rubric might have been inappropriate (though it was deemed valid by the Museum staff).

Regarding the first, perhaps face validity was not an appropriate method to check the instruments. Tropical Connections Hall requires a rapid transition of viewpoints and the instruments may not be sensitive to such circumstances. In this case, while staff provided face validity, checking wording, feasibility of the questions and sampling and appearance of the instruments, visitors may not have seen the items in the same light or with the same views of what each question had do with the exhibit (Ecological validity) (Gall, Gall, & Borg, 2003). Therefore, Hawthorne Effect (Gall, Gall, & Borg, 2003) and the extent that individuals are aware of participating in an experiment, are aware of the hypothesis, or are receiving special attention that might improve their performance, should have been taken into account. Finally, selection of more appropriate target exhibits with face validity might have resulted in a more accurate analysis, without such a risk.

The main idea of Tropical Connections Hall was difficult for the visitors to grasp as it tells the visitors about relationships between NC and the tropics, which is special to the Museum. Thus, future surveys of effectiveness of the main idea need to select more suitable target exhibits, perhaps using specific criteria for selection. Possible criteria are: (1) an activity that represents the goals of the institution directly more broadly; (2) an activity that represents the main idea directly; and (3) an activity that is not too well-known among the public (so that the public does not have too many biases in advance).

**Survey 3--The Visitor Survey about Label Preference**

This survey provided answers for Research question 2-h, what kind of exhibit labels do the visitors like? This survey clarified that no single, special feature was found as an effective label for
the visitors and thus label preferences are seen as diverse. However, responses showed that some visitors prefer labels with clarity so that they can find out what the label is trying to tell them at a glance. For instance, when the respondents examined the Modified Exploratorium Model, which was designed in a four-page book format, some visitors examined all pages from the first to the last in order, while others skipped the label, examined the other three labels first, and came back to the Modified Model to examine it. This implies that the respondents who first skipped the Modified Exploratorium Model either wanted to skim all the labels and come back to each label to examine each closely, or were reluctant to take actions on any particular label and were attracted by the Modified labels later. This behavior suggests that if a label is to be designed so that it requires an action by the readers, the action should be easy or attractive to visitors. Also, some visitors who chose the Exploratorium Model indicated that if they did not need to leaf through the pages to acquire the information, they would prefer the Modified Exploratorium Model rather than the Exploratorium Model. This suggests that they preferred the contents of the Modified label but in an easier format.

Visitor choices are based on their own taste and needs and precision varied according to the respondents, perhaps related to their needs. McCarthy (1987, cited by Serrell, 1996) categorized museum visitors into four groups: (1) Imaginative learners who learn by listening and sharing ideas and who prefer interpretation that encourages social interaction; (2) Analytical learners who prefer interpretation that provides facts and sequential ideas; (3) Common-sense learners who like to try out theories and discover things for themselves; and (4) Experimental learners who learn by imaginative trial and error. McCarthy’s diverse categories would predict results with similar diversity. At this point, however, we don’t know if the informal science staff expect such diversity or if they would meet visitor needs.

Visitors did prefer interpretive labels (Exploratorium Model and Modified Exploratorium
Model) over analytical labels (Title and Caption). Based on McCarthy’s category, it is likely that Imaginative and Experimental learners chose interpretive labels, and Analytical and Experimental learners chose interpretive learners. This result might also support that back-of-the-scene information satisfies visitor curiosity and stimulates positive attitude toward learning. Interpretive labels also might make them feel that they learned while visiting the exhibit. It would be interesting to repeat this part of the study while obtaining data that would categorize visitors using McCarthy’s types.

Visitor behavior may also have been a factor. During the first two hours of the survey period, 23 groups of visitors passed by the survey station and 15 groups out of the 23 did not make any stop at Prehistoric North Carolina exhibits where the target exhibit is displayed. This behavior was perhaps never expected by the staff when they offered their perceptions of the face validity of the items. This behavior might have been caused by breadth of the aisle-- a little less than 4ft-- perhaps narrow enough that visitors are concerned with blocking other visitors or the posture of the target exhibit makes it difficult to see (it is displayed almost horizontally so that visitors can see how it has been preserved when it was unearthed). The glass cover placed to protect it from damage might have made it difficult for the visitors to pay attention.

Research needs to be conducted to see how exhibits work in public areas with no attendants and why, as well as making a closer examination of visitor behaviors. At the same time, a methodology to attract visitors and enhance learning needs to be developed so that exhibits can have more influence on them. And, choosing an exhibit for research needs to take into consideration a variety of potential visitor responses, such as not stopping.

Some respondents refused to participate in this survey because they were nervous about providing personal information such as age and gender. The instrument did not include a question that asked the respondent’s highest education, despite the suggestion of one of the professional
researchers who checked for validity. If that question had been included in the survey, it might have taken even more time to collect 70 samples, or it might have been impossible to collect as many as 70 samples. In this sense, treatment of personal data requires careful consideration to assure visitor confidence and data reliability.

