DEVELOPMENT OF AN EVALUATIVE INSTRUMENT FOR USE IN THE ASSESSMENT OF EXHIBITS IN AN INTERACTIVE SCIENCE GALLERY

by
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ABSTRACT

The purpose of this study was to develop and test an exhibit evaluation instrument which would provide an objective mechanism for measuring the effectiveness of interactive science exhibits. The instrument was to be of a generalizable design so as to be appropriate for use with a variety of exhibits.

Information which was used to guide the development of the instrument was gained from previously published studies, and from a survey of science centres in Canada and the United States.

A goal-referenced approach to evaluation was followed in the design of the instrument. An exhibit was considered to be effective if it achieved its stated objectives. The instrument design employed two methods of gathering data: unobtrusive observations and structured interviews.

Testing of the instrument occurred during the months of March, April and May, 1989 at the Touch The Universe Gallery of the Manitoba Museum of Man and Nature. One hundred intermediate grade level students were observed. The three indicators used to determine an exhibit's effectiveness were: (1) the level of enjoyment provided to the visitor; (2) the extent to which a visitor's curiosity was stimulated; and (3) the ability of an exhibit to transfer its information content to the visitor.

Five randomly selected exhibits were used to test the instrument. The exhibits achieved their stated objectives to varying degrees. In general the instrument performed well, in that it was easily administered and provided a great deal of information regarding visitor use of selected exhibits.

DEDICATION

To Leslie A. Wurtak
wife, friend

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Finally, appreciation is expressed for the support and understanding of the author's family during the study.

George J. Wurtak

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CHAPTER 1. INTRODUCTION

1.1 Purpose of the Study

The purpose of this study was to develop and test an exhibit evaluation instrument which may be generalized for use with a variety of interactive exhibits. The instrument will provide an objective mechanism for assessing the effectiveness of interactive science exhibits in science centres and museums, with reference to their objectives. Specifically, the instrument will determine:

1. if visitors find interaction with a selection of interactive museum exhibits enjoyable;

2. if visitors find the experience 'stimulating' in that they encounter something that excites their curiosity[1]; and

3. if the exhibits effectively communicate their information content to the visitors.

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[1] Adapted from Harlen et al. (1986). Evaluation of the Pilot Phase of the Liverpool Interactive Technology Centre.

1.2 Background and Rationale for the Study

By the time children finish high school, they have spent 11,000 hours inside the classroom, and roughly 65,000 hours outside of it.[2] As Falk[3] suggests, it is clear that a major portion of the information children acquire about the world originates from sources other than school. Learning is a lifelong process that occurs not just in school, but in many places and at many points in an individual's life. Museums are considered to be vast educational resources which have the potential to serve as significant alternative environments for self-education.[4] They contribute considerably to out-of-school science experiences for visitors of all ages and characteristics.[5] Science museums and science centres generally have as a main goal increasing public understanding of science and technology.[6] Flexer and Borun[7] assert that science teachers utilize participatory

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[2] Medrich et al., 1981. The serious business in growing up: A study of children's life outside school.

[3] Falk, J.H. (1985). Search for Excellence in Informal Education.

[4] Decrosse, A. et al (1987); Hofman, H. (1973); Herbert, M. (1981); Mbago, M. (1983); Screven, C.G. (1976); Washburn, W. (1975).

[5] Koran J., S. Longino and L. Shafer. (1983). A Framework for Conceptualizing Research in Natural History Museums and Science Centers.

[6] Bridges, M. and L. Sianchuk, (1986); Carnes, A. (1986); Danilov, V. (1984); Stevenson, J. (1987); Ucko, D. (1983).

[7] Flexer, B.K. and M. Borun. (1984). The Impact of a Class Visit to a Participatory Science Museum Exhibit and a Classroom Science Lesson.

science museums to provide visual and kinesthetic learning experiences that are qualitatively different from the experiences associated with classroom lessons or printed text. Such nonformal and experiential learning opportunities enhance the individuals' understanding of the world around them and can be valuable as part of the education of school children and the general public alike. This is particularly true for understanding the sciences and technology, due to the nature of the types of learning best suited to these subjects (hands-on and through inquiry).

Twenty years ago, Oppenheimer[8] suggested that because science is a creative, exploratory, and problem-solving activity there is a growing need for an environment in which people can become familiar with the details of science and technology by seeing, handling and controlling laboratory apparatus and machinery. Seventeen years later, the need still exists. Some recent studies[9] indicate that out of school science experiences may play a valuable role in supplementing school science. It is evident that there is a place for out of school experiences, particularly those which

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[8] Oppenheimer, F. (1968). A Rationale for a Science Museum.

[9] R.E. Yager and J.E. Penick, 1985. Excellent Non-School Programs: The Search.

provide a real world interactive experience to complement the the structured science experiences which may be found in many schools and homes. Such experiences can provide special science enrichment value for children across the spectrum of ability, from the talented and gifted, to the average child, to the deprived or disabled child.

Our world is rapidly being reshaped by recent developments in science and technology. It is difficult for the average citizen (including school teachers) to keep abreast of new developments, as this information is often well - understood only by those individuals who are specialists in the field. Any mechanism which supplements the information and experiences provided by schools can act as an important enhancement to one's learning. All students can benefit by an early introduction to science through hands-on interaction in an environment rich in science resources.

Science centres are institutions that supplement formal education with an informal approach that allows visitors to accomplish first-hand learning, not only in science, but also in subjects such as mathematics, art, reading, cross-cultural education, nutrition and health. Hands-on exhibits, which comprise the bulk of exhibits in science centres, have been regarded as being very successful in

holding visitors' attention, and of encouraging learning by doing.[10]

Science centres provide a supplement to a child's formal education and encourage adults to continue learning. Such informal settings are known to have immense potential as learning resources for persons of all ages.[11] Museums and other informal environments are taking steps to foster science literacy among members of the community. Russell (et al)[12] stated that "there is a growing awareness amongst various sections of the community - scientific bodies, educators, museum personnel and the media, for example - of the need to make 'science' more accessible to the general public". Science museums share with government research agencies and the media the responsibility of informing the public about developments in science and technology. In doing so, these areas can be demystified. Concepts and applications are often conveyed to the museums' visitors in a participatory manner. Such experiences stimulate inquiry and may, to some extent, satisfy a visitor's thirst for knowledge. It is widely acknowledged that students who visit a science centre generally have an enjoyable and educational experience. However, the informal education sector has been historically

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[10] Bridges, M. and L. Sianchuk (1986); Dunitz, Robin J. (1985); Van Dorn, B. (1984).

[11] Falk, J. H. (1985). Search for Excellence in Informal Education.

[12] Russell T. et al. (1987). Developmental Stage Evaluation of Interactive Exhibits at Jodrell Bank Science Centre.

remiss in being accountable for its efforts. Greater efforts must be undertaken to determine the effectiveness of informal education exhibits and programs.[13]

Every year, millions of people stream through museums - young people and old people - people with varying degrees of education, people alone and in groups, from near and far.[14] Museums must develop methods to best serve this diverse audience, and the means through which they can determine which methods are most effective. As a result of their rapid growth and the shortage of research information about what makes an effective science centre, questions prevail regarding the extent of their success. Quite apart from questions of the physical and aesthetic aspects of exhibition spaces, including exhibit sturdiness and safety, pleasant artistic design, logical exhibit placement, label copy readability, and so on are the questions for which answers are much more difficult to determine. Such challenging questions attempt to determine the extent of educational impact an exhibit has on a visitor. There is a growing interest in structured investigations of museum exhibits and programs.[15] While numerous authors have

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[13] Falk, John H. (1985). Search for Excellence in Informal Education.

[14] Bitgood, S., D. Patterson et al (1986); Falk, John H. et al (1985); Gould Dunbar, N. and M. Borun (1980); Lord, B. and G. Dexter Lord (1988); Moore, R. (1988).

[15] Zyskowski, G. (1983). A Review of Literature on the Evaluation of Museum Programs.

argued the importance of exhibit evaluation,[16] few studies of the educational effectiveness of museum exhibits have been published[17].

The limited amount of research in this area is understandable. There is at present only minimal information available which describes how, what, and even why, people learn in nonformal settings. Formal measuring is difficult, time consuming, and still well in the realm of experimental psychology.[18] The luxury of having a reasonably homogeneous population of learners (e.g. age, knowledge, experience, often socioeconomic status) is not available to educators in nonformal environments. The settings are informal and novel, and the duration of visitor contact with exhibits is short. As a result, research information from other areas, such as education, may not be suitable for the museum environment.[19] In these settings, there is a wide range of visitor age, ability and interests. Satisfaction must be afforded to the entire visiting audience, and not limited to only one subset of the general public. Experimental control in these settings is difficult to achieve without changing visitors' behaviour

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[16] Griggs, S. (1981); M. Linn (1976); C. Screven (1976); Yallow, Strossen, Jennings, and Linn (1980); G. Zykowski (1983).

[17] Boggs, D. (1977); M. Borun (1977); R. Peart (1982).

[18] Alter, P. and R. Alter (1988). Exhibit Evaluation: Taking Account of Human Factors.

[19] Van Dorn, B. (1984). Science Museums and Science Education.

or overly detracting from their museum experience.[20] The study of effective exhibit techniques is a complex field; many factors (e.g. size, position, design, signage) can affect visitors' understanding of and response to a display.[21] Consequently, the relatively few museum educators and evaluators must contend with a complex system to evaluate, with only a small body of knowledge at their disposal. There remains a considerable amount of investigation to accomplish regarding educational evaluations of exhibits.

The majority of museum evaluation studies accomplished to date have been concerned with demographic surveys and visitor perceptions rather than educational evaluations or learning research.[22] An assertion has been made by Boggs[23] that museums give relatively little attention to systematic assessment of what they contribute to the education of the casual, unguided visitor whose purpose is, at least in part, recreational. Diamond[24] reports that there have been few systematic investigations of how social factors, and teaching in particular, operate in the science museum. The general lack of cohesiveness, the loose structure to most of the

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[20] Borun, M. et al. (1983). Planets and Pulleys: Studies of Class Visits to Science Museums.

[21] Borun, M. and M. Miller. (1980). What's In A Name?.

[22] Eason, Laurie P. and Marcia C. Linn. (1976); G. Zyskowski (1983); R. Loomis (1988).

[23] Boggs, David L. (1977). Visitor Learning at the Ohio Historical Center.

[24] Diamond, Judy. (1986). The Behavior of Family Groups in Science Museums.

thinking and terminology used, and a lack of any kind of research base to back up the various assertions regarding effective exhibits has been described by Shettel[25].

Further research in science centres and science museums will enable a better understanding of how they serve as resources for science learning in our society, as well as gaining important insights into the mechanisms by which public learning occurs. In order to maintain their audience, museums must pay close attention to the effectiveness of their exhibits and programs. As Falk[26] stresses, "it is particularly essential that programs in the free-choice world of informal learning actively seek to respond to the needs, interests, and experiences of the learner, for if they do not, the learner will not come back a second time (if even for a first)."

Cognitive testing in museums has been conducted occasionally in attempts to measure museum-based learning[27]. Extent of visitor learning results from these studies are inconsistent. Behaviour studies[28] indicate that visiting time per exhibit is short, and that few labels are read. From behaviour studies, the assumptions are that little, if any, learning by the visitor occurs during a visit. Research

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[25] Shettel, Harris H. (1973). Exhibits: Art Form or Educational Medium?

[26] Falk, J.H. (1985). Search for Excellence in Informal Education.

[27] Shettel, (1968); Washburn, (1975); Eason and Linn, (1976); Boggs, (1977); Borun, (1977); Serrell, (1980); Peart, (1982).

[28] Bitgood, S. et al (1987); Harlen, W. et al (1986); Pitman-Gelles, B. (1981).

through alternate approaches is required in order to determine the extent of information-transfer occurring during a museum visit.

Further investigation of the effectiveness of exhibits is required. Shettel's important study[29], which involved exhibit rating by museum experts (curators, directors, designers), revealed that there is no agreement among them as to what makes a good exhibition. Research is still required to determine the types of exhibit techniques that are most successful in conveying information from museum staff to visiting public. Screven[30] argues that the way in which the physical design of an exhibit affects the motivational, perceptual, affective, and learning potentials of unguided visitors in the informal museum environment is not well understood. Answers to such questions are vital to the success of an institution of learning.

As Joel Bloom, Director of the Franklin Institute, stated[31]:

> "In order to understand and utilize the full educational potential of the museum, we must include meaningful evaluation procedures in our operating programs and engage in innovative research into the mechanisms of museum learning."

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[29] H.H. Shettel, 1968. An Evaluation of Existing Criteria for Judging the Quality of Science Exhibits.

[30] Screven, C.G. (1986). Exhibitions and Information Centres: Some Principles and Approaches.

[31] in M. Borun, 1977. Measuring the Immeasurable: A Pilot Study of Museum Effectiveness. ASTC.

1.3 Definition of Terms

Museum: A non-profit permanent establishment not existing primarily for the purpose of conducting temporary exhibits, exempt from federal and provincial government taxes, open to the public and administered in public interest, for the purpose of conserving and preserving, studying, interpreting, assembling and exhibiting to the public for its instruction and enjoyment, objects and specimens of educational and cultural value (Canadian Museums Association, 1977).

Science Centre: A major institution which has substantial emphasis and commitment in two fundamental areas - "science and technology" and "informal education" and which is expected to include the use of interactive exhibits and experiential learning programs in a museum setting (Association of Science-Technology Centres, 1978). These institutions often deliberately set out to have few collections and distance themselves from science museums by stating nonformal learning as their primary purpose (Orchiston and Bhathal, 1984; Baird, 1986).

Interactive exhibit: an exhibit which encourages visitors to physically participate in the learning experience; it provides

the opportunity to touch, manipulate, and interact with the exhibit (Danilov, 1982).

Interactions: all actions made by a subject once he/she has been initially attracted to the exhibit. In order to be considered a subject for the study, the visitor must have spent a minimum of two seconds focussing attention on the exhibit.

Label copy: written material in, on, or near an exhibit which provides directions, information, or explanations associated with the exhibit.

Gallery: an area containing a collection of exhibits which examine or contribute to a particular theme or storyline (Peart, 1982).

Stimulating: encountering something that provides excitement and/or surprise (Harlen et al, 1986).

Formal learning settings: institutions in which the learner is officially registered, and the activities usually involve a systematic sequence of courses and lessons which are arranged to specific time offerings and examinations (Beer, 1985). Formal learning settings include schools, colleges, and universities.

Nonformal learning settings: environments outside of formal learning settings which provide recreational, voluntary, experiential, and perceptual learning opportunities (Beer, 1985).

Attracting power: the number of subjects from the target population who stop and look at any part of an exhibit.

Holding power: the actual viewing time (total seconds the subject remains stopped at an exhibit)

Effectiveness: the extent to which an exhibit or gallery achieves its goal(s) or objective(s).

Cued visitor: a visitor who has been informed of the study, prior to his/her involvement in the study.

Non-cued visitor: a visitor who has not been informed of the study prior to his/her involvement in the study.

TTU: Touch The Universe Science Gallery

1.4 Limitations and Assumptions to the Study

Limitation 1

In order to conduct unobtrusive observations of visitors interacting with the exhibit, the evaluator was required to observe the interactions from a distance. This may have limited the accuracy of recordings of some behaviours (e.g. reading exhibit text).

Limitation 2

The correct conveyance of visitor perceptions of various aspects of the exhibit was limited by their ability to verbally articulate thoughts and feelings to the evaluator.

Assumption 1

The interviewed visitors are honestly cooperating with the study in describing their perceptions.

Assumption 2

The sample is representative of the larger population of English speaking school children in the intermediate grades.

1.5 Thesis Overview

The rationale and purpose of the study has been provided in Chapter 1.

In Chapter 2, a survey of literature works pertinent to this study is given. An introduction to the functions and types of science centres is presented together with a description of the Touch The Universe science centre (implementation site) and a review of previous studies of science centres. Also presented in Chapter 2 is a brief discussion of goal-referenced evaluation.

The methodology used in developing the instrument is described in Chapter 3. Results from the science centre survey are provided, as is a rationale for the instrument design. The method of implementing the instrument is also described in this chapter, following a discussion of the selected exhibits and the population.

Chapter 4 presents and discusses the results of the analysis. A comparison is made among the group of exhibits for both observed actions and responses to interviews, and individual exhibit effectiveness is discussed.

The final chapter summarizes the findings of the study and appropriate conclusions are stated.

CHAPTER 2. LITERATURE REVIEW

2.1 Structure of the Literature Review

In order to provide a knowledge base relating to the area of this study, the review of the literature focusses on four areas:

1. An overview of the recent growth, the changing philosophies, and the educational roles of science centres.

2. A description of the Touch The Universe science gallery (site of the instrument implementation) and of the findings from its previous evaluation.

3. A review of previous museum evaluation studies which have been carried out in science centres, organized by the specific type of visitor study.

4. A brief discussion of the goal-referenced model of evaluation, which was used in this study.

2.2) Introduction to Science Centres

Public Acceptance

The past several decades have seen the development of many hands-on Science and Technology centres in the Western World. In 1975 there were about 30 museums of contemporary

science and technology in North America.[1] As of 1984, the membership of the Association of Science-Technology Centers reached 150 institutions, with approximately 100 of them in the United States.[2] Canada has been a leader in modern times in science center development. In the last three years, several major science centres have been developed in Western Canada, and recently a proposal was made to establish a billion dollar network of science centres in Alberta.[3] World-class science centres may be found in Canada, and as in the rest of the world, these are heavily used by the visiting public. Annual attendances of several million people at large science museums are common. In 1980, the Ontario Science Centre attracted about 1.5 million visitors per year[4], total attendance at the National Air and Space Museum in Washington, D.C. was approximately 5.5 million, and several others have annual attendance levels between three and five million.[5] Attendance at science-technology centres increased

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[1] Danilov, V. (1975). Science Museums as Education Centers.

[2] Van Dorn, B. (1984). Science Museums and Science Education.

[3] In April, 1989, Jim Gray, Executive Vice-President of Canadian Hunter Exploration Ltd. challenged the Provincial and Federal governments, the Corporate sector, and the general public to raise $1 billion for the construction of four science centres in Alberta.

[4] Moriyama et al. (1980). The Sudbury Science Centre.

[5] Gould Dunbar, Nancy and Minda Borun. (1980). The Science Museum Audience.

dramatically throughout the 1970's. In 1981, the annual attendance of science centres and museums that were at least partially science centres was approximately 40 million.[6] Science centres certainly appear to have been accepted by the North American public. According to Kimche[7], more people visit science museums than any other single type of museum[8]. A 1974 study showed that 38 percent of all museum visits were to science museums, 24 percent to history museums, and 14 percent to art museums. A 1979 survey showed an even higher science museum attendance: 45 percent of visits were to science museums, as opposed to 24 percent to history museums and 12 percent to art museums.[9] If attendance trends are considered to be indicators of acceptance, then science centres must be considered to be well accepted by the North American public.

Changing Philosophy of Science Centres

While museums of science and industry are not new to the museum world, the rapid expansion of science centres has brought with it a new philosophy of museum exhibits. Jerome Bruner's view that the learner should be involved in the act

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[6] Gould Dunbar, Nancy and Minda Borun. (1980); V. Danilov (1982)

[7] Kimche, Lee. (1978). Science Centres: A Potential for Learning.

[8] Of the 345 million people who attended 5,985 museums in the United States, 160 million, or 45% of the total attended the 861 science-related museums (14% of all museums).

[9] Danilov, Victor J. (1982). Science and Technology Centers.

of discovery is widely held by educators.[10] Many contemporary museum educators also share the important idea that active participation heightens the acquisition and retention of information.[11]

Today's science centres are remarkably different in philosophy from early science museums. A typical goal statement of a modern science centre is reflected by the statement of Science North's (one of the newest centres in Canada) mission:

> " The mission of Science North is to provide a stimulating, bilingual program of formal and leisure learning involving people in the relationship between science and technology and everyday life ...".[12]

This statement, which is typical of the modern science centre philosophy, differs considerably from the philosophies of early science museums. The Henry Ford Museum (established in 1929) was the first large-scale museum of science and technology in the western hemisphere. This museum's first mission statement was one of dedication to preserving America's heritage. An explicit declaration of public education as a main purpose was missing from this statement.

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[10] Eason, Laurie P. and Marcia C. Linn. (1976). Evaluation of the Effectiveness of Participatory Exhibits.

[11] Shettel, Harris H. (1973). Exhibits: Art Form or Educational Medium?

[12] Science North's Mission Statement, 1988.

The current goal involves the display of its huge collection to reflect American history, and to inform and educate the public in terms of how technology changed America.[13]

The New York Museum of Science and Industry (1930) - the first of the contemporary science and technology museums in the United States - was modelled after the efforts of new industrial museums in Europe. These attempted to popularize science and technology by displaying exhibits that moved and by encouraging people to handle the exhibits. Public participation with exhibits was the major milestone in the departure from the old to the new philosophy. The New York Museum had a goal of being "primarily educational rather than primarily historical".[14]

One of the pioneering and most popular science centres in the United States is San Francisco's Exploratorium, built in 1970. Its theme is human perception, and its exhibits focus on "simple science". Director Frank Oppenheimer believed that understanding the world in which we live is not only enjoyable and addicting, but probably essential to our survival.[15] Another major science centre, the California Museum of Science and Industry in Los Angeles, sees its more informal approach to education as complementing formal

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[13] Adams, G.D. (1988). Understanding and Influencing Word-of-Mouth.