Further research needs to be done in terms of; (1) the relationship between label preference and visitor’s learning styles as defined by McCarthy (1987, cited by Serrell, 1996) in order to define the concept of “precise” according to visitor learning style; and (2) find a way to put analytical information, including back-of-the-scene information, on a label concisely. For those purposes, the following two surveys can be proposed: (1) administer continual surveys on a format of the Modified Exploratorium Model with the aim of including back-of-the-scene information; and (2) to design a new label format with the aim of including graphics, back-of-the-scene information, the clear main idea, and constructing knowledge on anticipated prior knowledge of visitors. As Serrell (1996) states, diversity in visitor preference for labels encourages exhibit developers to provide a variety of ways for visitors to perceive and process information. Furthermore, thinking about label styles also helps them accept the task of motivating people as a primary responsibility, something useful for all museum practitioners.

Survey 4--The Visitor Survey about Visitor Expectations toward On-site Museum Lessons

In answering Research question 2-i, What do the visitors expect from the on-site museum lessons? a set of two surveys for school students and their teachers was designed. The surveys showed that (1) the students’ expectations closely correlated with their teacher’s expectations; (2) the major expectations of the teacher who takes students to museum on-site lessons are represented as broadening student perspective beyond the wall of schools in terms of meeting with other people and knowing science that exists outside of the textbook while providing students with a chance to learn science in a friendly atmosphere.
Based on the results of this survey, it appears that museum on-site lessons must offer classes that deal with special learning topics that the students cannot learn in classroom science or that support school science. Institutions can also offer special or unique opportunities such as back-of-the-scene information related to the topics and how a researcher came up with the findings or discovery or what the importance of his or her discovery might be. In order to achieve these, the instructors of on-site lessons must check their activities to see if they satisfy the visitor’s expectations mentioned above and, if not, they must consider what to do in order to satisfy them. Instructors must ensure efficiency and clarity of the lesson as well because on-site lessons are usually the only aspects of informal science education institutions with time limits.

This survey clarified some expectations of science teachers and their students. Although the lessons took place in informal institutions during instruction by informal staff, students are still placed within a framework of formal science, indicating that it is quite natural that the students would be influenced by their teacher. But, further research needs to be done in other settings such as adult classes, teacher education classes, or school groups with different developmental (age) levels.

This survey, indicates it would be effective for the instructors to keep the National Science Education Standards (NSES) and/or the education standards in their states or counties for reference on a regular basis. Since the NSES and other standards indicate what to include in K-12 science lessons, staff can compare it to their current and future lessons and, perhaps, determine what is new or relevant to the lesson participants and their teachers. If the instructors are in charge of adult lessons, they can refer to newspapers, popular science magazines, TV topics and the AAAS publication *Science for All Americans* (AAAS, 1989) as well.

The assessment of on-site lessons might threaten instructors who feel that they are being evaluated on their abilities, rather than investigating the general effectiveness or value of on-site lessons. While this makes it difficult to assess the effectiveness of on-site lessons themselves, an
alternative is a visitor survey to investigate visitor expectations, such as the one in this research, as one way to avoid this threat.

This survey ended up investigating participants’ expectations toward the lessons; however, a more comprehensive analysis is needed relating to consistency among the results, the lesson plans, and the goals of the lesson at a higher level in order to create more effective on-site lessons. Furthermore, if such a consistency can be documented, it would be very useful in instructor training sessions and in providing grounding for an effective operations manual.

Visitor expectation varies according to individuals, environment, and timing of the lesson. To maintain currency of data, visitor surveys must be used routinely in order to modify the lesson plans as needs occur and to know the evolving tendencies of visitors. For the same reasons, assessment methods for daily operations must become routine. However, again, while evaluation of the ability of the instructor is ultimately necessary, it should not be included in the assessment of effectiveness of the lesson. Also, for more appropriate assessment of the effectiveness of the lessons, more systematic assessment instruments need to be designed as opposed to just administering a subjective questionnaire that asks how the participants enjoyed learning or how the lesson was useful. Rather, assessment instruments must look at what visitors learned or whether they got the main idea of the lesson. Assessments need special care so that the lesson participants do not feel that they are tested on the extent of what they learned (outcome-based evaluation). A form of concept mapping might be one of the ways to satisfy these conditions, providing the instructor or investigator has the skill to develop the instrument and analyze the data.

The survey used in this study needs to be improved in terms of the instrument design. The primary goal of the survey was to investigate the effectiveness of the on-site lessons. However, the instruments had to be designed to assess visitor expectations in order to avoid evaluating the instructor’s behaviors. While knowledge of visitor expectations lets the staff imply how the lessons
work, it does not provide definite data to show the effectiveness of the lessons themselves, especially because the survey site of this survey, Curiosity Class, was managed by many instructors including both staff members and docents. To deal with such a circumstance, new perspectives are needed to assess the effectiveness of the lessons. It might be assessment of instructor performance, lesson plans, participant understanding if time allows, or a combination of all.

Survey 5--Designing Assessment Instruments for Daily Operations

This survey answered research question 2-j, What are considered effective assessment instruments for daily operations? This survey took two steps: development of an assessment instrument for an interactive area, Discovery Room, according to the staff’s needs; and implementation of the instrument to see how well it worked for the staff to know visitor behaviors. In this survey, the assessment instrument was designed to be easily used by both the investigator and respondents, while providing clarity of data for the investigator.