[14] Danilov, Victor J. (1982). Science and Technology Centers.

[15] Cole, K.C. (1982). On Simple Science.

schooling. The Museum, and others like it, make interactive exhibits, computer classes, resource centres, and creative, expert staff available to teachers as well as the general public.[16]

Canada's oldest and probably best known science centre is the Ontario Science Centre, founded in 1969. This centre, located outside Toronto (in Don Mills) is " a substantial and well-established, predominantly interactive display of scientific and technological achievement".[17] Although it has existed for decades, its visitors benefit from ongoing exhibit change, as is common at most current science centres. Among the newer science centres in Canada is Sudbury's Science North (opened in 1984). It has incorporated many of the now widely-accepted strategies and philosophies for innovative science learning into its exhibits, facilities, and programs. Some of its interesting features are: a "swap shop" for specimen and information trading, the use of exhibit "explainer" staff, and "object theatres".[18]

One of the possible motivations for the shift in science centre philosophy, in display techniques and type

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[16]Dunitz, Robin J. (1985). Interactive Museums.

[17]Silverstone, Roger. (1988). Museums and the Media: A Theoretical and Methodological Exploration.

[18]Cutting, Jim. (1985). Science North: A Different Approach to Science Centres.

of content is the public demand for more involvement in the learning process. Members of the public visiting museums demand more physical interaction with museum materials, and more relevance to the everyday world in which they live and work. The staff of modern science museums understand that the public now demands experiences that allow more than a passive means of learning about science and technology. An exhibit consisting of a retired piece of apparatus and a wall of text describing it would have been a typical exhibit in an early science museum. In a science museum with a modern philosophy, an exhibit of similar content would allow the visitor to physically control the exhibit and personally rediscover or reconstruct the exhibit's intended message.

Educational Role of Science Centres

The modern philosophy of science centre exhibits allows the visitor to become personally involved in his or her own learning in association with these exhibits. Although interactive exhibits vary considerably in terms of size, level of visitor participation, and mechanisms, they usually allow the visitor to physically participate, or to relate the content to their own background experience. Often the exhibits leave the visitor with more questions than answers, stimulating the inquiry learning process. Some of the interest in this philosophy stems not so much from its ability to promote understanding of complex concepts as from its power

to pose interesting questions to the visitor.[19] If the visitor is offered a warm, inviting learning environment, the hard and sometimes inhibiting edge of science learning (as most people have experienced) can be removed.[20]

Science centres have done much to replace the image of museums as passive repositories of the culture of the past containing relics for study by scholars. The perception of museums held by many people as described by Peart[21] - "morgue-like atmospheres, long halls with no windows, and glass exhibit cases full of objects with Latin labels"- is being eroded as the role of museums evolve. Museums have shifted away from their original position, serving mainly as repositories of artifacts for scholarly research, to include public education as a major goal. At the same time, education in nonformal learning environments is being recognized as having a significant impact on the lives of both children and adults. Museums have a unique role to play in societal learning, as described by Kimche[22]:

> "Museums are the only institutions that can provide the general public with these kinds of participatory experiences, together with an accurate scientific interpretation of the materials that are involved.

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[19] Cole, K.C. (1982). On Simple Science.

[20] Cutting, Jim. (1985). Science North: A Different Approach to Science Centres.

[21] Peart, Robert W. (1982). Knowledge Gain, Attitudinal Change, and Behaviors at Museum Exhibits Ranging from Abstract to Concrete.

[22] Kimche, L. (1978). Science Centres: A Potential for Learning.

> The interaction of these two factors - the predisposition on the part of the visitors to be receptive to the museum's message, and the capability of the museum to transmit the message in a multisensory and yet authentic manner - indicates the presence of conditions favourable to learning."

Science centres clearly serve as valuable centres of education. According to Thier and Linn[23], there are four aspects of science centres that make them potentially of great importance for learning:

1. People come to science centres and museums generally by choice.
2. People choose activities suited to their own needs.
3. Individuals can interact with materials that might not otherwise be available.
4. The interested public can be alerted to information about advances in science not likely to be available elsewhere.

The shift in emphases and goals of museums is most apparent in science centres, where exhibits are conceived, constructed and displayed with education of the general public in mind. The early purposes and perceptions of museums are being replaced by a modern version of the image. This new image depicts a science museum as a dynamic, exciting place where

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[23] Thier, H.D. and M.C. Linn. (1976). The Value of Interactive Learning Experiences.

everyone is invited to learn in a hands-on manner about the technological issues of society and the scientific phenomena of our world.

2.3) Touch The Universe Science Gallery

The Manitoba Museum of Man and Nature in Winnipeg has established itself as a world-class museum of human and natural history[24]. The newest addition to its list of galleries is entitled "Touch The Universe", an interactive science gallery. This gallery opened on May 10, 1986 with approximately 60 multi-dimensional interactive exhibits which were intended to connect the laws of science to everyday experience. Its exhibits are similar in content and design to many science centres, including such notable ones as the Ontario Science Centre (Toronto), the Exploratorium (San Francisco), and the Franklin Institute (Philadelphia)[25]. Exhibits in the gallery are colour coded and organized according to the sensory experience which the exhibit provides: sight (blue), sound (yellow), touch (red), smell/taste (green), and a general introductory section.

It is the Touch The Universe gallery in which the exhibit evaluation instrument was implemented. The TTU floor plan, alphabetical list of exhibits, and descriptions of selected

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[24] A three-star rating was accorded the Manitoba Museum of Man and Nature by the Michelin Travel Guide, 1987.

[25] Proactive Information Services. (1986). Touch the Universe Gallery: A Formative Evaluation.

exhibits may be found in Appendix C. The Touch The Universe Gallery (TTU) is unique in a number of ways:

1) it is one of the newest galleries of interactive science exhibits in Canada[26];
2) it was until very recently the only nonformal science/ technology learning centre between Sudbury and Calgary (and remains the single such physical science learning centre in the Province of Manitoba);
3) it is housed in the largest heritage institution in the Province of Manitoba.

Total attendance of the Manitoba Museum of Man and Nature in past years approaches 400,000 visitors, including 100,000 school children. Attendance of the Touch The Universe gallery has been approximately 100,000 per year, consisting of approximately 25,000 children in school groups and 75,000 adults. Since approximately 30 percent of all school children in the Province of Manitoba visit the Museum at least once each year, the potential educational impact of the exhibits and programs on society is very large.

However, attendance at the TTU Gallery has been declining since opening to the public in 1986. Reasons for this decline are not clear, but possible explanations include

[26]Several other science centres are currently undergoing development.

dissatisfaction with the exhibits on display, or the need for more frequent exhibit changes, and the increased competition for the public's leisure time and money. Further studies are required to determine the cause(s) of the declining attendance.

Previous TTU Evaluation

There had been only one previous study undertaken in the TTU Gallery. Because the Manitoba Museum, like many other museums, did not have professional evaluators on staff, the study was conducted by a hired consulting firm[27]. This study, initiated prior to the official Gallery opening, was divided into three phases (Introductory, Developmental, and Monitoring). The evaluative approach was described by the study's author[28] as:

> "heavily formative, would address summative issues as well", and "combined both qualitative and quantitative techniques and incorporated facets which have been identified as the 'goal-referenced', 'naturalistic' and 'informed decision-making' evaluative approaches".

The report on the study of the TTU Gallery indicated that:

1. 98% of visitors felt it was a "fun place";
2. 93% felt the exhibits made them stop and think;

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[27] Proactive Information Services.

[28] IBID

3. 82% felt the exhibits fooled them[29];

4. 80% felt the experience caused them to find out why some of the things were happening;

5. 50% felt the working condition of the exhibits was worse than expected;

6. 8 exhibits were particularly unsatisfactory, and require further investigation;

7. no finalized development plan had been articulated prior to gallery construction, and there was inadequate leadership and direction during construction;

8. a considered decision was made by the staff in charge to avoid setting learning goals for the Gallery or the exhibits;

9. "it was assumed that if visitors experiment with the exhibits and their interest is stimulated, the learning process is being promoted";

10. no specific exhibit objectives had been described prior to the design and construction of most of the exhibits. Since objectives were required in order to carry out the study, the evaluator conducted interviews with three supervising staff who answered the question: "What is this exhibit supposed to accomplish? ". In this way, general exhibit objectives were formulated.

11. at the start of the formative evaluation exhibit development was at an advanced stage (33% of the exhibits were completed and permanently placed, and 14 more exhibits were in the final stage of completion). At the same time, the exhibit copy was incomplete or inadequate, and in order to have functional exhibits for evaluation, the evaluator became co-author of the exhibit text.

As a result of earlier considered decisions to not set learning goals for the exhibits, an assessment of the

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[29] Whether this is a positive or negative reaction to the exhibits is not stated. Taken in the context of the original philosophy, to fool a visitor would be a positive result. At present, this is not necessarily the case.

educational impact of the exhibits was not possible in the above study.

The study reports: "Given the late stage of development, the copy was viewed as the vehicle which would ensure that each exhibit was, in fact, meeting its objectives." Evidence was not provided to support the argument indicating that exhibit copy ensures an exhibit's effectiveness in terms of meeting its objectives.

During the writing of exhibit text, reference was made to the supervisors' articulated objectives ("what the exhibit is supposed to accomplish"). The method used in the study to determine whether the exhibit copy was effective in allowing the exhibit to achieve its objectives involved two strategies:

1. viewing previously recorded videotape to document the length of time visitors spent reading the copy;
2. asking the visitors for a response (YES/NO) to the questions: "Did you read the instructions/explanations?" "Did you understand them?" "Did they help you use the exhibit?"

The assessment and experimental validity of this study have been questioned. Conclusions which were drawn are based on indirect measurement of data, and the assumptions which were made with reference to exhibit effectiveness were unsupported. For example, the length of time spent looking at an exhibit's text was used as an indication that the exhibit text was effective. Other variables may have

influenced the length of time spent looking at/reading the copy (e.g. visitor education level, fatigue level, complexity of content, complexity of exhibit, level of viewer interest in the content, design interest of viewer, lighting level). These variables were not taken into consideration in the findings of the study. Another assumption was that text was being read when a visitor looked in the direction of the label copy. The study's report indicated "that children read about one, to one and one-half sentences of text when looking at the instructions". The method by which this was determined is not described in the report.

Visitors were asked for their opinions about the exhibit text, to determine its contribution to the conveyance of the scientific principle. Empirical measures were not used to objectively determine if exhibit text was actually effective in this regard. Because the visitors were limited in their responses regarding whether or not they read and understood the copy, (due to the nature of closed-ended questions) there is a risk that an incorrect response will be provided, either knowingly (e.g. to avoid embarrassment) or unknowingly (e.g. visitor perceives a level of understanding, when in actual fact he/she has not understood the content or process). Other researchers have indicated that visitor self-reports are unreliable,[30] as visitors are reluctant to make critical

[30] Cameron, D. (1967); S. Bitgood and K. Richardson (1986); P. Alter and R. Alter (1988); S. Bitgood (1988c); T. Knott and D. Noble (1989).

evaluations of museums and other "morally good things", and tend to want to please or second guess the interviewer. There was no impartial assessment of the level of visitor understanding of the content of the exhibits.

Another method which was used to assess the exhibits was an analysis of the effectiveness of individual exhibits in terms of meeting their identified objectives. However, the objectives as stated in the report are not in a measurable form. Consequently, conclusions about the effectiveness of exhibits based on the above information are suspect.

The study used a visitor interview instrument to provide information about visitor attitudes and demographics. Learning outcomes for members of the public as a consequence of exhibit interactions were not assessed.

A separate survey was distributed to teachers who attended the TTU gallery with their schoolchildren. Teacher survey responses indicated that they visited TTU for a hands-on experience, a new experience, to encourage the process of discovery, and to provide enrichment. Teachers indicated that they would like written materials indicating the relationship of TTU to the curriculum and explanations of the science behind the exhibits. The report indicates the need for "explainers" (staff or volunteers who assist the public) and for more information. It does not indicate whether or not the students understood the purpose of the exhibits. Teachers indicated a high level of satisfaction with the gallery.

There was no attempt to evaluate the extent of knowledge acquisition or retention by the students.

The TTU evaluation report made several recommendations:

1. for all new exhibit developments, it is imperative that exhibit goals and objectives be outlined prior to commencement of construction, and this should delineate the intent of the exhibit, how it relates to other exhibits, and to the Gallery concept;

2. decisions to delete exhibits should similarly take the objectives into account;

3. additional in-person interviews should occur to ascertain visitor attitudes about the gallery in general, and towards specific exhibits;

4. video observations be conducted when new exhibits are installed and when visitor interviews indicate dissatisfaction with a specific exhibit(s);

5. teacher questionnaires be continued on a regular basis.

The study did not attempt to determine:

1. the extent of specific science knowledge acquired or retained[31] as a result of interaction with specific exhibits or through the gallery visit as a whole;

2. the extent of change in attitude toward science by the visitors[32];

3. the extent of change in a visitor's career interests[33];

3. the attracting power of individual exhibits;

4. the holding power of individual exhibits;[34]

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[31] This is usually an underlying purpose for science centres, as stated by H. Shettel, (1968).

[32] IBID

[33] IBID

[34] The most commonly used objective measures of an exhibit's success are "attracting power" and "holding power" (Borun, 1977).

5. specific guidelines/criteria for the development of exhibits;

There still exists a need for studies to be undertaken to provide the above information. In addition, because of significant changes to the gallery since the completion of the study, in a number of ways the results of the study may no longer be appropriate (e.g. "most/least popular exhibit", "exhibits fooled them", "working condition of the exhibits is much worse than expected"). Further investigation of visitor experiences in the TTU Gallery, educational impact of exhibits, and exhibit success in terms of measurable objectives would be most appropriate. There is also a need for carefully considered, measurable learning objectives for each of the exhibits in the TTU gallery.

2.4 Previous Studies of Other Science Centres

Museum personnel have a renewed interest in evaluation of their enterprises. This is due in part to the recent and growing science-technology movement in many countries around the world, and the realization that there has been little systematic information collected to guide the development of these types of exhibits[35]. During the late 1970's, at the

[35] Russell, T. et al. (1988). Evaluation of the Pilot Phase of the Cardiff Interactive Technology Centre 'Techniquest'.

peak of federal funding for museum programs, federal agencies needed to document the success of publicly funded programs, and accountability became a concern.[36] As a result, museums expanded their efforts in exhibit and program evaluation. It has also been suggested that in times of weak economy, accountability and assessing achievement of objectives increase in importance.[37]

Museum evaluation has been ongoing since the 1920's, although the number of researchers has always been small.[38] The types of evaluation conducted early in this century was largely restricted to demographic and behaviourial information.[39] This information documented visitor profiles, and determined how people move and react in museums, how they dispense their time, and where they go and with whom. Interest turned elsewhere during the second World War[40].

It is only since the late 1960's that museums have become involved in a significant way in self-evaluation. Bitgood[41] states that prior to this period, there were never more than a handful of studies in any 3-year period. It has only been

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[36] Borun, M. (1989a). Assessing the Impact.

[37] Roggenbuck, J.W. and D.B. Propst. (1981). Evaluation of Interpretation.

[38] Borun, M. (1989a). Assessing the Impact.

[39] Robinson, Edward S. (1928, 1931); Melton, A. W. (1933, 1936).

[40] Borun, M. (1977). Measuring the Immeasurable: A Pilot Study of Museum Effectiveness.

[41] Bitgood, S. (1988b). Visitor Studies: Coming of Age.

since the early 1970's that serious attention has been directed toward the study of behaviour and learning in the manipulative settings of science and technology centres and museums.[42] [43] Yet, even with the recent interest in evaluation of the effectiveness of informal learning environments, expertise in evaluating science centres is still in the developmental stage.[44] In some cases, researcher in recent studies have been as anxious to learn about the effectiveness of their measuring instruments, as the effectiveness of the exhibits which they were assessing. In a statement of her study's purpose, Harlen[45] states that in addition to gathering information about specific exhibits, a parallel purpose of the study, "because of the new territory of operations, was to evaluate the evaluation, that is, to learn more about how the procedures and instruments of evaluation can be adapted to make them more useful." Few instruments have been developed and found to be reliable. Alter and Alter[46] described the lack of information and instrumentation in the area of exhibit learning. They explain that not enough is known in this area,

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[42] Koran, J. et al (1983). A Framework for Conceptualizing Research in Natural History Museums and Science Centers.

[43] Washburne, R. and J. A. Wagar. (1972). Evaluating Visitor Response to Exhibit Content.

[44] Russell, T. et al (1988). Evaluation of the Pilot Phase of the Cardiff Interactive Technology Centre 'Techniquest'.

[45] Harlen, W. et al. (1986). Evaluation of the Pilot Phase of the Liverpool Interactive Technology Centre.

[46] Alter, P. and R. Alter. (1988). Exhibit Evaluation: Taking Account of Human Factors.

and that formal measuring of this type is difficult, time consuming, and still well in the realm of cognitive psychology. Many museum evaluation studies are small, often conducted by individual museum staff, marketing firms and university students, and frequently unpublished. As this information becomes known and organized, results and instruments will be accessible to museum evaluators. Literature in the museum field is now calling for a standardization of evaluation techniques and the publication of results[47].

There has been a growing interest in structured investigations of museums since 1979.[48] Findings of formal visitor research by contemporary investigators has resulted in a small but important body of literature. However, as Bitgood[49] states, this emerging body of knowledge is not yet well organized. Despite a great increase in research in museums over the years, specific museum-based research designed to predict visitor behaviour is generally scarce.[50] The body of research that exists in other areas, such as education and psychology, can contribute to the assessment of educational impact of museum exhibits. However, because of

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[47] Borun, Minda (1977); Peart, Robert W. (1982).

[48] Zyskowski, G. (1983); C. Screven (1984).

[49] Bitgood, S. (1988a). Introduction: Visitor Studies - 1988.

[50] Falk, John H. et al (1985). Predicting Visitor Behavior.

the informal nature and novelty of the museum environment, and the short duration of contact with the visitors, research models developed for the school setting may not be suitable for science museums.[51]

The following discussion of previous visitor studies is organized according to categories suggested by Screven.[52] The four categories are: Audience Surveys; Behaviour Studies; Evaluation Studies; and Experimental Research.

Audience Surveys

Demographic and psychographic information about visitors and non-visitors is gathered through audience surveys. As mentioned above, surveys were one of the first aspects of visitor studies to be implemented, occurring early in this century. Typical information which is gathered from a sample of the audience includes characteristics of individual visitors and groups, frequency of visits, reasons for coming/not coming, attitudes, values, opinions, and expectations.

The need for ongoing public surveys is argued by Alt[53] since they provide an opportunity to monitor changing trends. His study revealed that although characteristics of the

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[51] Van Dorn, B. (1984). Science Museums and Science Education.

[52] Screven, C. (1984). Educational Evaluation and Research in Museums and Public Exhibits: A Bibliography.

[53] Alt, M.B. (1980). Four Years of Visitor Surveys at the British Museum (Natural History) 1976-79.

Museum's public remained the same, its opinions and behaviour did not.

Demographic surveys are widely administered by museums, and the interview method and interpretation of data is relatively straightforward.[54] Consequently, this type of evaluation is quite common. Some results of these studies[55] follow:

- age, education, income, and place of residence are chief determinants of museum visitation;
- the museum audience is a fairly homogeneous group, almost evenly divided between the sexes, most likely to fall into the 25 to 45 year-age range and predominantly well-educated;
- the average visitor has a higher income and more education than non-visitors;
- the most common reasons for attending a museum are for fun or recreation, to learn something, and as a family outing;
- visitor expectations, attitudes towards museums, and levels of satisfaction differ by seasons.

Behaviour Studies

These consist of systematic observations of visitor behaviour in museum environments. This was one of the first areas of systematic visitor research, being initiated in the 1920s.[56] The type of information gathered includes: how people move and react, how long they stay, where they go, with whom, and how they spend their time. Behaviour studies have been

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[54] Borun, M. (1977). Measuring the Immeasurable: A Pilot Study of Museum Effectiveness.

[55] Cameron, D. and D.S. Abbey (1961); E.J. Smits (1964); P.S. Doughty (1968); B. Serrell (1977); M.B. Alt (1980); Gould Dunbar, N. and M. Borun (1980); S. Bitgood, D. Patterson et al (1986); W. Harlen (1986); S. Rode-Perkins (1987); and M. Hood (1988); Lord, B. and G. D. Lord (1988).

[56] Borun, M. (1977); R. Peart (1982).

used to provide an indication of learning. A major assumption underlying this type of exhibit evaluation is that the greater the amount of time spent at an exhibit, the greater the amount of learning.[57] Behavioural studies, like audience surveys, is commonly undertaken by museums. These studies are often used in conjunction with other methods of evaluation, such as structured interviews. Some of the results of recent behaviour studies[58] follow:

(regarding the influence of exhibit type):
- exhibit type significantly affects visitor flow patterns;
- the more interpretive the label, the greater is the attracting power, holding power and interaction;
- a correlation exists between attracting power, holding power and interaction;
- attracting power of three dimensional exhibits with real objects is greater than exhibits with graphics and a flat image;
- sound significantly increases the attracting power of an exhibit;
- holding power and interest increases as the exhibit becomes more real (multi-sensory);
- the number of displays affects the "popularity" of an exhibit hall, but not its "attracting power";
- clusters of "bad" exhibits (poor in terms of attracting and holding power) placed near the entrance receive more attention than "good" exhibits located towards the rear of the museum;
- visitors, particularly girls and women, are more attracted to, and spend greater amounts of time at, exhibits which allow visitors to physically interact;
- boys are more likely to interact with a manipulative exhibit than are men;
- the most frequently contacted exhibits depend on visitors sensing or considering aspects of their own physical presence (either see or hear themselves) as part of the interaction and those exhibits which invite the visitors to make hypotheses as to outcome.

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[57] Shettel, H. (1968); S. Rode-Perkins (1987).

[58] Shettel, H. (1973); L. Eason and M. Linn (1976); C. Screven (1976); M. Borun (1977); S. Cone and K. Kendall (1978); R. Peart (1982); J. Koran et al (1984); R. Carlisle (1985); J. Falk et al (1985b); W. Harlen (1986); J. Koran et al (1986); S. Rode-Perkins (1987); T. Russell et al (1987, 1988).

(regarding interactive science exhibits):
- viewing time for individual exhibits varies widely, but the average viewing time of science exhibits generally ranges from 30 to 60 seconds, and females generally spend more time interacting with exhibits than males;
- most visitors physically engage interactive exhibits, without encouragement;
- the percentage of visitors who read exhibit text is inconsistent between studies, ranging from approximately 20% to 90%;
- visitors often do not follow directions; male visitors work alone at exhibits more frequently than females;
- visitors usually complete the intended exercise of the exhibit;
- many visitors return to exhibits previously contacted;

(regarding visitor movement):
- most children orient themselves at the beginning of their visit (look around, choose exhibits);
- the number and duration of stops and verbal interactions during a museum visit tend to diminish as the visit progresses;
- visitors frequently become disoriented in museums;
- visitor movement does not follow logical sequencing of exhibits, but focusses on large and dramatic exhibits;

(regarding learning conditions):
- there is a positive correlation between the amount of viewing time, level of motivation and extent of concept learning;
- cooperative behaviours are common within groups of children;
- there is a relationship between time spent in front of an exhibit, recall of that exhibit, and verbal interactions among family members;
- family group learning from exhibits tends to result from direct observation accompanied by explanations from parents to children, and that mothers are more likely to verbally interact with children;
- fathers direct most verbal behaviour towards their sons;
- females verbalise more frequently than do males;

As stated by Peart,[59] the major weakness with behavioural studies is that they only describe what the visitor is doing. Only by using assumptions can they indicate the educational

[59] Peart, R. (1982). Knowledge Gain, Attitudinal Change, and Behaviors at Museum Exhibits Ranging from Abstract to Concrete.

effectiveness of exhibits, in terms of knowledge gain and attitudes. Learning studies, or educational impact studies, which use direct measures to determine exhibit effectiveness are often used to supplement behaviour studies.

Evaluation Studies

These studies measure the educational impact of exhibits on the behaviour, interests, or other characteristics of viewers. Alternatively, these methods may be used to determine if a particular exhibit achieved its goals. These evaluations are used to gather information that can be used to make decisions about future exhibit methods.[60]

As mentioned above, evaluation studies are frequently used in conjunction with behavioural studies since exhibits must both attract and hold an audience before learning can occur. Shettel[61] argues that attracting power is the unique element which must be considered by exhibits, and which differentiates them from other forms of visual communication (such as pictorially-based educational television, slides and movies). Any possible teaching attempt is wasted unless people come to view an exhibit; by the same token, an exhibit which attracts an audience but fails to reach its educational and attitudinal objectives cannot be considered to be

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[60] Screven, C. (1984). Educational Evaluation and Research in Museums and Public Exhibits: A Bibliography.

[61] Shettel, H. (1968). An Evaluation of Existing Criteria for Judging the Quality of Science Exhibits.

successful. In a recent study, Falk (et al)[62] concludes that equating attracting power and/or holding power with exhibit effectiveness may lead to inaccurate conclusions.

Harlen[63] used an evaluative method which employed both behavioural and evaluative techniques. However, the determination of information transfer which occurred from interaction with individual exhibits relied upon an indirect measure. Visitors were asked if they got a "little" or a "lot" of new information from a favourite exhibit. The validity and accuracy of the responses in terms of cognitive gain would need to be confirmed through direct measures.

Evaluation studies have been used by investigators to measure teaching power directly, rather than concentrating on popularity as a measure of success. Borun[64] states that it is "certainly appropriate that objective evaluation techniques be used to measure the effectiveness of the science museum in achieving (its) goals". Evaluation studies have been used in museums since the late 1960's.[65] Eason and Linn[66] report that visitor questionnaires and interviews are effective procedures

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[62] Falk, John H. et al. (1985). Predicting Visitor Behavior.

[63] Harlen, W. et al (1986). Evaluation of the Pilot Phase of the Liverpool Interactive Technology Centre.

[64] Borun, M. (1977). Measuring the Immeasurable: A Pilot Study of Museum Effectiveness.

[65] Peart, R. (1982). Knowledge Gain, Attitudinal Change, and Behaviors at Museum Exhibits Ranging from Abstract to Concrete.

[66] Eason, L. and M. Linn. (1976). Evaluation of the Effectiveness of Participatory Exhibits.

for evaluating visitor responses. However, significant problems with these studies have been reported,[67] largely due to the use and interpretation of indirect measures (for example, correlating holding power with level of interest or learning). Some of the results from evaluation studies follow:

Regarding cognitive gain, there is some inconsistency between various researchers with regard to the extent of knowledge gain from a museum visit. Some researchers[68] report a clear increase in cognitive test scores upon viewing certain exhibits. Other researchers[69] report little knowledge gain. Knowledge gain amongst schoolchildren was significant only in some studies.

In assessing the effectiveness of participatory exhibits in conveying science content to groups of visitors, Flexer and Borun[70] found that such exhibits can and do teach science to fifth and sixth grade students. However, a concise, well-written and well delivered classroom science lesson was determined to be more effective in teaching science. The strength of the science museum visit was shown to lie in the

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[67] Borun, M. (1977); Peart, R. (1982).

[68] Borun, 1977; Eason and Linn, 1976; Falk et al, 1985b; Peart, 1982; Rode-Perkins, 1987; Screven, 1976; and Shettel, 1973.

[69] Boggs, 1977; Serrell, 1980.

[70] Flexer, Barbara K. and Minda Borun. (1984). The Impact of a Class Visit to a Participatory Science Museum Exhibit and a Classroom Science Lesson.

affective domain, as the exhibit was perceived to be far more enjoyable and interesting than a classroom lesson. The exhibit experience also provided a high motivational aspect, as the students indicated a desire to learn more about the specific subject content. Another study involving groups of schoolchildren indicated that coordinated, interdisciplinary school-museum programs produce significant increases in student knowledge scores over school only programs.[71]

Falk[72] established that non-verbal behaviours were highly correlated with positive affect and cognitive learning, and that children who spent a reasonably long time at the exhibit, demonstrating positive behaviours in the process, showed a significant increase in concept learning scores from pre- to post-visit test.

As is the case for cognitive gain, there is also some inconsistency in the literature with regard to attitudinal change following a museum visit. Borun[73] reports that there is a clear decrease from pre- to post-visit test in a positive feeling about the museum. Harlen[74] reports that the overwhelming majority of visitors feel positively about the

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[71] Reese, D. and E. Moore. (1970). The art museum and the public school: An experiment.

[72] Falk, John H. (1983). Time and Behavior as Predictors of Learning.

[73] Borun, M. (1977). Measuring the Immeasurable: A Pilot Study of Museum Effectiveness.

[74] Harlen, W. et al. (1986). Evaluation of the Pilot Phase of the Liverpool Interactive Technology Centre.

institution upon exiting, and Boggs[75] reports a positive shift in attitudes. The results from affective studies of other researchers[76] are inconclusive.

The discrepancies in cognitive and affective change results between reports may be explained by differences in the individual studies. Some researchers[77] suggest that if the terminology were more clearly defined, some of the discrepancies may be reduced.

Other evaluation studies have provided information regarding the influence of specific aspects of exhibits on learning. Borun[78] reported that there is a strong inverse relationship between instructional power and number of participatory devices in a gallery. She further reported that push-buttons account for most of the negative correlation with instructional power, and although they work well to attract attention, they are not effective aids to the communication of scientific facts and principles.

In a study which combined evaluation with experimental research, Greenglass[79] made two discoveries. The first was that a relatively high range of conceptual level (a measure

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[75]Boggs, D. (1977). Visitor Learning at the Ohio Historical Centre.

[76]Peart, R. (1982). Knowledge Gain, Attitudinal Change and Behaviors at Museum Exhibits Ranging from Abstract to Concrete.

[77]Boggs, 1977; Screven, 1974.

[78]Borun, M. (1977). Measuring the Immeasurable: A Pilot Study of Museum Effectiveness.

[79]Greenglass, D. (1986). Learning from Objects in a Museum.

of information-processing ability) was found among adult museum visitors. Secondly, both high and low level adults did well in highly structured exhibits (i.e. when hints were provided along with questions in exhibit labels). Consequently, Greenglass suggested that all exhibits should be highly structured for maximum effectiveness with adults from various conceptual levels.

Experimental Research

Experimental research studies involve the effects of independent variable manipulation along with experimental controls that allow generalizable information about their effects.[80] [81] Changes in visitor attention, time spent, learning, attitude change, etc. as a result of the modification of specific exhibit design features are included in this category of visitor studies. Several examples of these studies follow:

Screven[82] compared the effectiveness of various types of guidance devices on visitor learning. He found that exhibits with labels (with or without supplementary labels) did teach something, and that labels with questions produced no improvement over the labels alone. When used in conjunction

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[80] Zyskowski, Gloria. (1983). A Review of Literature on the Evaluation of Museum Programs.

[81] Screven, C. G. (1984). Educational Evaluation and Research in Museums and Public Exhibits: A Bibliography.

[82] Screven, C. (1975). The Effectiveness of Guidance Devices on Visitor Learning.

with self-scoring punch cards, the effectiveness of labels improved. Even greater learning occurred when audio tapes and programmed booklets were used along with labels.

In a project which studied the change in visitor behaviour as a result of increased opportunity to manipulate objects, Koran[83] found that visitors, especially young children, were more attracted to, and spent a longer period of time at the exhibit when it was open and accessible than when it was covered and inaccessible. The addition of accessory tools (e.g. microscope) further enhanced the exhibit's attracting and holding power.

Peart[84] reports that concrete exhibits are more effective than those that are abstract, and that clear, concise labels increase knowledge gain, attracting power, and holding power. He states that it is the label, for the most part, that ultimately determines whether the exhibit will be effective.

Bitgood et al[85] found that visitors view exhibits longer and reported better viewability, greater ease of understanding, and greater dramatic appeal when lighting was at a medium as opposed to a low level. In a separate study involving the manipulation of five label variables, Bitgood

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[83]Koran, John J. Jr. et al. (1986). The Relationship of Age, Sex, Attention and Holding Power with Two Types of Science Exhibits.

[84]Peart, R. (1982). Knowledge Gain, Attitudinal Change and Behaviors at Museum Exhibits Ranging from Abstract to Concrete.

[85]Bitgood, S. et al. (1987). Formative Evaluation of a Cave Exhibit.

et al[86] report that three variables had a significant impact on visitors: number of words per label; size of the letters; and proximity of the label to the exhibit object. Label reading was increased by reducing the number of words per label, by increasing the size of the letters, and by moving the labels closer to the objects.

The relative effectiveness of various orientation systems was investigated by Cohen et al.[87] They report that maps and signs are both effective in reducing disorientation, and that a combination of the two provides further improvement. Maps were found to be used by visitors to a greater extent than were information people. In a different study measuring the effectiveness of guidance devices, Koran et al[88] report that an information panel at the beginning of a novel experience can enhance the potential learning from the experience.

2.5 Goal-Referenced Evaluation

The goal-referenced approach to museum exhibit evaluation originated from the realm of curriculum evaluation and psychological research.[89] The more established body of material from the educational and psychological fields provide

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[86] Bitgood, S. et al. (1986). Effect of Label Characteristics on Visitor Behavior.

[87] Cohen, M. et al (1977). Orientation in a Museum - An Experimental Visitor Study.

[88] Koran, J. et al. (1983a). The Relative Effects of Pre- and PostAttention Directing Devices on Learning from a "Walk-Through" Museum Exhibit.

[89] Screven, C. (1976). Exhibit Evaluation - A Goal-Referenced Approach.

the basis for this model of evaluation for determining communication (teaching) effectiveness of exhibits. There are commonalities between these fields and the museum field, since a major function of public museums is "education", and consequently museums should be concerned with the psychology of learning. This evaluative approach to museum exhibit evaluation places exhibits in the same methodological and research context as educational programs. In the educational psychologist's view the exhibit is an educational medium from which the visitor learns.[90]

The underlying assumption to goal-referenced approach is that museum exhibits are designed with the goal and hope that the people who view them will be affected in some useful way. Screven[91] argues logically that, if exhibits have been designed to communicate messages or elicit responses, evaluation can determine whether these objectives have been achieved. The term "goal" refers to measurable learning or performance outcomes shown by visitors as the result of exhibit exposure.

Central to the goal-referenced approach to exhibit evaluation are three questions:

1. What impact do you want?

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[90] Proactive Information Services. 1986.

[91] Screven, C.G. (1976). Exhibit Evaluation - A Goal Referenced Approach.

2. How will you attempt to achieve these objectives via your exhibit?

3. How will you know if any of these methods or materials have had the desired impact on your intended audience?

In this approach, exhibit goals and the intended audience are defined in measurable terms,[92] and then the exhibit is developed or modified. Visitors are exposed to the exhibit, and their reactions (e.g. attention, interests, attitudes, values, knowledge, skills) are measured. If the exhibit goal was to teach, then the evaluator attempts to measure learning; if the goal was to create a desired attitude, attitudinal change is measured. The results are then compared (evaluated) in terms of how well they match the original goals. If the match is poor, the exhibit or its goal is modified or adjusted. The goal-referenced approach is summarized in Figure 2.1.

Since the goal-referenced approach evaluates exhibits in terms of their intended goals and, if necessary, adjusts their design until the goals are attained, evaluation is not possible unless the exhibit developers have clearly (measurably) defined the intended educational or performance outcomes of the exhibit.

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[92] As described by H. Shettel (1973); and M. Borun (1989a).

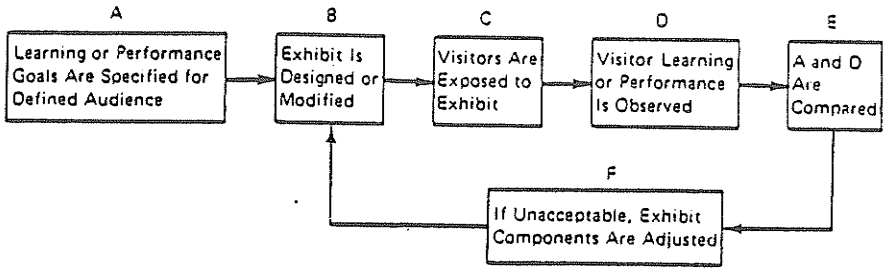

Figure 2.1 Simplified flow chart of goal-referenced evaluation.
(from Screven, C.G. 1976)

The goal-referenced approach may be used in either formative or summative evaluations of exhibits. The distinction between these two types of evaluation was originally made by Scriven,[93] and is now in common use in education. Formative evaluation of museum exhibits takes place during planning and constructing an exhibit, or modifying a new one, and the results are used to change and improve elements of the exhibit to achieve its intended effects on visitor learning and performance. Summative evaluation provides the basis for deciding whether or not the exhibit, or its design features, should be continued, repeated, removed, and so on.[94]

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[93] Scriven, Michael. (1967). The Methodology of Evaluation.

[94] Screven, C.G. (1976). Exhibit Evaluation - A Goal-Referenced Approach.

This study used the goal-referenced approach to summative evaluation of the Touch The Universe Gallery exhibits.

Summary

The preceding review of literature has given a background to the purposes of this study. The references related to four areas: the growth and changes in philosophies of science centres; a description of the TTU gallery (site of the study) and of its previous evaluation; the evolution of museum studies and results from four categories of visitor studies; and the goal-referenced approach to evaluation.

CHAPTER 3. METHODOLOGY

This study was designed to be conducted in a two-phase approach, and used a largely descriptive methodology. Phase one involved the design of a general, non-exhibit specific, evaluation instrument which could be used to evaluate the effectiveness of science centre exhibits in light of their objectives. Phase two involved testing the instrument in the Touch The Universe Science Gallery.

PHASE 1. DEVELOPMENT OF THE EXHIBIT EVALUATION INSTRUMENT

Information which was used to guide the development of the exhibit evaluation instrument was gained from two sources:

i) previously published studies[1], and

ii) from a survey of science centres.

3.1.1) Science Centre Survey: Development and Implementation

A copy of the survey which was sent to the selected science centres may be found in Appendix A. The survey was distributed to a total of forty-five (45) science and technology institutions in Canada, the United States of America, and Great Britain.

[1] Most notably Borun (1977), Harlen (1986), Peart (1982), Rode-Perkins (1987), and Russell (1988).

Survey Information Requested

Several types of information were requested from the selected institutions to assist in the development of the exhibit evaluation instrument. Descriptive data about each centre was requested in order to obtain a working knowledge of the responding institutions. The survey included questions which would provide an indication of the degree to which the exhibit evaluation instrument being developed would be useful.

The information requested from each centre included the approximate total number of interactive exhibits displayed and the percentage of exhibits contained in each of three levels of complexity.

The institutions were asked to categorize their interactive science exhibits into three levels so as to determine the range, complexity, and frequency of each of the interactive exhibit types in the surveyed centres. This categorization of exhibits could provide further information with regard to the extent to which these institutions would find an interactive exhibit evaluation instrument useful. Science centres which are considered to be "interactive science centres" often display exhibits of a non-interactive nature (i.e. "passive"). Since the exhibit evaluation instrument undergoing development was intended for use primarily with truly interactive exhibits, some clarification and consistent use of the terminology and classification scheme was required. To this end, the institutions were asked

to classify their exhibits by the level of visitor interaction possible.

The first (or lowest) level of science exhibits represents exhibits which offer no opportunities for visitors to physically interact in their functioning. Level two and three exhibits encourage visitors to physically interact and/or control the functioning of the exhibit, to a greater or lesser degree, and often allow the visitor to test his/her prediction of the exhibit event's outcome. The three levels of interactive exhibits consequently established were:

Level 1. Passive exhibits, which are not generally considered participatory or interactive, comprise level one. These exhibits do not require a visitor's presence or interaction in order to fully function. The visitors' interaction is limited to passive involvement, such as viewing, hearing, or smelling the exhibit, without first being required to become physically involved with it. The visitor cannot cause any change in the operation of the exhibit. Such examples include: a stationary item on display, perhaps with accompanying graphics or text; and an object that moves continually, with no change to its display or movement allowed through visitor involvement.

Level 2. These exhibits require only limited visitor involvement: if they require a visitor's presence, it is only in order to begin functioning; the visitor has no control over the way the exhibit functions (except in some cases to start

it functioning); and the exhibit has no provision for visitor feedback. 'Push the button and watch what happens' type of exhibits are examples of level 2 exhibits. These exhibits often continue to work after a visitor leaves the area around the exhibit.

Level 3. This level is reserved for the most complex of exhibits, which usually require active or continual physical interaction by one or more visitors in order to make it functional. If the visitor ceases to physically interact with the exhibit, the exhibit ceases to function. Often the visitor has some choice or control over the way in which the mechanism operates, allowing for control of variables. The exhibit may allow for viewer feedback. An example of this type of exhibit is one which indicates the amount of electricity generated by a visitor pedalling a stationary bicycle connected to a generator and a selection of lights and gauges.

Other information which was requested from the surveyed institutions included the methods by which concepts are selected for development into exhibits and the authority which authorizes installation of these exhibits.

Examples of exhibit objectives were requested in order to ascertain the degree to which science centres make use of specific (measurable) statements[2] of exhibit objectives, and

[2] As described by Shettel (1973) and Screven (1974).

thus give some indication of the appropriateness of a goal-referenced approach to evaluation of exhibits. These exhibit objectives were also intended to be used to assist in the development of interview questions which would be open and non-prejudicial with respect to individual exhibits.

The institutions were requested to rank a given set of eight exhibit criteria on the basis of their importance in the process by which decisions are made to install exhibits. High ranking criteria were to be included in the exhibit evaluation instrument. The surveyed institutions were also asked to describe, in their own words, the factors which they felt made an exhibit successful. These factors were also to be included in the exhibit evaluation instrument.

Copies of any exhibit evaluation instruments now used by the surveyed institutions were requested through the survey, with an intention of incorporating sections of relevant information into the instrument under development.[3]

Information regarding extent and frequency of exhibit evaluation and the types of evaluation currently being undertaken in the various institutions was intended to provide a further indication of the potential usefulness of the exhibit evaluation instrument to be developed.