The detailed instrument development procedure is described in Chapter 3. As for the effectiveness of the instrument, the results provided the staff with direct information about which activity is effective and which is not, and the staff increased their knowledge about visitor behavior and refined their further needs regarding the Discovery Room activities. Informal conversation with the staff from other divisions indicated that this assessment instrument also enhanced staff awareness about what to include and how to develop instruments to assess the effectiveness of visitor learning, not just attitudinal reinforcement. In other words, the existing assessment tended to focus on the respondent’s subjective ideas such as popularity or enjoyment, but staff realized that instruments needed to include objective measures such as the degree of understanding or engagement in activities. In this way, this survey drew attention to the importance of assessment of daily operations in general. Assessments of daily operations need to be feasible, longitudinal, and continuous. However, most examples of assessment reported in journal articles are not suitable for
daily operations as they are typically either assessment of special events, short-term assessment, or too complex to implement routinely for daily operations.

This survey for the Discovery Room may have been successful because the Room is not a public area, but an interactive space where docents or the staff always work with the visitors and the instrument was able to be totally customized to the coordinator’s immediate needs. Further research is needed to refine how routine assessments might function for the daily operation of public areas where visitors walk around freely without any intervention by staff.

Informal Science Education for the Next Generation

Based on the survey results and discussions, the following two sections seek to answer research question 3, How can we achieve the desired state? This section starts by clarifying what has been achieved in informal science education (the actual state) and what has not (the desired state). Next, development of an Educational Scheme for Informal Science Institutions is proposed with an anticipated format as a possible way to achieve the desired state. Third, in the next section, some future implications are described from three viewpoints: what research is needed in order to complete an Educational Scheme; what informal science education must do to develop and demonstrate maximum potential in education; and some final thoughts about how an Educational Scheme might help to accomplish the desired state of informal science education.

What Has Been Achieved and What Has Not?

Informal science institutions usually have sufficient materials, such as specimens and devices. Most staff possess sufficient knowledge, instructional skills, and positive dispositions, all of which enable them to construct processes and procedures. Furthermore, the five surveys in this study suggest several ways to enhance the educational potential of each institution. Especially, the four visitor surveys enabled development of more accurate assessment instruments in order to investigate the actual state of visitors.
However, coordination between materials and others (processes and procedures) has not been implemented enough yet, or processes or procedures depend on the staff’s intuition, without a solid manual to maximize the educational potential. Furthermore, as the results of the on-line survey administered to the informal science staff clarified, they do not have a clear vision of education (processes) or operations manuals (procedures). In addition, institutions have not maximized chances for visitor learning and the building of networks connecting knowledge and people are incomplete. Two causes can be mentioned as possible reasons for this inconsistency. One is that museum activities cannot fully meet the visitor’s needs until we know more of the nature of these needs. We also lack evaluations of the extent to which visitors wish to learn science in informal science institutions. Indeed no research has reported a front-end evaluation based on this viewpoint.

Some institutions may lack resources (materials, ideas, knowledge, appropriate instructors, and so on) or use them inappropriately, causing inefficiencies in attaining the institution’s goals. A system that enables the staff to develop themselves and to arrange suitable resources within and outside of the institution would allow them to demonstrate their full educational potential. Strategic partnerships might help this, but, as the on-line survey indicates, partnerships with other informal science institution, universities, and industries have not been developed.

As many have noted, a vital aspect of informal science education institutions is that they provide the visitor with free choices in what to study, how to do it, and for how long. With this in mind, maximal efficiency must involve visitors learning by themselves. Visitors will learn in their own ways and museums must ensure that visitors are not inhibited in this freedom, while maximizing opportunities for learning. Visitors also take messages from activities prepared for them, develop knowledge through the activities, and broaden their perspectives. Contrary to many existing museum activities that focus on introducing and explaining scientific concepts and natural phenomena, the desired museum must aim at allowing and enhancing individual knowledge
construction, regardless of prior experience of the visitor.

_The Need for an Educational Scheme for Informal Science Institutions_

We must fill in the gap between the actual and desired states of informal science institutions so that staff can progress toward their own desired state of museum operations. Even within a relatively unstructured environment, we must shift the educational focus to one of providing visitors with structured opportunities to construct useful and meaningful knowledge. By putting effective activity designs into practice through arranging possible resources and staff, we can derive maximum potential in education. A systematic operations manual that is based on research and tied to the local goals and resources guide this resource arrangement. But, for an informal science education institution to be able to implement such a manual requires that the manual be developed so that any kind of informal science education institution, at any time in its evolution and development, can see value in it and use it effectively. This tension between a universally useful operations manual and one that local museum staff see as guiding their own particular efforts requires careful research, consideration, and presentation. As a final conclusion this study proposes as a brief idea the documentation and development of such a manual, called here an _Educational Scheme for Informal Science Institutions._

The _Educational Scheme for Informal Science Institutions_ (Scheme) would provide informal science educators with principles of education and guidelines for practice to enhance their educational effectiveness in daily operations. Practical and universally usable by all kinds of informal science institutions that welcome diverse visitors, the Scheme respects and encourages the initiative of each institution, but each institution must know its own goals, resources, and ideas well in order to demonstrate maximum potential in education. The Scheme would also enable coordination of materials, processes, and procedures, maximizing the common flow of learning and enhancing visitor knowledge construction and long-term learning. The common flow of basic
learning can be seen as the order of see (curiosity), think, and touch (Brittain, 1994). Higher-order learning can be represented as the order of understanding, creativity, and presenting or exchanging information.