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[3] Unfortunately, the response to this request was disappointing. This is discussed in detail later in this chapter.

Implementation of the Survey

The developed survey was directed to the appropriate personnel responsible for evaluation of exhibits:

(i) in all institutions in Canada known or likely to have content similar to the TTU Gallery (chosen from the Canadian Museum Association's (1988) listing of museums, category 6-"Museums or Centres of Science and Technology" and the Association of Science-Technology Centres (1988) Membership List);

(ii) in a variety of similar institutions in the United States of America, known to have similar exhibits (also chosen from the Association of Science-Technology Centers (1988) Membership List);

and, (iii) in selected institutions in Great Britain known to have recently undertaken interactive exhibit evaluation studies.

A complete list of the institutions (and locations) surveyed may be found in Appendix A. Information received from the responses to the survey was incorporated with information from the literature to develop the exhibit evaluation instrument (located in Appendix B). The method of survey development is described in detail in Section 3.1.3 of this chapter.

3.1.2) Survey Data Analysis

Of the 45 institutions surveyed, 20 responded for an overall response rate of 44.4% (Table 3.1).

Institutions Surveyed	# Surveys Distributed	# Responses	Response Rate %
Canadian Institutions	22	11	50.0
Foreign Institutions	23	9	39.1
Total	45	20	44.4

TABLE 3.1 RESPONSE RATES TO SCIENCE CENTRE SURVEY

It is interesting to note that, of the 22 Canadian institutions surveyed, 11 responded, for a response rate of 50%. This contrasts with a response rate of 39.1% from foreign institutions. One possible explanation for the greater response rate from Canadian institutions is that the community of Canadian science centres is small (relative to the United States), and they often demonstrate a mutual willingness to assist one another. Given the small numbers of science centres involved, responses should not be regarded as representative of the science centre community as a whole.

Number of Interactive Exhibits

As Figure 3.1 indicates, the number of interactive science exhibits displayed by the responding institutions appears to range from very few (less than 10 exhibits) to very many (more than 300 exhibits). No institutions reported displaying from 21 to 50 or from 71 to 100 exhibits.

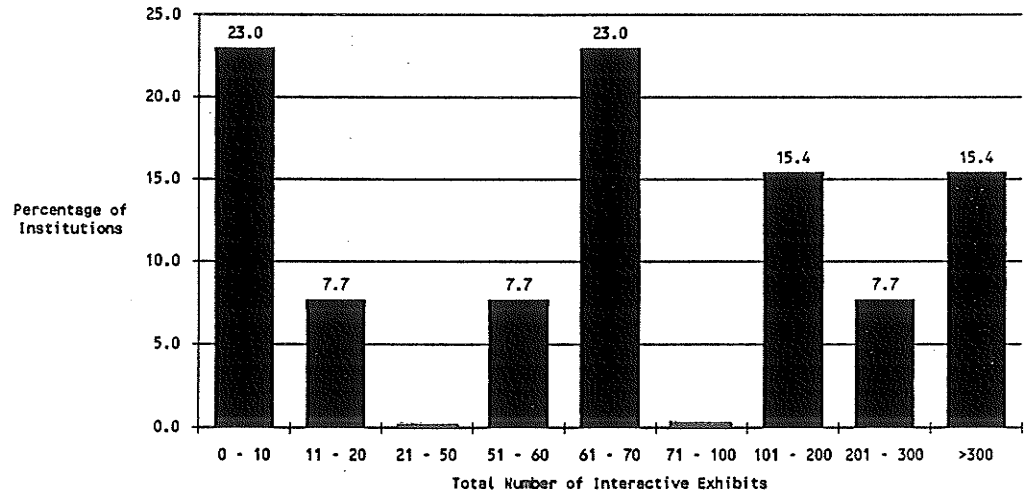


FIGURE 3.1 PERCENTAGES OF INSTITUTIONS X NUMBER OF INTERACTIVE EXHIBITS

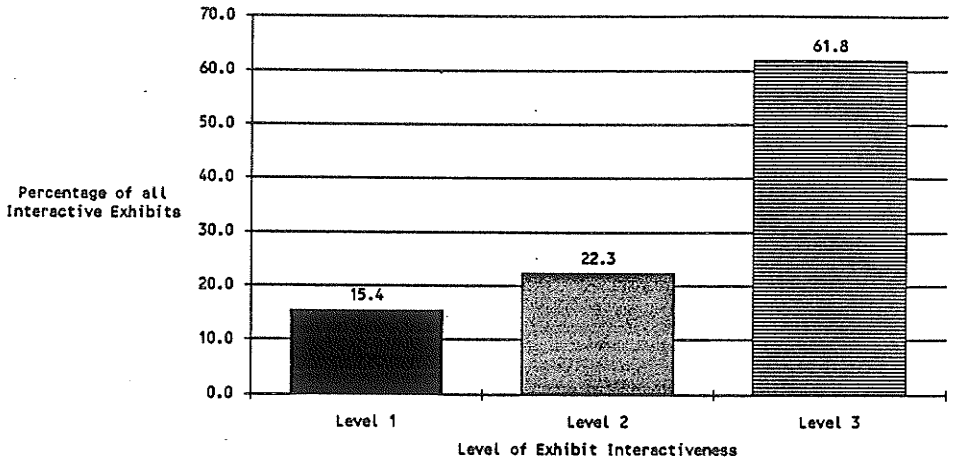
Three main categories of institutions may be created from these reported numbers: 30.7% of the respondents have very small numbers of interactive exhibits (less than 20 exhibits);

30.7% have a moderate number of exhibits (50 to 70 exhibits); and 38.5% of the respondents have many interactive exhibits (100 to over 300 exhibits). It appears that an evaluative instrument for interactive science exhibits could be very useful in many institutions.

Nature of Exhibits

Survey responses indicate that the majority (61.8%) of exhibits on display in science centres are of the level three type (highly interactive) (see Figure 3.2). Level two exhibits (limited interaction possible) comprise the next most abundant type of exhibit (22.3%). The least common "interactive exhibit" (15.4%) to be found in science centres belongs to the level one, or passive exhibit category.

The possibility exists that some centres may not have considered exhibits at this level to be interactive, and consequently omitted detailing the numbers of these exhibits altogether (even though they may have passive exhibits on display). However, the significant aspect of this information is that there are substantial numbers of level two and level three exhibits being displayed in many science centres. It is for these types of exhibits that the exhibit evaluation instrument is primarily intended; consequently the use of the evaluation instrument could be quite widespread.



Legend: Level 1: Passive Exhibits
Level 2: Exhibits requiring visitor's presence only in order to begin functioning
Level 3: Exhibits requiring active and continual visitor involvement in order to function

FIGURE 3.2 PERCENTAGES OF INTERACTIVE EXHIBITS X LEVEL OF INTERACTIVENESS

Authority for Exhibit Selection and Installation

Approximately 39.5% of the institutions surveyed select a concept for exhibit development through the recommendation of a committee (Table 3.2). This equals the number of institutions (39.5%) which rely on an individual staff member to select the concepts. A number of institutions (21%) develop exhibits based on their suitability for corporate sponsorship. Committees also play an important role in that

they constitute the final authority in approving installation of exhibits in 61% of the institutions (Table 3.3). In contrast, 33% of the institutions give the final authority for such decisions to a single position. Again, sponsor funding plays a role by determining the exhibits which are approved for installation in 6% of the institutions.

Basis of Exhibit Concept Selection	%
Individual Staff's Initiative/Selection	39.5
Selection by Committee	39.5
Suitability for Corporate Sponsorship	21.0

TABLE 3.2 METHODS USED TO SELECT CONCEPTS FOR EXHIBIT CONSTRUCTION

Authority	%
Single Authority	33
Committee	61
Sponsor Funding	6

TABLE 3.3 GOVERNING AUTHORITY WHICH GIVES FINAL APPROVAL FOR EXHIBIT INSTALLATION

As the majority of institutions make use of committees to select and approve exhibits for installation, the exhibit evaluation instrument is most likely to be used by members of

such committees. The instrument may provide assistance to those committees charged with the responsibility of recommending the construction of certain exhibits for installation, or for removing ineffective exhibits.

Extent of Measurable Exhibit Objectives

Exhibit topics and their statements of objective were requested in order to determine the extent of use of measurable objectives. As is shown in Table 3.4, over half (53.6%) of the exhibit objectives were defined in measurable terms.

Exhibit Objective Clarity	Suitable for Goal-Referenced Approach	%
Exhibit objective clearly defined in measurable terms	Yes	53.6
Exhibit objective not clearly defined in measurable terms	No	46.4

TABLE 3.4 PERCENTAGE OF INTERACTIVE EXHIBIT OBJECTIVES SUITABLE FOR GOAL-REFERENCED APPROACH TO EVALUATION

As a result, the exhibit evaluation instrument (which requires stated objectives) would be directly appropriate for use with the majority of current exhibits and their objectives. The remaining statements of objectives would require further clarification of intended outcomes in order to be measurable,

for use with the evaluation instrument. Such action would need to be considered by any institution interested in implementing this goal-referenced approach to exhibit evaluation.

Exhibit Criteria Rankings

The surveyed institutions were requested to rank (on a scale of 1 to 5) a given set of eight exhibit criteria in terms of their importance in the process by which a decision is made to install an exhibit. For each criterion, the number of responses for each degree of importance were tallied and multiplied by its point value (1 to 5). The maximum score for any single criterion was 80 points (100%), which would have been the case if all sixteen respondents to this question indicated it as an extremely important criterion (each respondent would give a score of 5). The results may be seen in Table 3.5. Seven of the eight criteria received a score of 61 points (76.3%) or greater. Consequently, all of the listed factors were deemed to play an important role in making such a decision, except for "revenue generating potential", and these factors should be considered in evaluative instruments. Only six (37.5%) of the institutions responding to this question indicated that revenue generation was of average or more importance in their decision to construct an exhibit.

Order of Importance	Criteria	Score	Percentage
1	Importance/Relevance of Principle to Visitors	69	86.3
2	Attracting/Holding Power	67	83.8
3	Resource Demand	66	82.5
3*	Design of Exhibit	66	82.5
4	Entertainment Value	65	81.3
5	Educational Value	62	77.5
6	Level of Possible Interactiveness	61	76.3
7	Revenue Generating Potential	34	42.5

*Duplicate numbers indicate tied scores

TABLE 3.5 RELATIVE IMPORTANCE OF CURRENTLY-USED CRITERIA IN MAKING A DECISION TO CONSTRUCT AN EXHIBIT

Factors of a Successful Exhibit

An open-ended question asked for the respondents' perceptions of what factors make an exhibit successful. Responses were grouped into eight broad categories of factors (see Figure 3.3).

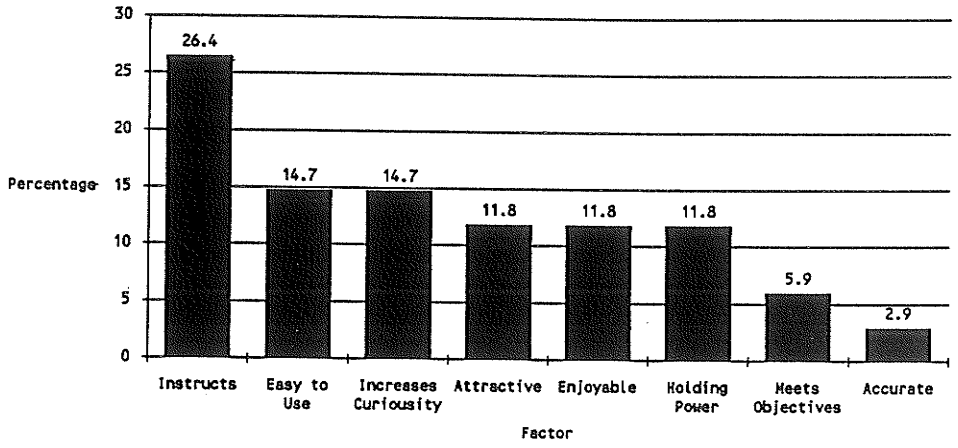


FIGURE 3.3 PERCEIVED FACTORS WHICH MAKE AN EXHIBIT SUCCESSFUL

There is some inconsistency between the importance ratings of the given set of criteria (Table 3.5) and the open-ended responses of what are considered factors of a successful exhibit. For example, the category "instructs" was considered by far the single most important factor in making an exhibit successful (26.4%), whereas "educational value (clearly teaches important concepts)" was ranked fifth in order of importance in the set of criteria for determining suitability. It is important to note, however, that although "educational value" scored in fifth place, its score (62) was only seven points lower than that of the first place criteria (69), indicating that they are not significantly different in terms of importance. Also, the two questions could be perceived as relating to two different stages of exhibit development. The given set of criteria included "resource demand" and "design",

which could be considered as very important before the exhibit is constructed. The question "what makes an exhibit successful?" may have been perceived to mean "what makes an existing exhibit successful?" and thus could have elicited a slightly different set of responses. A relatively small percentage (5.9%) of responding institutions freely suggested that "meets objectives" is a factor of a successful exhibit. This low level of response does not necessarily mean that a large percentage of institutions have concluded, after giving it consideration, that it is not important for an exhibit to meet its objectives. Rather, it may be consistent with other evidence[4] which indicates that formal evaluations are being conducted in few institutions. Consequently, the respondents may have been describing their current methods of determining success, to the exclusion of formally determining whether an exhibit is meeting its intended objectives. Most of the factors considered important for a successful exhibit to possess (i.e. "instructs", "easy to use", "increases curiosity", "enjoyable", "holding power") were included in the exhibit evaluation instrument.

Evaluation Instruments Received

The response to the request for copies of exhibit evaluation instruments from the surveyed institutions was very

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[4]Shettel, Harris H. (1989). Do We Really, Really Need To Do Visitor Studies?

disappointing, but not surprising. The intention was to incorporate as much relevant information and questions from these instruments as possible into the developed exhibit evaluation instrument. None of the institutions submitted copies of formal instruments which specifically measured exhibit effectiveness. Three institutions submitted copies of various evaluative instruments. These instruments were limited to demographic surveys, general visitor perceptions of the museum experience, and school program evaluations. No useful information from the few submitted instruments could be incorporated into the exhibit evaluation instrument. One reason in particular which might explain the poor response to the request for instruments is that, as earlier discussed, formal evaluations of exhibits are being conducted in relatively few institutions. Consequently there may be few formal instruments which measure exhibit effectiveness available.

Extent of Exhibit Evaluation

Although a large majority (88.2%) of surveyed institutions report involvement in the evaluation of their exhibits (see Table 3.6), evaluation on a regular basis is restricted to a minority of them (45.5%) (see Table 3.7). Of the institutions that conduct any type of exhibit evaluation, few (9.1%) report conducting exhibit evaluations on a daily

basis. Most of the institutions that are involved in exhibit evaluations do so only on an infrequent basis.

	%
Institutions Which Evaluate Exhibits	88.2
Institutions Which Do Not Evaluate Exhibits	11.8

TABLE 3.6 PERCENTAGE OF INSTITUTIONS WHICH DO AND DO NOT EVALUATE EXHIBITS

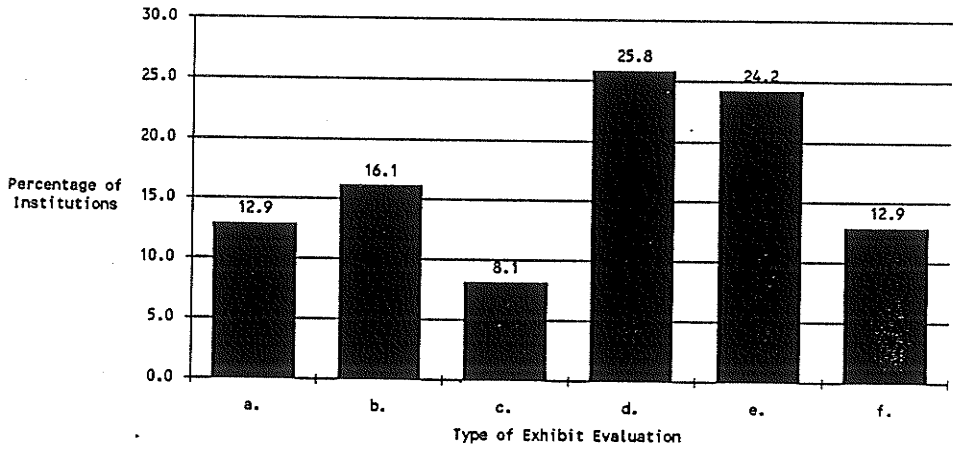
Frequency	%
Daily	9.1
On-going	36.4
Infrequent	54.5

TABLE 3.7 FREQUENCY OF EXHIBIT EVALUATIONS, OF THE INSTITUTIONS WHICH CONDUCT EVALUATIONS

Types of Exhibit Evaluations Used

As can be seen in Figure 3.4, of the institutions which conduct exhibit evaluations, at least half of all evaluations are clearly informal, consisting of casual observations and

staff discussions. Only 12.9% of the institutions which conduct evaluations use formal observations while another 12.9% make use of formal or informal visitor interviews.



Legend:
a. In-person interview
b. Staff-conducted questionnaire of visitors (on-site)
c. Self-conducted visitor questionnaire (pick-up/mailed)
d. Discussions amongst staff
e. Casual observations of visitor interaction
f. Formal observations of visitor interaction

FIGURE 3.4 PERCENTAGE OF INSTITUTIONS X TYPE OF EXHIBIT EVALUATION USED (BY INSTITUTIONS WHICH CONDUCT EXHIBIT EVALUATIONS)

There appears to be a need in the museum community for formal exhibit evaluation instruments. This is evident, since a limited number of institutions are involved in formal exhibit

evaluations, and because few institutions evaluate exhibits on a regular basis. Considering that the development of formal exhibit evaluations requires a large expenditure of time, it appears that there is a strong possibility that few formal exhibit evaluation instruments have been developed.

Evaluation of School Student vs General Public Interactions

The majority of respondents (58.8%) report that their exhibit evaluation methods for school groups do not differ from the methods used with the general public (see Table 3.8). Consequently, it is important that any new exhibit evaluation instrument be adaptable for use with both types of museum visitors.

	%
Exhibit Evaluation Methods for School Groups Differ from Those for the General Public	41.2
Exhibit Evaluation Methods are the Same for School Groups and the General Public	58.8

TABLE 3.8 PERCENTAGE OF INSTITUTIONS WHICH USE DIFFERENT EXHIBIT EVALUATION METHODS FOR SCHOOL GROUPS AND THE GENERAL PUBLIC

3.1.3) Exhibit Evaluation Instrument Development

The overall purpose of developing an exhibit evaluation instrument was to provide an objective mechanism for measuring the success or effectiveness of interactive science exhibits. In order to judge an exhibit successful or effective, there is a need to define the term "exhibit effectiveness". Eason and Linn[5] define exhibit effectiveness as "measurable transmission of information about scientific principles from the exhibits to the visitors". Shettel's[6] definition is "a measurable change in viewer behavior produced by the exhibit and consistent with the stated aims or objectives of the exhibit". Using Screven's[7] "goal-referenced approach", an effective exhibit is one which achieves its intended goal(s) or objective(s). Because the objectives of interactive science exhibits are not necessarily restricted to those that promote only "transmission of information about scientific principles", but may include such objectives as causing stimulation and increasing curiosity, altering concepts, and providing simple enjoyment as well as new knowledge, this study employed a goal-referenced approach.[8]

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[5] Eason, Laurie P. and Marcia C. Linn (1976). Evaluation of the Effectiveness of Participatory Exhibits.

[6] Shettel, Harris H. (1973). Exhibits: Art Form or Educational Medium?

[7] Screven, C. G. (1976). Exhibit Evaluation - A Goal-Referenced Approach.

[8] See Chapter 2 for further discussion of the goal-referenced approach to evaluation.

The developed evaluation instrument (Appendix B) consists of two sections. The first section, an observation guide, was developed for use during unobtrusive observations in order to document visitor interactions and total time spent interacting with each exhibit. The second section, an interview guide, was a questionnaire to determine enjoyment level, whether an exhibit stimulates the visitor, knowledge gain, and ease of exhibit use. The use of multiple methods of exhibit evaluation seems most appropriate:

> "No one evaluation technique by itself can accurately measure the outcomes of a program.... The best approach is to choose more than one method to make up for the limitations of another....it is often best to select one method to measure audience behavior and a second that assesses visitor enjoyment, knowledge or attitude".[9]

Similar combinations of instruments have been used by a number of museum researchers.[10]

3.1.3.1) Observation Guide

This first section of the evaluative instrument was designed to record both the total time a visitor spends with an exhibit, and the sequence of visitor behaviours during this period.

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[9] Roggenbuck, J. W. and D. B. Propst, (1981). Evaluation of Interpretation.

[10] Russell et al, 1988; Rode-Perkins, 1987; Harlen, 1986; Peart, 1982; Screven, 1974.

Holding Power

The duration of time spent interacting with an exhibit can provide a measure of an exhibit's "holding power"[11]. This, in turn, may assist evaluators in determining the extent to which visitors find an exhibit interesting, and its potential for motivating the visitor. Diamond[12] has found that the total time spent with an exhibit or "holding power" can be considered directly proportional to interest level. Similarly, Screven[13] [14] argues that an exhibit's motivational properties may be correlated with its ability to hold attention. In addition, a longer total viewing time has been associated with increased quality of visitor experience, "including meeting the exhibit's educational, aesthetic, and entertainment objectives[15].