Since informal science education institutions allow visitors to implement these types of learning with excitement and enjoyment, informal science education is viable and valuable. Visitors who experience this learning order will be encouraged to increase enthusiasm, inquire into things, socialize, and communicate with the staff and other visitors. Besides the value of knowledge construction, museum learning can develop networks among museums, between the staff and visitors, and among visitors. Such interactions between ideas and people develop a learning community with an intermediary of the world of science itself. All of this would be enhanced by the order represented in a systematic operations scheme. Thus, the Scheme integrates and coordinates people, ideas, and materials and lets the institutions appeal to staff, visitors, and the outside agencies or people.

The Scheme will contain three aspects in terms of its roles and values:

1. It achieves coordination of materials and others (process and procedures);

2. It plays the role of consultant, offering sufficient suggestions based on any anticipated goals and activities of a broad array of institutions, and allows for diverse visitor behaviors and curiosity; and

3. It helps develop three networks: (a) a Museum-Museum network, (b) a Museum-Visitor network, and (c) a Museum-Outside network. “Outside” includes any external resources such as universities, industries, and local amateurs.

Possible contents of the Scheme are goals/roles of informal science institutions, a rationale for activities (exhibits and programs), assessment, and professional development of the staff. Some of these might include rich descriptions of specific processes and procedures while others might
describe how to develop these. In all contents, the Scheme must consist of both practical and universal suggestions that are based on research findings and that fit the broad and specific goals of individual institutions.

Some Final Thoughts on Improvement of the Sampling Methods- Future Implications

Both the on-line and visitor surveys were administered to volunteer respondents due to the difficulty implementing either random or stratified sampling. Though this happens often in educational or social studies research, the sampling methodology needs to be refined in order to obtain more accurate results that truly reflect the actual state of visitors.

All surveys in this study, especially the on-line survey, had such small samples, and resulting low power, that it is risky to generalize much from the results. Enlarging the sample size to achieve adequate a priori power values could be achieved by setting a longer time span for survey administration or by having more researchers administer the surveys. Second, asking volunteer monitors for opinions about the institution’s operation might be helpful. Although providing no quantitative data, opinions from those who would like to contribute something, from appreciations to further implications, could provide valuable suggestions based on their insider’s perspectives. In the future, the researcher needs to estimate more carefully the effort necessary to collect a desired sample size. For example, in the survey about effective labels, many people were attracted to the sample labels that were prepared for the survey and they volunteered to participate. It was easy to collect the desired 70 responses for this survey. But, in the survey of Tropical Connections Hall, the investigator found it difficult to collect the same number of samples even after spending far more time on the collection. From these two surveys, it can be implied that the reward (a piece of candy) was not an important factor in a visitor deciding whether or not to complete the survey. The determinant then seems to be how the survey attracted them at a glance and how it made them feel that their responses would contribute to the institution’s operation. Therefore, it seems, positive
willingness of the respondents provides rather accurate data even though it is collected through convenient sampling.

Third, avoiding biases in the survey by managing responses increases reliability of the data. One way to do this is by providing an identification number to each sample. By doing this, it becomes possible to prevent multiple participation of a respondent and to limit unauthorized people from completing the survey. The on-line survey used the listserv of the Association of Science-Technology Centers (ASTC), allowing for all with access to this web site to complete the survey, collecting more reliable responses with high motivation toward the survey. While one could rely on the responses from those who responded, numerous biases would be evident in such a procedure.

The visitor surveys were administered in the North Carolina Museum of Natural Sciences, which has a keen focus on biology, ecology, geology, and paleontology of North Carolina in addition to the relationship with the tropics. More data is needed from different institutions such as science- and technology-related museums, science centers, and children’s museums (which focus more on education and where the target audience is younger than found in most museums), university museums, and specialized museums such as mine museums, or health museums. Broadening this study to include more institutions of a variety of types would enhance both the validity of the data collected as well as generalizability.

What Additional Research Is Needed to Develop the Scheme?

Data from this study prompted thinking about the need for an Educational Scheme for Informal Science Institutions and provided an initial step toward its development. To further this idea, additional research and work is needed:

1. Administer a visitor survey aimed at people who claim they do not like learning or museums, including those who are visitors but do not stop to look at exhibits. Knowing why some never
visit museums and why a few visitors just walk through the aisle without paying attention to exhibits would be useful to improve the current operations. This survey would also clarify visitor behaviors that do not fall in any of McCarthy’s categories (McCarthy, 1987, cited by Serrell). This survey could be administered as a form of a series of workshops. During the workshops, the investigator would keep counseling participants about how they regard museum learning, what prevents them from learning, and in what ways they wish to visit museums. These workshops could show the value and back-of-the-scene information of the museum, frequently checking the participants’ reactions and responses, as well as responding to visitor’s needs appropriately. These workshops will also possibly clarify the fifth tendency of visitor learning noted by McCarthy.

2. Develop a guideline for assessment of daily operation and a front-end evaluation. Since many informal science staff find it difficult to provide longitudinal assessments or daily operation assessments, a guideline which can be used universally will be helpful for them. For example, since the assessment instrument for the Discovery Room aimed at ease of use for the staff to administer routinely and for a long-term, it would be possible to develop a useful guideline based on this experience. In addition, the main reason why the activities need be designed to fit a broad range of visitors’ needs is because of the lack of front-end evaluation experience on the part of developers. Usually front-end evaluations are administered unofficially (Korn, 1994) and are among the most difficult of formative, summative, and front-end evaluations. However, if front-end evaluation methods were systematically and feasibly developed, visitor learning would be enhanced. Together with the workshops and surveys of people who do not like learning in museum settings, this would help develop a Museum-Visitor network while training the staff.