Visitor Behaviours

Specific nonverbal behaviours have been shown to correlate highly with positive affect and cognitive learning; and the interaction factors of both total time spent with an

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[11] Shettel, Harris H., (1976). An evaluation of Visitor Response to "Man in His Environment."

[12] Diamond, Judy. (1986). The Behavior of Family Groups in Science Museums.

[13] Screven, C. G. (1976). Exhibit Evaluation - A Goal-Referenced Approach.

[14] IBID, (1975). The Effectiveness of Guidance Devices on Visitor Learning.

[15] Bitgood, Stephen et al. (1987). Formative Evaluation of a Cave Exhibit.

exhibit and specific nonverbal behaviours have been shown to provide better predictions of learning than either on its own[16]. Accordingly, the observation guide itself combined a second method of measuring visitor behaviour, to be used in conjunction with total interaction time measures. This took the form of a checklist of behaviours, which recorded all visitor behaviours during the interaction period. Aspects of Harlen's[17] Check-list of Interactions, Russell et al's[18] [19] Checklists, and Rode-Perkins'[20] Visitor Interactions List were incorporated into this checklist (see Appendix B).

Definitions of Observed Actions

Definitions of the categories of observed visitor actions (as listed on the Observation Guide of the exhibit evaluation instrument) follow:

Reads Label: the descriptive text on (or associated with) the exhibit is given at least an observable glance. The glance must have a duration of more than one second.

Exhibit-Related Talk: general or instructional dialogue with reference to the exhibit.

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[16] Falk, John H. (1983). Time and Behaviour as Predictors of Learning.

[17] Harlen, Wynne et al. (1986). Evaluation of the Pilot Phase of the Liverpool Interactive Technology Centre.

[18] Russell, Terry, A. Van der Waal, and M. Whitelock. (1987). Developmental Stage Evaluation of Interactive Exhibits at Jodrell Bank Science Centre.

[19] IBID. (1988). Evaluation of the Pilot Phase of the Cardiff Interactive Technology Centre 'Techniquest'.

[20] Rode-Perkins, Susan. (1986). An Evaluation of Selected Exhibits at the St. Louis Science Centre.

Engages Exhibit by Own Initiative: any physical interaction with the exhibit, where the student has acted without encouragement from others.

Engages Exhibit With Persuasion from Others: any physical interaction with the exhibit, where the student has been encouraged by others to interact.

Watches Others: watching others physically interact with the exhibit, for one second minimal duration.

Works with Another, or Willingly Take Turns: cooperative physical activities during the interaction.

Completes the Exercise: correctly operates the exhibit as intended so as to allow achievement of the desired effect.

Unsuccessful Attempt: inappropriate interaction with the exhibit; exhibit is not physically used as intended, or is not used to the full extent as intended.

Repeats (Same Way): the same (or very similar) successful or unsuccessful physical interaction is repeated.

Repeats (With Modification): a successful or unsuccessful physical interaction is repeated, but in a modified form.

3.1.3.2) Interview Guide

This second section of the exhibit evaluation instrument involves the use of a structured interview to gather information regarding a visitor's perceptions of an exhibit, and to determine the extent to which an exhibit communicates its intended message. The use of a structured interview following observations of visitors has been used in a number

of previous studies[21]. Questions designed for the student audience were developed by referring to the information collected from the responses to the survey and were used to determine whether or not the intended exhibit objectives are being achieved, relative to enjoyment level, stimulation, knowledge transfer, and general ease of use. A comparison of the observed interactions (as recorded through use of the observation guide of the instrument) with the visitors' perceptions of their interactions was made possible through the development of suitable questions. Multiple choice questions were designed for the purpose of providing a measure of the visitors' actual understanding of the exhibit content. This series of questions indicates the effectiveness of the exhibit in transmitting information about scientific principles, and indicates variation in the instructional potential of different exhibits. A comparison of the visitors' perceptions of having understood the content with the actual level of understanding of the exhibit was also possible.

Framework of the Structured Interview

The series of interview questions were developed by using a framework of general questions which was intended to be appropriate for many exhibits, and then including questions

[21] Harlen W. et al (1986); Rode-Perkins, S. (1987); Russell, T. et al (1987), (1988).

which addressed the content of the specific exhibit under study. This allowed one generalizable evaluation instrument to be developed for use with a wide variety of interactive exhibits. In order to allow this open and non-prejudicial instrument to gather information which would indicate the degree of knowledge transfer from exhibit to visitor, several exhibit-specific cognitive questions were then included for each of the six selected exhibits. Wherever possible, multiple choice questions were used for these exhibit-specific cognitive questions. This type of question had been used successfully to collect information regarding cognitive gain in previous studies.[22] As had been recommended by Borun,[23] three exhibit-specific cognitive questions were employed to determine the visitors' level of exhibit knowledge. It was possible for visitors to acquire sufficient knowledge to correctly answer two of the questions by correctly physically interacting with the exhibit, and observing the effect. A correct answer to one of the questions would likely be provided only if the visitor had read and understood the exhibit's descriptive text, or had previously-acquired knowledge. This procedure allowed a further check on label copy effectiveness, for those visitors who had read the text.

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[22] Borun, M. (1977); S. Rode-Perkins (1986).

[23] Borun, M. (1977). Measuring the Immeasurable: A Pilot Study of Museum Effectiveness.

As suggested by Peart,[24] care was taken to avoid questions which contained data that provided answers to questions which followed in the questionnaire. Rode-Perkins'[25] recommendation, that questions regarding the visitor's perception of what an exhibit was trying to show be placed near the end of the interview rather than near the beginning, was followed. She argues that this reduces the possibility of creating a defensive wall between the interviewer and the visitor. Questions regarding the students' rating and perceived ease of understanding the exhibit were placed near the beginning of the interview, before the multiple choice cognitive questions. This was an attempt to reduce the possibility of influencing an exhibit's rating by students who, upon failing to answer the cognitive questions, may tend to lower the rating that would have been given had the interview not interfered with their visit. Many of the questions employed an open-ended style, as recommended by Borun.[26] This eliminated the potential problem of having abstract concepts in the words or phrases of the choices of answers offered to the visitor, and removed a language and conceptual barrier in the responses.

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[24] Peart, Robert W., (1982). Knowledge Gain, Attitudinal Change and Behaviors at Museum Exhibits Ranging from Abstract to Concrete.

[25] Rode-Perkins, Susan. (1986). An Evaluation of Selected Exhibits at the St. Louis Science Center.

[26] Borun, M. (1977). Measuring the Immeasurable: A Pilot Study of Museum Effectiveness.

Types of Information Collected

The questions included in the interview section of the exhibit evaluation instrument were designed to collect information from the visitors regarding the three major aspects of an exhibit's effectiveness. Each of these three aspects consist of several concerns which specific questions addressed:

Aspect A. Was the interaction enjoyable?

(a) what level of enjoyment was afforded the student by the exhibit?

(b) did the student feel the exhibit was easy or difficult to use?

(c) did the student feel the exhibit was easy or difficult to understand?

Aspect B. Was the experience stimulating? Did it arouse the visitors' curiosity?

(d) was the exhibit found to be surprising (aroused curiosity and was thus stimulating)?

(e) did the student feel that the exhibit made him/her curious about the subject (stimulated his/her interest in this area of science)?

Aspect C. How well does the exhibit communicate its message?

(f) was the student's perception that he/she read and understood the exhibit copy (signage), that the copy helped the student to use the exhibit, and that it was necessary to enable use of the exhibit?

(g) did the student's perception of the exhibit's purpose match the exhibit's actual purpose?

(h) did the student understand the specific knowledge which was intended to be conveyed by the exhibit?

(i) did the student perceive him/herself to have understood the exhibit's specific content knowledge?

Demographic Information

During the student interview component of the exhibit evaluations, demographic information was limited to the age, grade, and gender of the student, and the number of previous visits to the TTU Gallery.

PHASE II. TESTING THE EXHIBIT EVALUATION INSTRUMENT AT THE TOUCH THE UNIVERSE GALLERY

3.2.1) Exhibits Selected

The Touch The Universe Gallery contains approximately sixty (60) exhibits (see Appendix C for a complete list). The exhibit evaluation instrument was tested by implementing it with six (6) randomly selected exhibits which are outlined in Table 3.9 below.

EXHIBIT NAME	AREA OF TTU
Eye	Sight Area
Gravity Well[27]	Introductory Area
Music Room	Sound Area
Pin Table	Touch Area
Spectra	Sight Area
Zoetrope	Sight Area

Table 3.9 The Selected Exhibits

Descriptions and specific objectives of the selected exhibits may be found in Appendix C. Museum staff set visitor target percentages for objective achievement at 80% for the enjoyment aspect, 70% for the motivation or increase in curiosity aspect, and 60% for the information transfer aspect.

[27] Insufficient data was collected for this exhibit, due to the lack of visitor interest in interacting with it.

3.2.2) Sample Selection

The exhibit evaluation instrument was to be tested with intermediate level (grades 4, 5, and 6) students who were scheduled to visit the TTU gallery during the data collection period of March through May, 1989. The intention was to observe and interview twenty (20) students for each of the six selected exhibits, for a total of 120 visitors. Unfortunately one exhibit, the Gravity Well, did not attract any intermediate level students during the first four weeks of the data collection period. A decision was subsequently made to remove this exhibit from the study. The sampling of student visitors was carried out according to a schedule developed in advance of the implementation of the evaluation instrument. Each intermediate level class which registered in advance for a visit during the data collection period was included on the evaluation schedule. As a matter of Museum policy, schools are required to reserve the TTU gallery in advance of their visit. Dates were checked with the Museum's Education Department to determine at which times and on which dates classes of intermediate level students were scheduled to use the exhibits in the TTU gallery during the months of March, April, and May of 1989.

Reasons for Sample Choice

The intermediate level grades of school students (approximately nine to thirteen years of age) had been chosen for this study for several reasons. School students were selected for the study because they traditionally comprise the vast majority of visitors to the TTU Gallery during the period of the study, allowing a sufficient number of visitors for the study. Students in grades four through six were selected because students from the intermediate grades reflect the largest population of school visitors to the TTU Gallery. They are thus a very large audience and the TTU gallery is attempting to satisfy their needs and interests. Based on the experience of past years, these students were expected to visit the TTU Gallery in relatively large numbers in the months of March, April, and May. This large number of student visitors makes available a reasonably large population for random sampling. Populations of both older and younger students were excluded for practical considerations. Far fewer classes of high school students attend the TTU Gallery, and an adequate population size of these students for the study was much less likely than intermediate level students. Younger children were not included in the study. Information gained from earlier studies indicated that interviews with young children (below the age of seven) have proven entirely

unsatisfactory[28]. Student visitors who did not speak English were omitted from the study because answers to the questions would not have been understood by the evaluator.

Consequently, the sample of visitors involved in the study is not intended to reflect the demographic characteristics of the visiting student population as a whole; it is limited to representing the population of English-speaking classes of intermediate grade students.

Teacher Pre-Visit Contact

Prior to the day of the visit, the teacher in charge of each class was contacted by telephone. The exhibit evaluation exercise was explained to the teacher, and permission was requested to involve their students in the study. The request for permission form is a component of the exhibit evaluation instrument (Appendix B). This pre-visit contact procedure was similar to one described by Harlen[29] in the Liverpool Centre study, where the teacher in charge of the targeted class was approached prior to interviewing the students, to alleviate possible misgivings they might have had on seeing their students observed and questioned, with written recordings made. The identity of the students and schools involved in the study was kept confidential. All teachers contacted

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[28] Alt, M.B. (1980). Four years of Visitor Surveys at the British Museum (Natural History) 1976-79.

[29] Harlen, Wynne et al, (1986). Evaluation of the Pilot Phase of the Liverpool Interactive Technology Centre.

agreed to participate in the exercise. Teachers were also requested to provide a description of any student preparation for the visit, in terms of correlation of exhibit content with curriculum, and providing directions for use of the exhibits. All teachers reported that student preparations for the visit (if any) were of a general nature only (e.g. expected behaviour and conduct; travelling arrangements). Four teachers indicated that a related curriculum unit had recently been completed and that the visit was intended as a supplement to classroom learning. No teacher reported that exhibit-specific content was taught, or that specific exhibits were discussed.

Workstation Placement

Four interview workstations were set up in the TTU Gallery, each consisting of a small table with two chairs. As Harlen[30] indicated, it would prove difficult to interview visitors very near the exhibits, as non-usable multiple responses from interested friends could occur. Further, Yalow et al[31] explained that if visitors are alerted to an exhibit under study their attention to the exhibit could be increased, and that experimental control is required to ensure that visitors have no reason to suspect that the amount they

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[30] Ibid

[31] Yalow, Elanna S., et al. (1980). Improving Museums Through Evaluation.

learned from the exhibit would interest anyone. Screven[32] described the ease with which the effects of experimental exhibit conditions can be contaminated and stated that it is clear that museum research results can be affected by pre-exhibit experiences. For example, the obvious selection of participants before seeing the exhibit, or giving simple statements of exhibit objectives to visitors beforehand, may improve the learning from an exhibit. Consequently, interview workstations were located a short distance away from the exhibits undergoing evaluation in order to prevent the observer from influencing visitor activity. As a second method of preventing the introduction of such contamination of the results of this study, prior to approaching a visitor for the structured interview the evaluator observed and recorded the visitor's exhibit interaction in as unobtrusive a manner as possible. In addition to the need for reducing the risk of a cueing effect there were more practical reasons (such as space needs for a table and chairs, and minimizing intrusion into the flow of visitor traffic) for locating the workstations a short distance away from the exhibits under study. As a result, the workstations were as inconspicuous as possible, and did not interfere in any way with the visitors' interaction of the exhibits. Nor did they interrupt visitor traffic flow through the TTU gallery.

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[32] Screven, C.G. (1975). The Effectiveness of Guidance Devices on Visitor Learning.

3.2.3) Implementation of the Instrument

During the implementation of the instrument, randomly selected students were observed from a short distance as they interacted with the exhibit. Following the interaction, the students were approached and, if willing, interviewed.

Conducting the Observation

Section one of the instrument required the use of a stop watch and pencil in order to record the total time spent interacting with the exhibit and the sequence of interactions. The random selection of individual visitors was accomplished by the interviewer choosing the first student (from the end of the previous interview) who approached and interacted with the exhibit under study. The observed interactions of each randomly-selected student attending to the exhibit was documented in sequence as to category of interaction[33]. As mentioned above, the time spent at the exhibit was recorded as well.

Conducting the Interview

Following completion of the unobtrusive observation section of the evaluative instrument (as the student terminated interaction with the exhibit), and prior to the

[33] Following the models of Harlen et al (1986), and Rode-Perkins (1986).

student leaving the immediate area around the exhibit, he/she was approached. Interviews were conducted after all observations had been made so as to eliminate the possibility of an interviewer's comments affecting the exhibit interactions. The evaluator visibly displayed an identification badge to indicate to the student and others that the person who is talking to students is a bona fide staff member of the Museum. The evaluator was introduced as a staff member and an explanation of the purpose for the conversation was provided. The student was asked to answer a few questions, was assured that the procedure was not a test, and that his/her name would not be asked. (When students proffered themselves for interview, their offers were politely declined). If the student could comprehend the exercise, communicate with the evaluator,[34] and was willing to cooperate in the evaluation, he/she was then taken over to the interview workstation, away from the exhibit. This removed the risk of the exercise heightening other students' interest in any particular exhibit. The questions contained in the interview guide of the exhibit evaluation instrument were orally administered, and were asked exactly as they appeared on the interview guide. Visitors were never asked for their names or other identifying information. Each student was also given the opportunity to read the typed text of the questions.

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[34] Several special education students from integrated classes were excluded from the study on the basis of their inability to comprehend the exercise or communicate with the evaluator.

Verbatim comments and responses to the questions were recorded immediately in writing, directly on the instrument.

CHAPTER 4. PRESENTATION AND DISCUSSION OF THE INSTRUMENT DATA

This chapter consists of a description and discussion of the data which was collected through the testing of the exhibit evaluation instrument. It is organized into five sections. Section 4.1 is concerned with the characteristics of the students who participated in this study. Section 4.2 describes the behaviour of the students with the exhibits, while Section 4.3 describes the students' perceptions of, and and cognitive learning from, the exhibits. Section 4.4 discusses individual exhibit effectiveness with reference to their stated objectives. The final section (4.5) provides a summary of the effectiveness of the five exhibits involved in the study.

4.1 Characteristics of the Student Population

Each of the five exhibits was evaluated using a sample size of 20 students. Data was collected by observing 100 students from 25 different classes. It is noted that three males (two in grade 6 and one in grade 4) refused to be interviewed. Consequently, the sample size for behavioural observations and gender distribution was 100, while the sample size for verbal responses was 97. The grade levels of the classes willing to be involved in the study were approximately evenly distributed: nine grade 4 classes; eight grade 5 classes; and eight grade 6 classes.

Grade and Gender Distributions of the Participants

As can be seen in Table 4.1, the grade distribution of students actually involved in the study was less evenly distributed than the classes willing to be involved, with the greatest proportion of students being in grade six.

Gender	Grade 4	Grade 5	Grade 6	Total
Male	8	17	27	52
Female	15	18	15	48
Both	23	35	42	100

TABLE 4.1 NUMBER OF OBSERVED VISITORS, BY GRADE LEVEL AND GENDER

This uneven distribution is due to the fact that the proportion of males attracted to the selected exhibits varied considerably across the grade levels. More grade six males (27) participated in the study than did grade five male (17) or grade four males (8). Although the exhibits selected for this study were visited by approximately equal numbers of male and female students overall, it appears that the grade 4 males were under represented, and the grade 6 males were proportionately over represented. This may imply that the selected exhibits possess a lower degree of attracting power for younger males (ages 8 to 10) in comparison to grade 6

males (ages 10 to 12). The number of female students attracted to each of the five exhibits under study was approximately evenly distributed across the grade levels. A large majority of the grade 4 students were female, while a large majority of the grade 6 students were male. In the grade 5 group, the students were evenly divided between the genders.

Repeat Visitor Distribution

The number of visits to the TTU gallery by each student is shown in Table 4.2. As earlier mentioned, of the 100 students who were observed, three male students declined to be interviewed. As a result, the total sample size for items requiring verbal answers was reduced to 97 students.

	Number of Visits to TTU					
Grade	1*	2	3	4	>4	Student Total
Grade 4	13	5	1	1	2	22
Grade 5	19	5	4	4	3	35
Grade 6	22	7	6	3	2	40
Total	54	17	11	8	7	97

* First-time Visitors

TABLE 4.2 NUMBER OF TIMES STUDENTS HAVE VISITED THE TTU GALLERY (INCLUDING PRESENT VISIT), BY GRADE LEVEL

The first-time visitors comprised the largest single category, with 54 students (55.7% of the total) claiming in the interview to be visiting the TTU gallery for the first time. Frequencies of visits by the other students, both overall and by individual grades, generally decrease as the number of visits increase (17 students were on their second visit, 11 on their third, etc.). Approximately 44% of all interviewed students had visited the TTU gallery on at least one previous occasion. This fact may have played a role in influencing the manner in which the students approached and interacted with the exhibits.

4.2 Behaviour of Students with Exhibits

A checklist was used to record both the duration of a student's interaction with an exhibit, as well as the sequence of interactions (see Appendix B for a copy of the observation checklist section of the exhibit evaluation instrument).

Frequency of Contact with Exhibits

As stated earlier, the sample size for observations of interactions was 20 students for each of the five exhibits. Although this method of sampling did not allow for a quantitative measure of an exhibit's attracting power, the evaluator noted that the sample quota of 20 students was much easier achieved for some exhibits than for others. In particular, the entire collection period of nearly three

months was required to obtain 20 observations for the Eye exhibit, due to the low interest level of the students in this exhibit. It appears that this is not an exhibit which attracts grades 4 to 6 students to the extent of the other exhibits under study. A second exhibit which was not heavily used by the students was the Zoetrope, although the sample quota was achieved much more readily than the Eye.

	Grade 4		Grade 5		Grade 6		Overall	
Exhibit	Male	Female	Male	Female	Male	Female	Male	Female
Eye	2	7	4	1	5	1	11	9
Music Room	2	3	3	2	7	3	12	8
Pin Table	1	2	2	5	6	4	9	11
Spectra	2	1	7	5	2	3	11	9
Zoetrope	1	2	1	5	7	4	9	11
Total Contacts							52	48

TABLE 4.3 FREQUENCY OF CONTACT WITH EXHIBITS BY GRADE LEVEL, AND GENDER

As Table 4.3 indicates, the Music Room was the only exhibit to show a greater than 10% difference in overall contacts between genders, attracting a greater number of male students than female students. Most exhibits attracted an approximately equal number of male and female students. However, gender preferences for exhibits are apparent when the male and female groups are subdivided into grade levels. Of

the nine grade 4 students attracted to the Eye exhibit, seven (approximately 78%) were girls. In contrast, boys in grades 5 and 6 are more likely to interact with the Eye than are girls. More boys in grade 6 than girls are likely to use the Music Room and Zoetrope exhibits, while more girls in grade 5 than boys are likely to use the Zoetrope.

Average Time Spent at Exhibits

A wide range of interaction times was observed between the exhibits. The overall mean time spent in contact with an exhibit was 63.7 seconds. This is consistent with the findings of previous researchers[1] who found that visitors spend 60 seconds or less at each exhibit.

	Average Time Spent (Seconds)		
Exhibit	Male Students	Female Students	Overall
Eye	25.9	16.8	21.8
Music Room	153.0	116.9	138.6
Pin Table	27.1	38.5	33.4
Spectra	21.4	42.0	30.7
Zoetrope	57.3	123.7	93.9
Average	56.9	67.6	63.7

TABLE 4.4 AVERAGE TIME SPENT INTERACTING WITH EXHIBITS, BY GENDER AND OVERALL

[1] Borun (1977); Harlen (1986); Peart (1982); Russell (1988); Shettel (1973).

Female students spent an average of 67.6 seconds at each exhibit, while male students spent a slightly lower average amount of time at each exhibit (56.9 seconds). The greatest amount of time was spent at the Music Room, with an average expenditure of 138.6 seconds (see Table 4.4). The least amount of time spent at an exhibit, on average, was at the Eye (21.8 seconds). The Music Room has the greatest amount of holding power, while the Eye exhibit has the least. In terms of holding power, following the Music Room, in rank order are: Zoetrope, Pin Table and Spectra. Boys spent more time than girls at the Music Room and Eye, while the reverse is true for the other three exhibits. Most of the exhibits show a similar pattern of difference in time spent by boys versus girls, with one notable exception. Female students spent over twice the amount of time as male students with the Zoetrope. This may be due to the nature of the exhibit, in accordance with Harlen's[2] argument that the nature of an exhibit determines, to some extent, the duration of contact permitting a meaningful interaction. The effect of the zoetrope may be observed quickly, by using another person's drawing. If a visitor is inclined to spend the time, a personal series of pictures may be drawn and used with the exhibit. It seems that girls may be more willing than boys to spend the time

[2] Harlen, Wynne et al. (1986). Evaluation of the Pilot Phase of the Liverpool Interactive Technology Centre.

concentrating on the creation of a personal set of drawings.

Distribution of Observed Actions

Data associated with student interactions, broken down by each exhibit, are summarised in Table 4.5. If a student was observed undertaking an action at least once (many students repeated various actions several times), the student was considered to have engaged in that action. Individual students usually engaged in several actions while using an exhibit; rarely were all of the possible actions accomplished by a single student. The table illustrates percentages of the total sample size.

	Exhibit				
Observed Action	Eye	Music Room	Pin Table	Spectra	Zoetrope
Reads Label	25.0	25.0	10.0	35.0	20.0
Exhibit-related Talk	50.0	30.0	60.0	20.0	25.0
Engages Exhibit by Own Initiative	75.0	95.0	85.0	90.0	100.0
Engages Exhibit with Persuasion from Others	25.0	20.0	30.0	15.0	0.0
Watches Others	20.0	25.0	35.0	10.0	25.0
Works with Another or Willingly Takes Turns	30.0	60.0	45.0	15.0	25.0
Completes the Exercise	30.0	100.0	40.0	50.0	50.0
Unsuccessful Attempt	75.0	5.0	60.0	55.0	55.0
Repeats (Same Way)	30.0	0.0	5.0	10.0	20.0
Repeats (With Modification)	10.0	5.0	10.0	0.0	15.0

Table 4.5 DISTRIBUTION OF OBSERVED ACTIONS BY EXHIBIT (PERCENT)

Engagement with Exhibits

All 100 students were observed interacting with the exhibits in one way or another. Certain actions recorded can be seen to have occurred with high frequencies. The most obvious of these is "Engages Exhibit by Own Initiative". This evidence indicates that the students do physically interact with the exhibits, rather than passively observe. The average incidence of students physically engaging the exhibits on their own initiative was 89%, with a range of 75 - 100%. In contrast, on average only 18% of the students engaged the exhibit following persuasion from others. It appears that persuasion from others is not a requirement for students to use the exhibits, although 15 to 30% of the students were persuaded to interact with the exhibit by others. Patterson and Bitgood[3] report that social psychological variables, including the attracting and repelling power of crowds, influence visitor behaviour. In this study, it appeared from their general comments that students encouraged their peers to engage in those exhibits which they found to be very exciting ("Neat; look at this"). Conversely, students encouraged the assistance of others in interacting with those exhibits which created confusion as a result of a perceived lack of clarity of purpose or mechanism ("Hey, what is this supposed to do?"). Further study is required in order to

[3]Patterson, D. and S. Bitgood. (1988). Some Evolving Principles of Visitor Behavior.

determine the most likely reason for one student to persuade another to engage in each exhibit. On occasion, a student was persuaded to attend an exhibit, and subsequently physically engaged it several times during the period of interaction.

Social Interactions

Many interactive exhibits encourage social interactions, including discussion and cooperation with, and observations of, others. Student discussion was observed at every exhibit, with an average incidence of 37%. The most frequently discussed exhibit was the Pin Table (60%) with the Eye close behind (50%), while the exhibit causing the least discussion was Spectra (20%). The Music Room was the exhibit which involved the highest degree of participant cooperation (60%) followed by the Pin Table (45%). The overall average incidence of cooperative participation was 35%, and the exhibit where students cooperated least was the Spectra (15%). The Spectra and Zoetrope exhibits do not appear to foster student discussion or cooperation. The Spectra exhibit also does not appear to interest students in watching another student interact. This exhibit had the lowest incidence (10%) of students watching others. The Eye exhibit (20%) ranked just above the Spectra, with the average being 25%. This may be due to the nature of the exhibit. The Music Room, with its four separate instruments, was designed for use with up

to four visitors simultaneously while the Spectra, with its single diffraction grating wand, was designed as a single-person exhibit. One may assume that an exhibit which allows several people to interact with it at the same time probably encourages exhibit-related talk and cooperative participation. The exhibits associated with a relatively high degree of exhibit-related talk and cooperation may be viewed favourably by those visitors who attend a museum largely for social reasons (e.g. family outings), where discussions and cooperative interactions are an important aspect of the visit. Hood[4] found that social interactions are highly valued by frequent museum visitors (as well as non-visitors). Consequently, those exhibits which provide such experiences may prove enjoyable to many members of the general public. In addition, Patterson and Bitgood[5] report that exhibits which promote interactions between visitors are more likely to educate the viewers.

Reading Exhibit Labels

There is an apparent reluctance of students to read labels, with an average of 23% of the students (range from 10 to 35%) giving the signage an observable glance of at least one second duration. This degree of reading an exhibit's text

[4]Hood, M. (1983). Staying Away.

[5]Patterson, D. and S. Bitgood. (1987). Exhibit Design with the Visitor in Mind.

is consistent with studies of other researchers.[6] The degree to which label reading is a prerequisite for interaction with an exhibit varies from one exhibit to another. Activities invited by some exhibits are more self-evident than others. The Music Room (which had an observed student reading rate of 25% and was correctly used by 100% of the students) could be used correctly with little regard to labelling. Correct use of the Pin Table (with an observed reading rate of 10% and correctly used by 40% of the students) generally requires the introduction of the text. In the case of the Zoetrope (reading rate of 20%), the label was suspended from the ceiling, quite a distance above the apparatus of the exhibit, and large percentages of students indicated that they were not aware of any signage associated with the exhibit. As Harlen[7] has suggested, watching the behaviours of others may serve as a more immediate guide as to what to do with the exhibits than the labels. Russell[8] has reported that the incidence of reference to labels in children is low, though it increases steadily with age. Other studies[9] have found that children are much less likely to read label than adults. Visitors in

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[6] Harlen, Wynne et al (1986); Russell et al (1987, 1988).

[7] Harlen, Wynne et al (1986). Evaluation of the Pilot Phase of the Liverpool Interactive Technology Centre.

[8] Russell, Terry et al (1988). Evaluation of the Pilot Phase of the Cardiff Interactive Technology Centre 'Techniquest'.

[9] Bitgood, S. et al (1986); Koran et al (1986).

general have a desire to learn in a museum, but are unwilling to "work too hard at it" by spending much time reading.[10]

Repeated Interactions

Few students repeated an interaction (the same way, or in a modified form) with any of the exhibits. The overall average occurrence of any repeated physical interaction was 21% (in a range of 0 - 30%), with the same interaction undertaken by 13% of the students and 8% of the students modifying the interaction in some way. The Eye had the greatest incidence of repeat use in the same way (30%), while the Music Room had the least (0%). The Zoetrope (15%) ranked first in exhibits used by students in more that one way, while the Spectra (0%) was the exhibit least used in more than one way. This may be a reflection of the number of possible ways in which an exhibit may be used. It may also be a reflection of the difficulty level of comprehending the exhibit, as students often physically engaged the exhibit, stopped to read the label, and repeated the physical interaction in the same or a different way.

Successful and Unsuccessful Attempts

On many occasions, a student interacted with an exhibit in an incorrect manner before making another more successful

[10] Bitgood, Stephen (1989); J. Koran (1989).

attempt. The incidence of unsuccessful attempts ranged from 5% (Music Room) to 75% (Eye), with an average of 50%. It appears that many of the students did not initially understand the purpose, or requirements for correct use, of most of the exhibits under study as 55 to 75% of students experienced an unsuccessful attempt at four of the five exhibits. This indicates a need for improvement in the exhibits' method of communicating their correct manner of use and/or purpose. The percentage of students correctly completing the intended exercise of the exhibit ranged from 40% (Pin Table) to 100% (Music Room). This indicates that, after an unsuccessful attempt, many students repeated the attempt in a successful fashion. This confirms the results of Russell et al,[11] who reported that a repeat action seemed to be required in order to grasp the point of the exhibit. It is important to note that at the conclusion of interactions with four of the five exhibits, 50% or more students failed to correctly use the exhibit in a manner which would allow them to fully comprehend the exhibit's purposes.

4.3 Responses to Interviews

As earlier mentioned, all 100 observed students were willing to undergo the interview component of the exhibit evaluation, with the exception of one grade 4 boy and two

[11] Russell, Terry et al. (1988). Evaluation of the Pilot Phase of the Cardiff Interactive Technology Centre 'Techniquest'.

grade 6 boys. The following data is based on the responses to the interviews of the remaining 97 students. The purpose of the interview was to ascertain: the degree to which the students liked or disliked the exhibits; the amount of stimulation or heightened curiosity in the subject caused by their interaction with the exhibits; and the extent to which students comprehended the cognitive information which was intended to be communicated by the exhibits.

Enjoyment Ratings of Exhibits

Students were asked to rate the exhibits on a five point scale from extremely enjoyable to extremely unenjoyable. As Table 4.6 illustrates, students showed a tendency to choose an either extremely enjoyable (average of 25.4%) or enjoyable (average of 52.8%) rating for all exhibits. These findings are consistent with those of Rode-Perkins.[12] Borun[13] suggests that on typical 1 - 5 scales, 80 to 90 percent of the responses should indicate a rating of four (enjoyable) to five (extremely enjoyable), relative to other exhibits in the area. Exhibits which are given average or lower ratings by visitors often require improvement. As described by Knott and Noble,[14] visitors rarely complain about their museum experience.

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[12] Rode-Perkins, S. (1987). An Evaluation of Selected Exhibits at the St. Louis Science Centre.

[13] Borun, Minda. (1989). Introduction to Evaluation.

[14] Knott, T. and D. Noble. (1989). Jumping the Hurdles.

Rating	EXHIBIT				
	Eye	Music Room	Pin Table	Spectra	Zoetrope
Extremely Enjoyable	25.0	50.0	30.0	10.0	11.8
Enjoyable	50.0	50.0	60.0	45.0	58.9
Average	20.0	0.0	10.0	35.0	17.6
Not Very Enjoyable	5.0	0.0	0.0	10.0	5.9
Extremely Unenjoyable	0.0	0.0	0.0	0.0	5.9

TABLE 4.6 OVERALL STUDENT RATINGS, BY EXHIBITS (PERCENT).

Bitgood[15] stated that visitors often try to be "helpful" by exaggerating the pleasure of their experience or telling the interviewer what he/she thinks is expected. Since visitors generally tend to avoid criticism of exhibits, it may be expected that exhibits which receive moderate or lower ratings from visitors are those which have been relatively unenjoyable and require improvement. Upon examination of exhibits to determine those which received average or lower ratings by 25% or more of the students, it became apparent that the Eye (25%) the Zoetrope (29.4%), and the Spectra (45%) exhibits were relatively unenjoyable. All students declared the Music Room to be enjoyable or extremely enjoyable, with the Pin Table (90%) following closely. By subdividing students into gender groupings and by eliminating the "average" responses, a more

[15] Bitgood, S. (1988c). An Overview of The Methodology of Visitor Studies.

detailed analysis of exhibit ratings was made possible (see Table 4.7). Student percentages in both "Enjoyed" and "Not Enjoyed" categories are based on the total sample size (97 students), resulting in less than 100% being achieved in both categories for most of the exhibits. Three exhibits were found to be enjoyable by both male and female students (Eye, Music Room, and Pin Table), with the Eye

		EXHIBIT				
	Sub-Group	Eye	Music Room	Pin Table	Spectra	Zoetrope
Enjoyed	All Students	75.0	100.0	90.0	55.0	70.6
	Male Students	81.8	100.0	88.9	36.4	33.3
	Female Students	66.7	100.0	90.9	77.8	90.9
Not Enjoyed	All Students	5.0	0.0	0.0	10.0	11.8
	Male Students	0.0	0.0	0.0	18.2	33.3
	Female Students	11.1	0.0	0.0	0.0	0.0

TABLE 4.7 STUDENT SUB-GROUP RATINGS, BY EXHIBITS (PERCENT).

being enjoyed by approximately 15% more boys than girls. Of these three exhibits, the Eye was regarded as unenjoyable by over 11% of the girls. A large discrepancy in enjoyment levels between the two genders was observed for two of the five exhibits. The Spectra was enjoyed by nearly 78% of the girls, and by only 36% of the boys. Similarly, the Zoetrope was enjoyed by nearly 91% of the girls, and only 33% of the boys. It is interesting to note that the girls spent about

twice as long as the boys at each of these exhibits (see Table 4.4). One reason for the greater enjoyment of the girls over the boys in both exhibits may be that since they invested substantially more time in interacting with the exhibits, they had a greater opportunity to understand the purpose or content of the exhibits to a greater degree than the boys. Upon understanding the exhibits' purposes, or achieving their intended effect, the girls may have perceived more enjoyment.

Ease of Use Ratings

On a five-point scale ranging from very easy to very hard all exhibits were regarded as easy or very easy to use by the majority of students, ranging from 65% (Spectra) to 95% (Pin Table). As Table 4.8 indicates, more than 25% of the students found three exhibits to be average or hard to use: Eye (30%); Spectra (35%); and Zoetrope (29.4%).

	EXHIBIT				
Ease of Use	Eye	Music Room	Pin Table	Spectra	Zoetrope
Very Easy	55.0	45.0	65.0	15.0	29.4
Easy	15.0	45.0	30.0	50.0	41.2
Average	10.0	5.0	5.0	15.0	17.6
Hard	15.0	5.0	0.0	15.0	11.8
Very Hard	5.0	0.0	0.0	5.0	0.0

TABLE 4.8 OVERALL STUDENT PERCEPTIONS OF EASE OF USE, BY EXHIBITS (PERCENT).

When the genders were divided and the "average" category responses were eliminated, some further differentiation in terms of perceived ease of use became apparent. A greater percentage of male students found the Eye, Music Room and Pin Table to be easier to use than did female students, while the converse is true for the Spectra and the Zoetrope (see Table 4.9). Of the students who found the exhibits to be difficult to use, a greater percentage of females than males found the Eye difficult to use, while a greater percentage of males than females found the Spectra and Zoetrope difficult to use. These results generally correlate with the time spent at the

		EXHIBIT				
	Sub-Group	Eye	Music Room	Pin Table	Spectra	Zoetrope
Easy To Use	All Students	70.0	90.0	95.0	65.0	70.6
	Male Students	72.7	91.7	100.0	54.5	66.6
	Female Students	66.7	87.5	90.9	77.8	72.8
Difficult To Use	All Students	20.0	5.0	0.0	20.0	11.8
	Male Students	9.1	8.3	0.0	27.3	16.7
	Female Students	33.3	0.0	0.0	11.1	9.1

TABLE 4.9 STUDENT SUB-GROUP PERCEPTIONS OF EASE OF USE, BY EXHIBITS (PERCENT).

exhibits. Students who spend more time at the exhibit find it less difficult to use. Conversely, students who find the exhibit difficult to use spend less time with it.

Extent of Signage Reading

The actions of students (including reading labels) were documented through the use of unobtrusive observations during implementation of the first section of the exhibit evaluation instrument. Students who gave an exhibit's signage an observable glance of a minimum of one second duration were recorded as having read the label. As earlier mentioned, on average 23% of the students were recorded as having given the exhibit label at least an observable glance. This data contradicts the verbal responses given by the students with regard to label reading (see Table 4.10).

	EXHIBIT				
Text Read	Eye	Music Room	Pin Table	Spectra	Zoetrope
Perceived	50.0	40.0	40.0	55.0	17.6
Observed	25.0	25.0	10.0	35.0	20.0
Difference	+ 25.0	+ 15.0	+ 30.0	+ 15.0	- 2.4

TABLE 4.10 EXTENT OF STUDENT READING OF EXHIBIT TEXT (PERCEIVED AND OBSERVED), BY EXHIBIT (PERCENT).

In contrast to the observed reading behaviour, on average, 40.5% of the students reported having read the signs on the exhibit. Due to the difficulty of observing a student's eye movements from some of the observing stations, some inaccuracy in measurement may have occurred. However, it is unlikely

that nearly half of the declared reading behaviours were accidentally missed. Evidence from other researchers[16] indicates that visitors may provide unreliable data through self-reports. In all exhibits except the Zoetrope (which did not have text directly on the exhibit, but above it) more students stated having read the labels than actually were observed having done so. The question of having read a label was an important one, because of its influence on the following three survey questions dealing with the usefulness of the labels. Students who state that they have read the label, when in fact they have not, will not likely give a meaningful answer to a question regarding how easily they understood, or how useful they found the label. Other researchers[17] have described evidence to support the speculation that when visitors first glance at a label, they may make an unconscious decision whether or not to read the label based on the perceived length of the label. If this occurred during the present study, the students may have glanced very momentarily at a label upon approaching the exhibit, or during the physical interaction, which the observer missed. When being asked the question "Did you read the signs on the exhibit?", the student who glanced at the label may reply in the affirmative, even though no meaningful

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[16] Bitgood, S. (1989). Introduction to Visitor Studies.

[17] Bitgood, S. et al (1986). Effect of Label Characteristics on Visitor Behaviour.

reading may have occurred. Further study is required to provide further data in this regard. Rewording the question may aid in distinguishing students who read the label from those who merely glanced at it.

Table 4.11 shows that, of the students who declared to have read the signage, the majority felt that they understood it (77.2% on average), that the signage helped them to use the exhibit (86.8% on average), and that reading the signage was required in order to know what to do with the exhibit (90.2% on average). This data indicates that the students perceived the signage to be useful, overall. However, it is interesting to note that 50% of the students who read the signage on the Pin Table exhibit did not understand it.

	EXHIBIT					
Classification	Eye	Music Room	Pin Table	Spectra	Zoetrope	Average
Signage Was Understood	100.0	87.5	50.0	81.8	66.7	77.2
Signage Helped To Use The Exhibit	80.0	100.0	87.5	100.0	66.7	86.8
Would Not Have Known What To Do Without Signage	77.8	87.5	85.7	100.0	100.0	90.2

TABLE 4.11 STUDENT RATING OF EXHIBIT TEXT (OF THE STUDENTS DECLARING THEY READ THE EXHIBIT SIGNAGE), BY EXHIBIT (PERCENT).

Extent of Stimulation

As earlier described, stimulation and curiosity resulting from interaction with the exhibit was measured from the questions: (1) "Did anything about this exhibit surprise you?" and (2) "Does the exhibit make you really want to find out more about what it's showing?...How will you find out more about the idea behind the exhibit?". The former question was intended to determine the degree to which each exhibit offered a discrepant situation to the students, or otherwise contradicted their assumptions. Festinger (1957) has argued that the existence of nonfitting relations among cognitions (dissonance) is a motivating factor in its own right. The latter question was intended to determine whether or not the exhibit had an effect on increasing a student's interest in the scientific principle or concepts which the exhibit was attempting to communicate. Both questions were to provide an indication of the exhibits' role in stimulating curiosity and further inquiry. Opportunities were provided for the students to describe in detail what surprised them, and to provide further information as to how they might learn more about the idea behind the exhibit. The latter information was intended to be acquired through the use of a question which was worded in such manner so as to encourage the students to provide a considered response, as opposed to providing a rote response. Students clearly understood the meaning of the question regarding surprise, and readily gave their response, often with an unsolicited explanation. However, the question regarding a student's desire to find out more about what the exhibit was

showing caused frequent confusion. Students tended to be uncertain as to the meaning of the question, and required considerable probing to elicit a response (other than "I don't know"). The second part of this question was readily understood, however it is felt that the students often provided an answer which he/she felt was what the interviewer wanted to hear, rather than what the student truly felt. Questions worded in another way (e.g. "Would you like to learn more about this?") may be easier for the students to understand, and may provide more valid results. Results from the first question, regarding an exhibit's ability to surprise students may be seen in Table 4.12, while responses to the second question, regarding the students' increased curiosity, may be seen in Table 4.13.