3. Synthesize the findings of informal science education research. A synthesis of research findings is an urgent need in order to develop a theory base for informal science education research. As Hein (1998) points out, because of the lack of a solid, well indexed and well documented research
literature, it is not easy to answer questions such as; What is actually known about how humans learn, about effective practice in education, and about the conditions of learning? He also emphasizes that a synthesis of past and current research literatures provides “certainty” and makes us appreciate how current research is built on previous work and incorporate it, and how all of it is relevant to one’s own research. Such a synthesis of literature enhances both educational practices and educational research and establishes the research area of informal science education as well as enhancing theorization.

4. Organize a venue to share information among informal science educators. At this moment, no societies focus only on research-based education for informal science settings. For example, the American Association of Museums (AAM) deals with any kind of museum including art, history, and cultural. The ASTC, on the other hand, deals with science-related museums, but includes broad topics such as providing management data, methodology of fund-raising, and cost-benefit analyses in addition to enhancement of educational operation. Informal science institutions for the next generation need to be more focused on goals of formal or informal science education. The new venue must have such focused goals and it must be where everyone who is engaged in informal science education can communicate their experiences and attempts based on research. This will enhance a Museum-Museum network, a community of informal science institutions and research.

Also, the venue must provide opportunities for informal science institutions to arrange suitable resources to represent their goals in activities. These resources include ideas, objects, and personnel. Currently, an ASTC listserv functions as a coordinator where a person asks for information needed in his or her activity design and the readers respond to the request. Related to this, volunteers from the October 2005 ASTC annual conference held in Richmond, Virginia, started to organize a special interest group for small informal science institutions. They seek to
enhance communication among informal science educators by establishing special sessions at the ASTC annual conferences, listserv and through videoconferencing, establishing resource banks of expertise, connecting institutions to more formal mentor programs, and seeking ways to have partnerships with other organization such as the AAM and Association of Youth Museums (Hostetler, 2005). This group (for now, it is named the Small Museum Development Group or “smidge”) is now an informal group, but it is certainly an initial step of creating a Museum-Museum network. In addition, it would be effective to get amateur collectors or experts outside of the institutions involved in this group so that informal science institutions can enhance their educational potential, resulting in a Museum-Outside network.

What Direction Do Informal Science Institutions Need?

The Educational Scheme for Informal Science Institutions would be a universal operations manual to enhance education. Including daily operations of design, development, education, administration, and assessment, this Scheme could help institutions become more powerful and effective at their missions. This Scheme could also help institutions design outcome-based evaluation tools that enable them to check the extent of visitor learning (Friedman, 1993; Roberts, 2001; Sheppard, 2000), in addition to existing experience evaluation (Roberts, 2001).

This dissertation study includes evidence that assessment plays a key role in development of the Scheme. Everything should be based on firm evidence provided by assessment: we need assessment to know what visitors learned, visible reactions of visitors, and prior knowledge of visitors. All of these are helpful in making decisions related to activity design and how the activities work effectively for visitors. This study, at the same time, provided evidence that current assessment practices are not as effective for assessing these aspects as we expected. Improving assessment procedures must be a first effort if we are going to fully develop the potential of informal science education institutions. After we create an effective, reliable, and universally usable
documentation of assessment procedure, development of the other components of the Scheme will be accelerated because the procedure tells us what and how to do in order to produce accurate results based on the actual state, helping improve and create activities.

Although research on development of the Scheme has been started, it will never be complete as it is ever-developing. Therefore, it must have a variety of applications so that it can fit any line of progress of science and technology, as well as changes in societies and educational systems. For the Scheme to have full application, a number of case studies are needed as well as a venue to communicate among all informal science educators, from administrators to practitioners. The Educational Scheme for Informal Science Institutions, as a universal operations manual, will be formed and renewed as need arises.

However, the educational philosophies of informal science education institutions are relatively stable, no matter how much time passes or how science, technology, and society change. This is the largest and most definite difference between philosophy and applications. The goal of informal science education that aims at knowledge construction (personalization of knowledge) of visitors (Allen, 1998; Silverman, 1995) must be sustained despite any changes in society or across time. For that, too, theorization of research findings on informal science education through academic communications of case studies is a definite need.

Informal science institutions have focused on displaying objects and putting explanations with them. Most research has examined effectiveness based on how visitors enjoyed rather than how and what they have learned. Informal science institutions for the next generation must do even more, becoming as scientific as the processes they exhibit and teach about, studying their own operations in scientific ways. Museum exhibits and activities should reflect the latest research and understanding about how people learn and what motivates them. Rather than explaining everything about an activity, they must stimulate and prepare visitors to continue learning after leaving the
institution. By allowing visitors to leave without having everything explained visitors can keep their
museum experiences in mind and try to learn even more. Institutions must offer broad and deep
educational opportunities based on visitor knowledge level and interest. To be all they can be,
museums must promote a higher level of education for the public, not by offering explanations of
concepts or phenomena, but by offering scientifically and educationally structured and effective
learning opportunities for visitors to learn and enjoy.
REFERENCES


Korn, 1999


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Appendix A. The Visitor’s Bill of Rights

* Comfort- “Meet my basic needs.”
Visitors need fast, easy, obvious access to clean, safe, barrier-free restrooms, fountains, food, baby-changing tables, and plenty of seating. They also need full access to exhibits.