Was Surprised		EXHIBIT				
		Eye	Music Room	Pin Table	Spectra	Zoetrope
Yes	All Students	40.0	75.0	60.0	60.0	47.1
	Male Students	54.5	83.3	66.7	45.5	33.3
	Female Students	22.2	62.5	54.5	77.8	54.5
No	All Students	60.0	25.0	40.0	40.0	52.9
	Male Students	45.5	16.7	33.3	54.5	66.7
	Female Students	77.8	37.5	45.5	22.2	45.5

TABLE 4.12 STUDENT SUB-GROUP EXTENT OF SURPRISE, BY EXHIBITS (PERCENT).

On average, 56.4% of all students were surprised by something in, or caused by, the exhibit with little variation

between males and females. The Music Room (75%) was the most surprising, while the Eye was the least surprising to both genders.

Table 4.13 shows the number of students who indicated that their interaction with the exhibit had generated sufficient interest and/or curiosity within them to become interested in further investigation of the principle of the exhibit.

		EXHIBIT					
Increased Curiosity		Eye	Music Room	Pin Table	Spectra	Zoetrope	Average
Yes	All Students	50.0	73.7	63.2	63.2	46.2	59.3
	Male Students	63.6	66.7	66.7	63.6	66.7	65.5
	Female Students	33.3	73.9	60.0	62.5	40.0	53.9
No	All Students	50.0	26.3	36.8	36.8	53.8	40.7
	Male Students	36.4	33.3	33.3	36.4	33.3	34.5
	Female Students	66.7	26.3	40.0	37.5	60.0	46.1

TABLE 4.13 STUDENT SUB-GROUP EXTENT OF INCREASED CURIOSITY, BY EXHIBITS (PERCENT)

All exhibits except the Zoetrope (46.2%) increased the curiosity of at least 50% of the students. On average, 59.3% of the students felt the exhibits increased their curiosity. The Music Room (73.7%) caused the greatest percentage of students to want to find out more about its principle. The Eye exhibit stimulated the least amount of curiosity of all exhibits. Following interaction with the Eye exhibit, half the students indicated an increase in curiosity while the

other half indicated their curiosity did not increase. On average for all exhibits, a slightly greater percentage of male students experienced an increase in curiosity than did female students. A greater discrepancy between the genders occurred for the Eye and the Zoetrope exhibits. With both of these exhibits, an increase in curiosity occurred for the majority of male students (63.6% and 66.7% respectively), while curiosity increased as a result of interaction for a minority of female students (33.3% and 40.0% respectively). The male students spent a greater amount of time than did girls interacting with the Eye. A greater percentage of males enjoyed the eye than did females (see Table 4.7) and males indicated a greater degree of surprise than females (Table 4.12). Clearly, the eye exhibit had more impact on male students than it did on female students.

An examination of the results corresponding to surprise and curiosity levels indicates that the Music Room, and the Pin Table and Spectra (which share the second ranking), are the most likely exhibits of the five studied to increase a student's curiosity. The Eye and the Zoetrope are much less likely to increase curiosity, especially amongst female students.

Perceived Ease of Understanding

Students were asked to select, on a five point scale, a response to indicate how easy they felt the exhibit was to

understand. As earlier discussed, this question was placed near the beginning of the interview to reduce risk of being influenced by information contained in other (e.g. multiple choice) questions. The results are shown in Table 4.14.

	EXHIBIT				
Ease of Understanding	Eye	Music Room	Pin Table	Spectra	Zoetrope
Very Easy	45.0	30.0	35.0	10.0	18.2
Easy	25.0	35.0	10.0	35.0	36.4
Average	25.0	25.0	50.0	35.0	27.3
Hard	5.0	10.0	5.0	15.0	18.2
Very Hard	0.0	0.0	0.0	5.0	0.0

TABLE 4.14 OVERALL STUDENT PERCEPTIONS OF EASE OF UNDERSTANDING, BY EXHIBITS (PERCENT).

The majority of students felt that the Eye (70%), the Music Room (65%), and the Zoetrope (52.9%) were easy or very easy to understand. The Pin Table and Spectra exhibits (both 45%) were considered easy to understand by a minority of students. These results parallel to some extent the student ratings of exhibit text (see Table 4.11); half the students found that they did not understand the Pin Table signage, and the Eye, Music Room and Zoetrope signage was understood by the majority of students who read the labels. It appears that students who read and understand the exhibit text also find the exhibit

easy to use. It would be interesting to determine the cause and effect correlation of these factors.

Following breakdown into gender groupings, it was revealed that the majority of both male and female students felt the Eye, Music Room and Zoetrope were easy to understand. The Spectra exhibit was felt easy to understand only by a minority of students of both genders (see Table 4.15). The Pin Table was found to be easy to understand by a majority of male students, but only by a minority of female students. The Zoetrope caused the greatest overall percentage of students to indicate that it was difficult to understand (29.4%), followed by the Spectra (20%).

		EXHIBIT				
	Sub-Group	Eye	Music Room	Pin Table	Spectra	Zoetrope
Easy To Understand	All Students	70.0	65.0	45.0	45.0	52.9
	Male Students	72.7	66.7	55.6	45.5	50.0
	Female Students	66.7	62.5	36.4	44.4	54.5
Difficult To Understand	All Students	5.0	10.0	5.0	20.0	29.4
	Male Students	0.0	5.0	11.1	27.3	50.0
	Female Students	11.1	5.0	0.0	11.1	18.2

TABLE 4.15 STUDENT SUB-GROUP PERCEPTIONS OF EASE OF UNDERSTANDING, BY EXHIBITS (PERCENT)

Perceptions of Exhibit Purposes

In previous studies,[18] researchers have questioned visitors about what they felt an exhibit was showing them, to determine if an exhibit is effectively communicating its message. This strategy was one of the methods used in this study to determine an exhibit's instructional power. Each exhibit attempts to convey different scientific information. Descriptions of the intended purpose(s) of each exhibit may be found in section 4.4 of this chapter. The results of the responses to the above questions are shown in table 4.16.

	EXHIBIT				
Perception Of Intended Purpose	Eye	Music Room	Pin Table	Spectra	Zoetrope
Correct	100.0	5.0	0.0	0.0	35.3
Incorrect	0.0	95.0	100.0	100.0	64.7

TABLE 4.16 STUDENT PERCEPTIONS OF INTENDED EXHIBIT PURPOSE, BY EXHIBIT (PERCENT).

The purpose of Eye exhibit was correctly perceived by all students who interacted with it. The purpose of each of the

[18] Borun, M. (1977, 1989); S. Rode-Perkins (1987).

remaining four exhibits was not correctly understood by most students. Many students did not provide a response to the question. The scientific principle illustrated by the Music Room, Pin Table, and Spectra exhibits was not perceived by few, if any students. The Zoetrope's purpose was correctly perceived by approximately 35% of students. From the students' comments, it appears that some of the exhibits use design features which distract from the scientific principle which is intended to be conveyed. For example, a common student comment about the Pin Table exhibit was that they could see different colours of lights. While this is correct (and due to four differently coloured spot lights shining on the exhibit), the student attention was focussed on the changing colours of light, rather than on the wave motion of the pins.

There does not appear to be a correlation between correctly understanding the intended purpose of the exhibit and the degree to which students felt they read and understood the signage. Nor is there a correlation between correct perception of purpose and student ratings of the exhibits. Consequently, exhibits which were selected by students as favourites do not necessarily convey their intended purpose. However, there appears to be a direct correlation between the students' perceptions of ease of understanding what the exhibit is showing (Table 4.16), and correct perception of the exhibit's intended purpose (Table 4.15). The results indicate

that if an exhibit is perceived as difficult to understand by more than 50% of the students, it is likely that the intended purpose of the exhibit will not be correctly perceived by the majority of students.

Perceptions of Learning

Determination of the amount of learning has been found by other researchers[19] to be complex and difficult. This study involved two strategies to attempt to accurately determine, immediately following interaction with an exhibit, what a student has learned from the exhibit. The first strategy made use of an open-ended question: "What did you learn from this exhibit?". Results may be seen in Table 4.17.

	EXHIBIT				
Perceived Learning	Eye	Music Room	Pin Table	Spectra	Zoetrope
Connected To Principle Of Exhibit	75.0	5.0	0.0	5.0	41.2
Not Connected To Principle Of Exhibit	5.0	60.0	50.0	35.0	0.0
Nothing/ Don't Know	20.0	35.0	50.0	60.0	58.8

TABLE 4.17 STUDENTS' PERCEIVED LEARNING, BY EXHIBIT (PERCENT).

[19] Borun, M. (1989); S. Rode-Perkins (1987).

Only for the Eye exhibit (75%) was the perceived learning connected to the scientific principle which the exhibit was illustrating, by a majority of students. The Zoetrope (41.2%) followed in second place, while the Music Room, Pin Table, and Spectra had few, if any, students describe learning associated with the scientific principle of the exhibit. It is interesting to note that most students responded saying that nothing was learned, or that they did not know what was learned. These results are consistent with those reported by Rode-Perkins,[20] who describes the most frequent visitor response to a similar question as being a wrong answer or a non-response. The students who replied nothing/don't know in this study may have provided a different response if they were questioned some time following the interaction, allowing time for further thought about the exhibit.

Cognitive Test Scores

The second strategy used to determine the instructional effectiveness of the exhibits, and the extent of learning by the students, involved the use of three multiple choice questions about cognitive information for each exhibit. The results are shown in Table 4.18. The overall average test score was 40.2%. A test score of 50% or higher was realized for only the Zoetrope exhibit (74.5%). Post-test scores which

[20] Rode-Perkins, S. (1987). An Evaluation of Selected Exhibits at the St. Louis Science Center.

seem low (i.e. 50 - 55%) by school test standards are not necessarily an indication of a low level of learning in a museum setting. Other researchers[21] report that test scores of approximately 54% (on average) following exhibit interaction represent significant increases over pre-test scores.

	EXHIBIT				
	Eye	Music Room	Pin Table	Spectra	Zoetrope
Average Score (%)	18.3	30.0	45.0	33.3	74.5
Rank Order	5	4	2	3	1

TABLE 4.18 AVERAGE STUDENT SCORES (PERCENT) ON COGNITIVE TEST WITH RANKING, BY EXHIBIT.

Their information suggests that the average visitor leaves a museum knowing over half of the tested information content of the exhibits. In this study, the majority of students were clearly leaving the Zoetrope exhibit knowing most of its tested information content. This is not the case with the remaining four exhibits. The Pin Table, whose information content was known by nearly half (45%) of the students who had interacted with it, occupied the second position of

[21] Borun, M. (1977); S. Rode-Perkins (1987).

transmission of knowledge. The Eye exhibit had the lowest average test score (18.3%).

Upon comparing the two types of multiple choice cognitive questions, it appears that students correctly answered a greater percentage of questions dealing with the functioning of the exhibits, than the concepts and the scientific principles which the exhibits were intending to demonstrate. These findings are consistent with the results reported by Rode-Perkins.[22] This is not surprising, as students who visit the TTU gallery without understanding a scientific principle often need to read and comprehend exhibit signage (due to the nature of current exhibit design) in order to understand the concept behind the exhibit. Since few students read (see Table 4.10) the text for at least one second, and fewer still are likely to have comprehended the content of the text, a higher score was expected on the questions which did not have a prerequisite of exhibit text reading.

4.4 Results from Individual Exhibits

This section provides an examination of the data collected by the exhibit evaluation instrument for each of the five individual exhibits involved in this study. Results are reviewed with regard to the intended objectives of each exhibit (enjoyment level, stimulation of curiosity, and

[22] Rode-Perkins, S. (1987). An Evaluation of Selected Exhibits at the St. Louis Science Centre.

instructional potential categories). A profile of each of the exhibits in this study may be found in Appendix C, where each exhibit is described with regard to (a) the intended principle/concept to be conveyed, (b) its specific, measurable objectives, (c) a physical description of its design and function, (d) the exhibit text (label copy) and (e) verbatim student comments. The exhibits are treated in alphabetical order.

4.4.1 Eye Exhibit

This exhibit was enjoyed by 75% of all students, and ranked third in comparison with the other exhibits. A greater percentage of males (82%) than females (67%) enjoyed using this exhibit. The objective of providing an enjoyable experience to 80% of all students was not achieved for this exhibit.

The Eye is not likely to stimulate the curiosity of the majority of students, with 60% stating that they were not surprised by the exhibit, and 50% indicating that their curiosity did not increase as a result of the interaction. Male students are more likely than female students to have their curiosity stimulated by this exhibit.

Cognitive test scores for the Eye exhibit were the lowest of the five exhibits (18.3), indicating that the great majority of students do not understand the content of the

exhibit. The Eye had the highest incidence (100%) of students correctly perceiving the exhibit's purpose.

It appears that in general, although the students know what the eye exhibit is intending to show them, they are not stimulated by it, find it moderately enjoyable, and learn little of its information content.

4.4.2 Music Room Exhibit

This exhibit was rated enjoyable by 100% of the students who interacted with it, easily achieving its objective in this category.

The majority of both male and female students indicated that this exhibit both surprised them (75%) and increased their curiosity (74%). The exhibit's second objective was consequently satisfied as well.

However, only 5% of the students understood the purpose of the exhibit to be a demonstration of harmonization, and the average cognitive test score was 30%. The instructional objectives were clearly not achieved. This indicates that students enjoy and are excited about this exhibit, but little learning with regard to its information content is occurring.

4.4.3 Pin Table Exhibit:

The overwhelming majority of male (89%) and female (91%) students enjoyed interacting with this exhibit, satisfying the enjoyment level objective. A lesser majority of students

of both genders reported to have been surprised (60%) and had their curiosity stimulated (63%) by this exhibit. These percentages are below the objective of the exhibit in terms of stimulating the students' curiosity.

The exhibit does not appear to effectively communicate its message regarding the demonstrated scientific principle. None of the interviewed students correctly perceived the purpose of the exhibit, and the average cognitive test score was 45%. As a result, the exhibit did not achieve its objective regarding information transfer.

4.4.4 Spectra Exhibit

This exhibit received the lowest overall enjoyment level rating (55%), not achieving its objective of a minimum of an 80% level. Girls enjoyed using this exhibit significantly more than boys, and their rating (78%) was only slightly below the objective. It appears that changes are required in order to have a greater percentage of boys enjoy the exhibit.

Over 60% of the students had their curiosity stimulated by the Spectra exhibit. This is less than the 70% objective, consequently, the exhibit failed to reach this objective, for both boys and girls.

None of the students who interacted with the Spectra correctly identified the purpose of the exhibit. The average cognitive test score was 33%. The possibility of students

developing incorrect conceptions of an exhibit's principle may be of concern to exhibit developers. Scientifically incorrect information was reported to have been learned by a number of students. For example, one student left the exhibit believing that each gas in its natural state has a unique colour. The exhibit appears to have strengthened this misconception. The Spectra exhibit did not achieve the objectives with respect to enjoyment level, stimulation an interest in science, or transmission of cognitive information.

4.4.5 Zoetrope Exhibit

The Zoetrope was regarded as enjoyable by over 70% of the students, with females (91%) having a much greater frequency of enjoying it than males (33%). The enjoyment level objective was satisfied for female students, but not for male students.

The majority of students indicated that this exhibit did not surprise them, nor did it increase their curiosity. A greater percentage of male students (67%) than female students (40%) indicated an increase in curiosity, while the reverse is true for causing surprise. However, in all cases, the incidence is lower than the exhibit objective.

The Zoetrope average cognitive test score was the highest of any of the exhibits (75%). Not surprisingly, more students correctly perceived the intended purpose of the exhibit than

did for any other exhibit (except for the Eye). The Zoetrope exhibit satisfied its objective with regard to instructional power.

4.5 Summary

The primary purpose of this chapter was to present and discuss the data gathered from the implementation of the exhibit evaluation instrument. An exhibit was considered to be effective if it achieved its stated objectives. Objectives for each of the five exhibits involved in this study (see Appendix C) were compared to the results of the evaluation. Results indicate that the five exhibits which were involved in the study varied widely in terms of achieving their objectives (see Table 4.19).

EXHIBIT OBJECTIVE (Targetted Percent)	EYE	MUSIC ROOM	PIN TABLE	SPECTRA	ZOETROPE
Enjoyment (80%)	75%	100%	90%	55%	71%
Stimulates Curiosity (70%)	40%	75%	60%	60%	47%
+ Causes Surprise (70%)	50%	74%	63%	63%	46%
Instructional Potential (60%)	18%	30%	45%	33%	75%
# Objectives Satisfied (Maximum = 3)	0	2	1	0	1

TABLE 4.19 OVERALL RESULTS OF INDIVIDUAL EXHIBITS
(Rounded to Nearest Percent)

Three of the exhibits achieved at least one of their stated objectives, while two exhibits (Eye and Spectra) failed to meet any objectives. None of the exhibits met all three of their stated objectives; the Music Room exhibit ranked first by achieving two of its three objectives.

Although exhibit objectives were often not achieved by the total student sample, it was occasionally achieved by students of one gender. This indicates that some exhibits may be more effective in achieving their objectives for specific subgroups of the population.

Results were not available for one exhibit, the Gravity Well, since students did not interact with the exhibit during the first four weeks of data collection. This exhibit was subsequently removed from the study. The lack of attraction to school students by this exhibit indicates that the exhibit is not effective for this audience group. Evaluation of this exhibit with members of the general public is required.

CHAPTER 5. SUMMARY AND CONCLUSIONS

This chapter provides a summary of the study, including a summary of the exhibit evaluation instrument design, and the methodology used to collect the data. A synopsis is provided of the results of the data with respect to the effectiveness of the selected exhibits. The instrument's strengths and weaknesses are discussed as are implications for its future use in exhibit evaluation. Finally, recommendations for further research are suggested.

5.1 Summary of the Study

Many science centres and other nonformal educational institutions make use of exhibits as one method of communicating information to the general public. There are few formal evaluative instruments available to assist professionals in this field in determining the effectiveness of these exhibits. This study was concerned with the development and testing of a largely qualitative exhibit evaluation instrument.

Instrument Design

The intended instrument design was such that the instrument would be generalizable to be of use in evaluating an assortment of interactive exhibits in a variety of museum settings. To determine the extent and types of exhibit

evaluations currently being undertaken, a survey was developed and distributed to 45 science and technology centres in Canada, the United States of America, and Great Britain. The survey also documented factors which museum professionals feel are most significant in determining an exhibit's effectiveness, and requested copies of evaluation instruments used by those institutions. Survey results indicated that: (1) few formal exhibit evaluations are regularly conducted; (2) very few evaluation instruments are available; (3) there is general consensus with regard to the relative importance of various exhibit factors; (4) museum professionals believe evaluation of exhibit effectiveness is important; and that (5) a generalizable instrument would be useful and of much interest to other museums.

The exhibit evaluation instrument was designed by incorporating information acquired from the survey responses and from the literature. Three major indicators were used to determine an exhibit's effectiveness. These were: (1) the level of enjoyment provided to the visitor; (2) the extent to which a visitor's curiosity was stimulated; and (3) the ability of an exhibit to transfer its information content to the visitor.

The instrument's design allowed two methods of gathering data regarding an exhibit's effectiveness. An observation guide documented visitor actions, and the total time spent, while interacting with the exhibit. An interview guide

documented visitor perceptions of the exhibit, and allowed a determination of the extent of exhibit information content known by the visitor upon leaving the exhibit.

Population and Data Collection

The population involved in this study consisted of intermediate level school children who were visiting the Touch The Universe Science gallery of the Manitoba Museum of Man and Nature. A random sample of 100 visiting students, 20 for each exhibit, were observed interacting with the exhibits and interviewed immediately following the interaction. Of the 100 students, 52 were male and 48 were female. The grade distribution of students was 23%, 35%, and 42% for grades 4,5, and 6 respectively. The total sample size of the interviewed students was reduced to 97, as a result of three students declining involvement. Data were collected during weekdays from March through May, 1989.

Selected Exhibits

Five randomly selected exhibits were evaluated using the developed instrument to test its usefulness in assessing exhibit effectiveness. The five exhibits were: Eye exhibit; Music Room; Pin Table exhibit; Spectra exhibit; and Zoetrope exhibit. Descriptions of the exhibits and their stated objectives are located in Appendix C.

5.2 Summary of the Exhibit Evaluations

Only one of the five exhibits (Music Room) evaluated with the instrument satisfied the majority of the stated objectives. Two exhibits, the Pin Table and the Zoetrope satisfied one of their three stated objectives, while the Eye and the Spectra exhibit failed to satisfy any of their objectives. This suggests that either the exhibits or their objectives (or both) should be modified to allow achievement of objectives. The effectiveness of the exhibits may be increased by making appropriate changes to the physical design or the text of the exhibit.