* Orientation- “Make it each for me to find my way around.”
Visitors need to make sense of their surroundings. Clear signs and well-planned spaces help them know what to expect, where to go, how to get there and what it’s about.

* Welcome/belonging- “Make me feel welcome.”
Friendly, helpful staff ease visitor’s anxieties. If they see themselves represented in exhibits and programs and on the staff, they’ll feel more like they belong.

* Enjoyment- “I want to have fun.”
Visitors want to have a good time. If they run into barriers (like broken exhibits, activities they can’t relate to, intimidating labels) they can get frustrated, bored, confused.

* Socializing- “I came to spend time with my family and friends.”
Visitors come for a social outing with family or friends (or connect with society at large). They expect to talk, interact and share the experience; exhibits can set the stage for this.

* Respect- “Accept me for who I am and what I know.”
Visitors want to be accepted at their own level of knowledge and interest. They don’t want exhibits, labels or stag to exclude them, patronize them or make them feel dumb.

* Communication- “Help me understand, and let me talk, too.”
Visitors need accuracy, honesty and clear communication from labels, programs and docents. They want to ask questions, and hear and express differing points of view.

* Learning- “I want to learn something new.”
Visitors come (and bring the kids) “to learn something new,” but they learn in different ways. It’s important to know how visitors learn, and assess their knowledge and interests. Controlling distracting (like crowds, noise and information overload) helps them, too.

* Choice and control- “Let me choose; give me some control.”
Visitors need some autonomy: freedom to choose, and exert some control, touching and getting close to whatever they can. They need to use their bodies and move around freely.

* Challenge and confidence- “Give me a challenge I know I can handle.”
Visitors want to succeed. A task too easy bores them; too hard makes them anxious. Providing a wide variety of experiences will match their wide range of skills.

* Revitalization- “Help me leave refreshed, restored.”
When visitors are focused, fully engaged, and enjoying themselves, time stands still and they feel refreshed: a “flow” experience that exhibits can aim to create.

Appendix B Cover letter of the on-line survey

Hello all,

I am a doctoral student in Department of Math, Science and Technology Education at North Carolina State University. I am currently working on my dissertation under the supervision of Dr. John Penick and in my dissertation I am seeking to develop a scheme for the operation of educational activities in informal science education settings. In particular, I am looking for common themes and policies that might be universally applicable.

My research employs a broad survey that examines goals/roles, activities (exhibits and programs), assessment and professional development in museum settings. The survey consists of three instruments in the form of questionnaires: one for exhibit developers, one for museum educators who are in charge of programs, and another for directors or staff in charge of administration.

I need your expert opinion to represent the actual circumstances and needs that are addressed in these survey instruments. If you are interested in participating in the survey, please go to the following URL: http://ced.ncsu.edu/2/mathsci/museum/index.html and answer the questions. I will be grateful if you could complete the survey by November 24, 2004. If you wish to contact me, please do so through the email address below.

Thank you in advance for your kind consideration.

Sincerely,
Midori Suzuki
email: Midori_Suzuki@ncsu.edu
Appendix C. The survey of the effectiveness of the main idea toward exhibit understanding

Visitor survey- Tropical Connections Hall (without the main idea)

Please make a short answer to the following questions after your visit.

1. What did you know about Tropical Connections exhibits prior to the visit?

2. What do you think are the main ideas of these exhibits?

3. What kind of relationships do North Carolinians have with tropical forests?

4. Please provide background information about you.
   a) How old are you? (______ ) years old.
   b) Are you male or female? (Please circle one.) Male Female
   c) Is this your first visit to Tropical Connections Hall? Yes No
      If no, how many times did you visit to the Hall? (______ ) times

Thank you for your cooperation!
Please read the introduction below before your visit to this section. It provides the main idea of the Tropical Connections exhibits. After exploring the exhibits, please answer the questions on the back. (Please do not read the questions until finishing your exploration.)

The central concept behind the Tropical Connections is that any place in the world is connected with and has interrelationships with any other place. North Carolina and the tropics have a lot in common as well.

In the Tropical Connections gallery, explore the relationships that North Carolina shares with the tropics. Listen as people discuss environmental concerns shared by the two regions. Track migratory butterflies and birds on a fiber-optic globe. Discover the importance of biodiversity, at home and in the tropics.
1. What did you know about Tropical Connections exhibits prior to the visit?

2. Did the main idea provided on the other side of this sheet help you to understand the whole exhibits? Please circle the number that shows your feeling.
   1. Yes, very much.
   2. Yes, moderately.
   3. I’m neutral.
   4. Not so much.
   5. Not at all.

3. What kind of relationships do North Carolinians have with tropical forests?

4. Please provide background information of you.
   a) How old are you? ( ) years old.
   b) Are you male or female? (Please circle one.) Male Female
   c) Is this your first visit to Tropical Connections Hall? Yes No
   If no, how many times did you visit to the Hall? ( ) times

Thank you for your cooperation.
## Rubric for Tropical Connections Hall Survey

<table>
<thead>
<tr>
<th>Score</th>
<th>definition</th>
<th>examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>nothing</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>not much/ little</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>some/ a little</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>enough</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>very much</td>
<td></td>
</tr>
</tbody>
</table>

### Item #1: What did you know about Tropical Connections exhibits prior to the visit?

<table>
<thead>
<tr>
<th>Score</th>
<th>definition</th>
<th>examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Blank answer.</td>
<td>I don’t know.</td>
</tr>
<tr>
<td></td>
<td>Does not find a main idea.</td>
<td>A good one.; I enjoyed about Tropical Creatures.</td>
</tr>
<tr>
<td></td>
<td>Does not answer the question.</td>
<td>To teach the relationships shared by humans and animals in the NC forests.</td>
</tr>
<tr>
<td></td>
<td>Gives inaccurate description.</td>
<td>To educate me.</td>
</tr>
<tr>
<td>1</td>
<td>Does not address an idea represented</td>
<td>God created it and its beauty should last forever.</td>
</tr>
<tr>
<td></td>
<td>in the Hall.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Addresses an idea represented in the Hall, but</td>
<td>How much species are diverse.</td>
</tr>
<tr>
<td></td>
<td>do not address “connections.”</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Addresses an idea represented in the Hall, as</td>
<td>How we in NC are connected to the environment of the tropics and raise</td>
</tr>
<tr>
<td></td>
<td>well as includes “connections and totally</td>
<td>our awareness so we will know why it’s important to conserve the tropics.</td>
</tr>
<tr>
<td></td>
<td>accurate.</td>
<td></td>
</tr>
</tbody>
</table>

### Item #2: What do you think are the main ideas of these exhibits?

### Item #3: What kind of relationships do North Carolinians have with tropical forests?

<table>
<thead>
<tr>
<th>Score</th>
<th>definition</th>
<th>examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Blank answer.</td>
<td>Nothing.</td>
</tr>
<tr>
<td></td>
<td>Does not find a relationship.</td>
<td>I’m not from NC.; A lot of relationships.</td>
</tr>
<tr>
<td>1</td>
<td>Does not address a relationship represented</td>
<td>Some N. Carolinians have been done or would like to have a job that deals</td>
</tr>
<tr>
<td></td>
<td>in the Hall.</td>
<td>with tropical forests.</td>
</tr>
<tr>
<td></td>
<td>Does not answer the question.</td>
<td>Humidity.</td>
</tr>
<tr>
<td>2</td>
<td>Addresses a relationship represented</td>
<td>The exhibit shows that life in the tropics is similar on many levels to</td>
</tr>
<tr>
<td></td>
<td>in the Hall with some inaccuracies and lack</td>
<td>life in the North.</td>
</tr>
<tr>
<td></td>
<td>of concreteness.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Addresses a relationship represented</td>
<td>Some of the same species live NC on their migration south.</td>
</tr>
<tr>
<td></td>
<td>in the hall and totally accurate.</td>
<td>Share some vegetation and animal life.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Migration of birds.</td>
</tr>
</tbody>
</table>
Appendix D. The survey of the effective labels

Please answer the following questions about this exhibit.

1. What about Willo did you know prior to your visit?

2. Please circle the number of your most favorite label. #1 #2 #3 #4

3. Why do you like that label?

4. Please provide background information about you.

   How old are you? (Please circle one.) under 18 18 – 30 31 – 50 over 50
   Are you male or female? (Please circle one.) Male Female

   Thank you for your cooperation!

Please answer the following questions about this exhibit.

1. What about Willo did you know prior to your visit?

2. Please circle the number of your most favorite label. #1 #2 #3 #4

3. Why do you like that label?

4. Please provide background information about you.

   How old are you? (Please circle one.) under 18 18 – 30 31 – 50 over 50
   Are you male or female? (Please circle one.) Male Female

   Thank you for your cooperation!
Willo- A Dinosaur with a Heart

Kingdom Ornithischia
Phylum Genasauria
Class Cerapoda
Order Ornithopoda
Family Hypsilophodontidae
Genus Thescelosaurus
Species neglectus

Age Late Cretaceous (66 million years ago)
Location Hell Creek Formation, South Dakota
Size 4m long, 300kg (13ft long, 665lb)
Collector Mike Hammer
What are the odds of finding a fossilized dinosaur heart? Until recently, most specialists would have said slim to none. But the seemingly impossible has occurred within the 66-million-year-old skeleton of a small, plant-eating *Thescelosaurus*, nicknamed 'Willo'-- and the structure of the heart is surprisingly advanced.

It is the first dinosaur ever found to contain a fossilized heart. Although soft tissues such as skin have previously been discovered, this is first time the structure of an internal organ was preserved.

Scientists in North Carolina and Oregon used medical technology to probe an iron-stained concretion inside the dinosaur's chest. With imaging equipment, they succeeded in reconstructing 3-D structures through the interior of the concretion. The images reveal a heart that was more like that of a bird or a mammal than those of reptiles, adding substantially to evidence suggesting that at least some dinosaurs had high metabolic rates.
What to do:
Look at the skeleton of “Willo” closely.

What to notice:
You can see something round in the chest.
What do you think the round object is?
It is a fossilized dinosaur heart!

So what?
Usually soft tissues like skin or hearts do not fossilize. This specimen is the first discovery of a fossilized internal organ. An iron-stained concretion was found inside the chest. The iron came from the blood inside the heart, not from the surrounding sediments. Imaging technology reveals a heart similar to a bird or mammal. This discovery suggests that at least some dinosaurs would have been warm-blooded.
What does this *Thescelosaurus* skeleton tell you?

-Look at the round object in the chest of “Willo.”
It is a fossilized heart of this dinosaur. Usually soft tissues like skin or hearts do not fossilize. This specimen is the first discovery of a fossilized internal organ.

How do we know it is a heart?
1. Three dimensional imaging technology revealed that the structure is very much like a heart, with ventricles and aorta.

2. Also, researchers found an iron-stained concretion inside the chest. The iron came from the blood inside the heart, not from the surrounding sediments.

How is this discovery important to dinosaur studies?
Researchers found that the structure is similar to that of birds and mammals.

This suggests that this dinosaur species had a high metabolic rate, and might have been warm-blooded.
Student Survey- Curiosity Class

What do you expect from your program at the Museum? Please circle the faces that best describe your feeling.

<table>
<thead>
<tr>
<th>To touch rocks, live animals and plants</th>
<th>Yes</th>
<th>Maybe</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>🧡</td>
<td>🧡</td>
<td>🧡</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>To meet people who work in the Museum</th>
<th>Yes</th>
<th>Maybe</th>
<th>No</th>
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<tbody>
<tr>
<td></td>
<td>🧡</td>
<td>🧡</td>
<td>🧡</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>To have fun</th>
<th>Yes</th>
<th>Maybe</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>🧡</td>
<td>🧡</td>
<td>🧡</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>To learn cool things that only a museum can teach</th>
<th>Yes</th>
<th>Maybe</th>
<th>No</th>
</tr>
</thead>
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<td></td>
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<td>🧡</td>
<td>🧡</td>
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<table>
<thead>
<tr>
<th>Learn something new</th>
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<th>Maybe</th>
<th>No</th>
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<td>🧡</td>
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<table>
<thead>
<tr>
<th>To be in a friendly atmosphere</th>
<th>Yes</th>
<th>Maybe</th>
<th>No</th>
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<tbody>
<tr>
<td></td>
<td>🧡</td>
<td>🧡</td>
<td>🧡</td>
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</table>

<table>
<thead>
<tr>
<th>Learn things without being graded</th>
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<th>Maybe</th>
<th>No</th>
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<td></td>
<td>🧡</td>
<td>🧡</td>
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</table>

Thank you for your cooperation.

Student Survey- Curiosity Class

What do you expect from your program at the Museum? Please circle the faces that best describe your feeling.

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<th>No</th>
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<td>🧡</td>
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</tbody>
</table>

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<th>Maybe</th>
<th>No</th>
</tr>
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<th>Maybe</th>
<th>No</th>
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<td>🧡</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Learn things without being graded</th>
<th>Yes</th>
<th>Maybe</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Thank you for your cooperation.
Teacher survey- Curiosity Class

1. Background information about you.
   
a) How long have you been teaching? (     ) years.

b) Were you trained in natural science? (Please circle one.) Yes  No

c) How often do you take your students to science-related museums or centers?
   (     )

2. How much do you expect each of the following to be part of the Curiosity Class?

<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>Not much</th>
<th>I’m neutral</th>
<th>Moderately</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using the Museum’s collections such as rocks, live animals and plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instruction by Museum staff who are knowledgeable about natural science</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear messages that I can apply to my classroom teaching</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade specific instruction that extends my students’ prior knowledge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning that is free from grades</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. What benefits do you expect the Museum class to provide to you and your students?

Thank you for your cooperation.
Dear teachers who participated in the Curiosity Class survey,

Regarding your visit to Curiosity Class on November 10, please answer the following question quickly: **What did you tell your students about the visit to Curiosity Class?**

Please circle the number that best describes what you told your students.

1. I told them that we were going to take a lesson "Animal Detectives" in NC Museum of Natural Sciences and briefly told them what we would learn in the lesson.

2. I told them that we were going to take a lesson “Animal Detectives” in the Museum, but did not tell them the detail of the lesson.

3. I told them that we were going to visit the Museum, but did not tell them that we would take the lesson.

Thank you so much for your cooperation.
Appendix F. The survey of the effective assessment

Discovery Room Visitor Survey

Please tell us about your family.
Number of adults ( )

Please circle the most appropriate answer for your family.
(1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree)

1. Discovery Room was inviting. ----------------------------------------------- 1 2 3 4 5
2. The staff was friendly. ------------------------------------------------------- 1 2 3 4 5
3. The staff was knowledgeable about the Room. ---------------------------------- 1 2 3 4 5
4. The specimens and the boxes enhanced learning. ----------------------------- 1 2 3 4 5
5. The staff was helpful in answering our science or nature questions. -------- 1 2 3 4 5
6. The staff was available when we needed to talk. ----------------------------- 1 2 3 4 5
7. We learned something about science or nature in the Room ------------------ 1 2 3 4 5
8. The materials in the Room were interesting to our children. ------------------ 1 2 3 4 5
9. Visiting this Room will enhance our next family nature experience. -------- 1 2 3 4 5
10. The Room balanced learning and playing opportunities. --------------------- 1 2 3 4 5
11. The Room enhanced our appreciation of natural world. --------------------- 1 2 3 4 5
12. We would come back again. ------------------------------------------------- 1 2 3 4 5

Please circle on the three most interesting exhibits to your family.

Thank you for your cooperation!
Please return to docent desk!