There appears to be a correlation between the effectiveness of an exhibit (in terms of achieving their stated objectives) and the relative time spent by students interacting with the exhibit. The Music Room was the most successful exhibit, and was by far the exhibit where students spent the greatest amount of time relative to the other tested exhibits. The Eye and the Spectra exhibit were the least successful in satisfying their objectives, and were the exhibits at which students spent the least amount of time. Using this correlation, museum personnel may be able to determine which exhibits are relatively more successful in achieving their objectives by carefully documenting the amount of time spent at each exhibit. A similar correlation may be drawn between the visitor's perception of an exhibit's ease

of use, and its effectiveness in terms of meeting its objectives.

Students often did not accurately report their actions. Students reported reading exhibit labels up to 30% more frequently than when they were actually observed reading the labels. This indicates that visitor self-reports are not necessarily accurate. As such, the instrument's second method of measuring visitor actions provides confirmation. This is particularly useful in the case of determining the extent to which a visitor understands some aspect of the exhibit. Visitors often attempt to please the interviewer with their answer, rather than being completely honest in their response. The empirical test of the level of visitor understanding included in the instrument is important to determine accurately their level of understanding.

The majority of students incorrectly used all exhibits, except for the Music Room. This indicates that exhibit developers should consider methods to improve communication of the "How to Use this Exhibit" message found on each exhibit.

Some of the exhibits encouraged social interactions (talking about the exhibit, cooperating in its use, and watching others use it) to a greater degree than other exhibits. Many visitors attend museums for the social activities which accompany the visit. If a goal of exhibit developers is to encourage social interactions, then the

design of the exhibit should allow several visitors to use it simultaneously.

5.3 Strengths and Weaknesses of the Instrument

Overall, the exhibit evaluation instrument has proven to be a valuable asset to exhibit evaluators. One of the instrument's strengths is its ability to document the ways in which visitors use the exhibits, and to empirically determine the extent to which an exhibit satisfies its stated objectives. It provides an objective means of determining if an exhibit is communicating its intended message. The instrument gives exhibit developers/evaluators a systematic method of assessing the success of an exhibit. Used in combination with the traditional approach of staff perceptions of exhibit effectiveness and casual observations, the instrument will allow a more comprehensive evaluation of exhibits.

The instrument is relatively easy to use, is efficient in that an evaluation may be accomplished in approximately five to seven minutes, and provides a large amount of useful information with respect to exhibit effectiveness.

A major strength of the instrument is that it may be generalized for use with a wide variety of museum exhibits. Although primarily intended for use with interactive science exhibits, it is also suitable for use with other types of interactive exhibits (e.g. historical or cultural exhibits).

In addition, the majority of components of the observation and interview guides are appropriate for use with more traditional (i.e. static) exhibits.

Responses to a survey from a diverse group of museum professionals provided a list of factors which are considered to be important for an exhibit to possess. The instrument's ability to determine the effectiveness of exhibits is largely based on the assessment of these factors. Consequently, the instrument is likely to be regarded as useful by staff of many science centres and other nonformal educational institutions. All survey respondents expressly indicated an interest in receiving a copy of the instrument for their institutions. Many institutions desire to add objective instruments to their inventory of evaluative methods. Museums which consider the generation of empirical data important and necessary to base exhibit development decisions will find this instrument very useful.

Another strength of the instrument is one which is central to its design. The instrument satisfies to some extent the desire (or requirement) of staff in various institutions to collect visitor experience data through the use of both qualitative and quantitative evaluations. Unanticipated visitor reactions to, comments about, and perceptions of exhibits are recorded directly on the instrument. It is possible to interpret data gathered by the instrument using numerical analysis. If so inclined, museum

staff may make some minor modifications to the instrument (for example, quantify all responses and comments) and perform more detailed statistical analyses. Comments and responses to instrument questions can be further classified, categorized and quantified. However, no knowledge of statistical operations (other than the calculation of averages or means) is required to make full use of the instrument. This is a major asset of the instrument, since few museums have exhibit staff familiar with more complex statistical measures. The instrument can be effectively used by museums with little experience in formal evaluations.

Exhibit evaluations are easily conducted with this instrument. A museum staff member or volunteer requires only minimal training before being able to use the instrument comfortably. There are four aspects of required training: (a) understanding the correct method of selecting a random sample of visitors; (b) developing a thorough understanding of the definitions of observed actions; (c) adhering to the established sequence of questions and recording responses word for word; and (d) being familiar with general interview techniques, such as using a non-threatening manner, and methods of probing without prompting.

There are some inherent limitations in the instrument. A major requirement for effective use of the instrument, as with any goal-referenced evaluation, is the documentation of measurable exhibit objectives. Specific and measurable

objectives are often not articulated by museums. The establishment of such objectives is required to allow full use of this instrument.

The instrument could be further improved in several areas. Although not intended to be measured in this study, it may be useful to document the way in which a visitor first approaches the exhibit as a measure of attracting power. If this is a desired measurement, the addition of a "method of approach" category to the instrument will enable a determination of whether the visitor is attracted to the exhibit from a distance, or simply happens upon it. This category in the observation guide may provide an indication of an exhibit's attracting power.

The category "engages exhibit by own initiative/with persuasion" might be better reserved for the initial action. A category such as "manipulates apparatus" would then document subsequent actions. It would also be useful to know whether a visitor correctly uses the exhibit on the first attempt, as well as on subsequent attempts. Data which describes the extent of correct exhibit use on the visitors' first attempt would give exhibit developers an objective measure of an exhibit's ease of use.

Changing the wording of the action "reads label" to "looks at label" removes the assumption that a visitor is actually reading the exhibit text. Visitors who appear to be

reading may in fact be simply resting with their eyes open, or thinking about something completely different.

Easier data compilation would result by recording the number of previous visits on the first page of the instrument. Adults occasionally feel uncomfortable in specifying their precise age to an interviewer. Replacing the age and grade questions with several age categories should occur if the instrument is used with the general public.

In terms of the structured interview, most of the questions were easily understood by the students. The addition of another question could help determine whether the visitor's curiosity or interest in the scientific principle increased. This third question would provide further data to strengthen the interpretation of the existing questions.

Questions which allow only a yes or no answer should have a third category ("not sure" or "don't know") for possible responses. It is crucial that the wording of the exhibit-specific multiple choice questions and answers are unambiguous and easily understood by the visitors. Again, the "don't know" choice should be available as a possible answer to these questions.

5.4 Recommendations for Further Research

The instrument developed in this study was intended to assess the effectiveness of interactive exhibits in terms of achievement of their stated objectives. It documents the

degree to which certain exhibits convey information content. The instrument does not attempt to determine the precise reasons why certain exhibits are more effective in achieving those objectives. It is important for exhibit developers to understand the extent to which an exhibit achieves its objectives. It is also important for museums to determine the factors which allow certain exhibits to meet their objectives more fully than others. That is, it is important to know why the information is conveyed, as well as what information is conveyed. It is therefore recommended that further studies focus on the exhibit factors which encourage visitors to acquire content information from exhibits.

Some of the students' comments indicated that components of exhibits may actually be distracting visitor attention from the scientific principle of the exhibit. As a result, it is recommended that a study be undertaken to determine in which exhibits this distraction is occurring. Once identified, methods of eliminating or reducing such distractions should be tested.

Since many visitors tend not to read exhibit text, and those that do read it do not fully understand it, it is also recommended that museums establish the readability level of the exhibit text. Studies should also be undertaken to determine whether there exists an optimum number of words for signage of interactive exhibits. The role of the typeface and point size of exhibit text in encouraging visitors to read

should be established. Further studies are required to determine whether alternatives to text (such as pictographs) are more effective in communicating directions for exhibit use.

This study did not attempt to determine attracting power of exhibits. Further studies are required to determine the various factors which cause an initial attraction of visitors to individual exhibits.

The final recommendation is to have follow-up studies in the schools to determine the extent of recall of exhibit information content. It would similarly be interesting to determine whether a science centre visit has a lasting effect on a student's interest in science. A future study should address the question: do students demonstrate an interest in science which is greater than students who have not visited a science centre?

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APPENDIX A

SCIENCE CENTRE SURVEY

i. Survey Instrument

ii. List of Science Centres Surveyed

APPENDIX A (i)
SURVEY INSTRUMENT

SCIENCE CENTER EXHIBIT SURVEY

Please return the completed survey form to:

George Wurtak
Director of Programs
Manitoba Museum of Man and Nature
190 Rupert Avenue,
Winnipeg, Manitoba, Canada
R3B 0N2

Name of Institution:_____

Mailing Address:_____

_____

Contact Person Name & title:_____

Telephone :_____

[IF MORE ROOM IS REQUIRED BELOW, PLEASE CONTINUE ON REVERSE]

1. What is/are the goal(s) of the Center/Institution?_____

_____

_____

2. Does your institution have interactive exhibits:
   - ____ a. mainly in a separate gallery/area ---------> go to #3
   - ____ b. mainly dispersed throughout the public galleries ----------> go to #4
   - ____ c. no interactive exhibits ----------> go to #10

3. Please state the goal(s) of the interactive exhibits area, if different from #1 above: (same as in #1 above ____) _____

_____

_____

_____

4. Please give examples of specific objectives for 2 interactive exhibits: (indicate if exhibits do not have separate objectives: ____)

Exhibit #1 name:_____

Exhibit #1 theme:_____

Exhibit #1 objective(s):_____

_____

_____

4. (continued)
Exhibit #2 name:_____

Exhibit #2 theme:_____

Exhibit #2 objective(s):_____

_____

_____

5. If you were to classify your interactive exhibits into the following three categories what number or percentage of the exhibits fall into each: (Total number of interactive exhibits = _____)

____(#) ____(%) **LEVEL 1.** Passive exhibits (do not require a visitor's presence in order to fully function);
____(#) ____(%) **LEVEL 2.** Exhibits requiring a visitor's presence only in order to begin functioning (e.g."push-button")
____(#) ____(%) **LEVEL 3.** Exhibits requiring active and continual visitor involvement in order to function; allow viewer dependent variation or exhibit-viewer feedback

6. On what basis are interactive exhibit concepts chosen for construction/installation in the center?
____ c. individual staff's initiative
____ b. selection of idea by committee
____ a. suitability for corporate sponsorship
____ d. Other: _____

_____

_____

7. Below are some criteria which may be used for determining the suitability of a particular exhibit concept for display. Of the criteria that you currently use, how important a factor are they in your final decision? (5 = extremely important; 4 = very important; 3 = somewhat important; 2 = not very important; 1 = unimportant)

(1 - 5) ____ a. design of exhibit (size/layout/durability)
____ b. attractiveness/dramatic effect/drawing & holding power
____ c. educational value (clearly teaches important concepts)
____ d. entertainment value (novel/amusing/curious)
____ e. level of interactiveness possible for visitors
____ f. importance/relevance of scientific principal to visitor
____ g. resource demand (money & time to produce/maintain)
____ h. revenue generating potential
____ i. other criteria used (& rating)_____

_____

_____

(Please attach any guideline/checklist documents - formal & informal)

8. Upon what authority(s) are exhibit proposals given final approval (in practice) for installation? [please state position(s) or committee name(s)]:_____

_____

9. Are your interactive exhibits evaluated? No____ Yes____
If so, a. how frequently? _____

_____

b. what is the purpose of the assessment?_____

_____

_____

c. What is done with the evaluation results?_____

_____

_____

10. What methods do you use to assess the effectiveness of your exhibits?

____ a. in-person interview
____ b. staff-conducted questionnaire of visitors - on site
____ c. self-conducted visitor questionnaire (pick-up/mailed)
____ d. discussions amongst staff
____ e. casual observations of visitor interaction
____ f. formal observations of visitor interaction
____ g. exhibits are not evaluated

Please describe methods used in (a)-(f):_____

_____

_____

11. What makes an exhibit successful, in your view? (please be as specific as possible)_____

_____

12. Do you evaluate school groups differently from the general public? No____Yes____If yes, please explain:_____

_____

_____

_____

13. Please attach questionnaires, surveys, or other evaluative tools, including informal forms, etc.

14. Please provide: brochures, floor plans, square feet, fact sheets, program listings, teacher sheets, attendance, admission fees, hours etc.

15. Would you prefer that any of the information provided above be kept confidential? No____ Yes____ Which questions?_____

_____

16. Would you like to receive a copy of the compilation of the questionnaire responses? Yes____ No____

*** THANK YOU FOR YOUR CONTRIBUTION TO THIS STUDY ***

APPENDIX A (ii)
LIST OF INSTITUTIONS SURVEYED

The following 45 institutions were surveyed:

I. Canada (22):

1. Science World B.C. (Vancouver)
2. Royal British Columbia Museum (Victoria)
3. Edmonton Space Sciences Centre (Alberta)
4. Alberta Science Centre Society (Calgary)
5. Calgary Aero Space Museum
6. Alberta Science Centre (Calgary)
7. Edmonton Telephones Historical Information Centre
8. Fort McMurray Oil Sands Interpretive Centre (Alberta)
9. Saskatchewan Science Centre (Regina)
10. Saskatchewan Natural History Museum (Regina)
11. Hamilton Museum of Steam & Technology (Ontario)
12. Science North/Science Nord (Sudbury)
13. Ontario Science Centre (Don Mills)
14. Exploracom Computer Exploration/Enterprise Centre (Toronto)
15. Royal Ontario Museum (Toronto)
16. London Regional Children's Museum (Ontario)
17. National Aviation Museum (Ottawa)
18. National Museum of Natural Sciences (Ottawa)
19. National Museum of Science and Technology (Ottawa)
20. National Postal Museum (Ottawa)
21. Nova Scotia Museum Complex (Halifax)
22. Aitken Bicentennial Exhibition Centre (Saint John, N.B.)

II. United States of America (21):

23. Brooklyn Children's Museum
24. California Museum of Science and Industry (Los Angeles)
25. Carnegie Museum of Natural History (Pittsburgh)
26. Centre of Science and Industry (Columbus, Ohio)
27. Detroit Science Centre (Detroit)
28. Discovery Centre of Science and Technology (Syracuse)
29. Field Museum (Chicago)
30. Franklin Institute Science Museum (Philadelphia)
31. Lawrence Hall of Science (Berkeley)
32. Museum of Science and Industry (Chicago)
33. Museum of Science and Industry (Tampa)
34. National Museum of American History (Washington, D.C.)
35. National Museum of Natural History (Washington)
36. New York Hall of Science (Corona)
37. Oregon Museum of Science and Industry (Portland)
38. Pacific Science Centre (Seattle)
39. Planet Ocean (Miami)
40. Science Museum of Minnesota (St. Paul)
41. Science Museum of Virginia (Richmond)
42. Springfield Science Museum (Springfield)
43. St. Louis Science Centre (St. Louis)

III. Great Britain (2):

44. Science Museum (London)
45. Liverpool Interactive Technology Centre

APPENDIX B

EXHIBIT EVALUATION INSTRUMENTS

i. Generalizable Evaluation Instrument

ii. TTU Exhibit Instruments

APPENDIX B (i)
GENERALIZABLE EVALUATION INSTRUMENT

INTERACTIVE EXHIBIT EVALUATION INSTRUMENT

Exhibit Name:_____

Date:_____ Evaluator:_____

Total time:_____

Visitor Target #:_____ Male or Female: _____

PART 1. CHECK LIST OF OBSERVED INTERACTIONS

OBSERVED ACTION	SEQUENCE OF ACTION (1,2,3....etc.)														TOTAL #
Reads Label															
Exhibit-related Talk															
Engages Exhibit by own initiative															
Engages Exhibit with Persuasion from others															
Watches Others															
Works with Another or willingly take turns															
Completes the Exercise															
Unsuccessful Attempt															
Repeats (Same Way)															
Repeats (With Modification)															

Comments: _____

_____

_____

PART 2. STRUCTURED INTERVIEW

1. How old are you? _____ 2. What grade are you in? _____

3. How would you rate this exhibit?...

extremely enjoyable	enjoyable	average	not very enjoyable	extremely unenjoyable

What did you like/dislike about the exhibit? _____

_____

4. How easy was this exhibit to use?

very easy	easy	average	hard	very hard

Why do you feel this way? _____

5. How easy is it for you to understand what this exhibit is showing?
It is.....to understand

very easy	easy	average	hard	very hard

Why? _____

6. What did you learn from this exhibit? _____

_____

7. Did anything about this exhibit surprise you? Yes ___ No ___ What surprised you?

_____

8. Does the exhibit make you REALLY want to find out more about what it's showing? Yes___ No ___

How will you find out more about the idea behind this exhibit? _____

_____

9. Did you read the signs on the exhibit? Yes___ No___ if not, why not: _____

_____ (if "No", go to question 13)

10. Did you understand what you read? Yes___ No___ if not, why not:_____

_____

11. Did what you read help you? Yes___ No___ if not, why not:_____

_____

12.Would you have known what to do without reading? Yes___ No___ Explain:_____

_____

13. What is this exhibit all about? What is it trying to show you?

_____

_____

(Insert three questions based on the information content of the exhibit, below.)

14.

15.

16.

17. How should we change this exhibit to make it better?_____

_____

_____

18. Is this your first visit to the _____(Name of Institution or gallery)_____?

Yes ___ No ___ If no, how many times have you visited before? _____

THANK YOU FOR YOUR HELP!

NOTES FOR USING THE EXHIBIT EVALUATION INSTRUMENT

BEFORE THE EVALUATION

1. Select the exhibit(s) which you will be evaluating. Stating measurable objectives for exhibits is a prerequisite for use of this instrument. A typical measurable objective specifies (1) what a visitor should be able to do or say following interaction with the exhibit; (2) under what circumstances this will occur; and (3) what is considered a "passing grade". An example of a typical objective is: "Seventy-five percent of visitors aged 12 years or over who spend a minimum of two seconds at this exhibit will be able to name at least three planets".

2. Prepare three questions based on the information content of the exhibit which reflect the intended learning outcomes. It is recommended that these questions be multiple choice (although open-ended questions are also appropriate), and based on the exhibit objectives. Include these questions on the instrument (questions 14, 15 and 16).

3. If you intend to evaluate the exhibits by observing and interviewing students, obtain permission to do so from the teacher in charge before the day of the visit. (See the separate page, "Requesting Permission From Teachers".)

4. You will need to have a stopwatch, pen, and several evaluation instrument forms prepared for use with the exhibit being evaluated. Place a table with two chairs near the exhibit to be used as a workstation for conducting the interview.

PART 1. UNOBTRUSIVE OBSERVATION

5. Before you begin observing a visitor, complete the exhibit name, the date, and name of the evaluator.

6. Position yourself at the exhibit observing station. The risk of contaminating the data collected through unobtrusive evaluations will be reduced if the visitor is not aware of being observed. However, if the visitor by chance notices you observing him/her, continue to collect the data.

7. When you are ready to begin, it is important to have a method of randomly selecting the visitors (e.g. "target" the first visitor you see approach the exhibit). Politely refuse unsolicited offers of help from visitors.

8. As a targetted visitor approaches the exhibit, start the stop watch and begin recording observations. If time allows, indicate whether the visitor is male or female; otherwise, do this later.

9. Record each different action of the visitor, using the check list on the instrument. Number the actions in order of occurrence. Put a number in the "sequence of action" box beside the appropriate observed action title each time you observe the start of an action.

For example, a visitor who approaches an exhibit might first read the exhibit signage (write "1" in the first row), then watches someone else (write "2" in the sixth row), then reads the signage again (write "3" beside the "1" in the first row) and so on. At the end of the observing session, some of the "sequence of action" boxes may be empty while others may have many numbers.

10. When the visitor has finished interacting with the exhibit and begins to leave the area of the exhibit, stop the stopwatch and record the total interaction time (beside "end time"), so that the total time spent interacting with the exhibit can be determined.

PART 2. STRUCTURED INTERVIEW

1. As the visitor leaves the area of the exhibit, approach him/her, and identify yourself as a staff member (a visible identification badge is useful). Explain that you are evaluating the exhibit he/she just used and ask if they would answer some questions about the exhibit for you. Inform them that they do not need to answer any questions if they so choose. Try and establish a friendly role with the visitor. Assure them that this is not a test, and they do not have to give you their name.

A typical introduction would be:

> "Hello, my name is _____, and I work here. We are trying to find out if our visitors like this exhibit, and if the exhibit works correctly. Would you mind spending a few minutes answering some questions? You don't have to answer any of these questions if you don't want to, but we would appreciate your help. Don't worry, this is not a test, and I don't need to know your name. Your help is really important for (the Museum). Can you help us, please?"

2. If the visitor agrees, lead him/her over to the workstation, sit down side by side at the table and read out the interview questions on the attached form. Also show the student the printed question as you read it.

Write down the answers quickly, using the visitor's wording as much as possible. Be careful to write out what the student said (rather than what you think he/she meant). The interview session should be done quickly (3 - 5 minutes) so as to not interfere too much with the visitor's visit to the rest of the exhibits.

3. When the interview is completed, thank the visitor for helping the institution to improve its exhibits.

4. Return to the exhibit and target another visitor (i.e. go back to Part 1, step 5 and begin again). Remember that the visitor chosen should just be approaching the exhibit (i.e. not already standing at, or using, the exhibit).

REQUEST FOR PERMISSION FROM TEACHERS

School Name: _____ Teacher: _____

Date Contacted: _____ Time: _____

* *

Hello, Mr(s)._____, this is __(name)__, __(position)__, at the __(Institution)__ calling.

I understand you are bringing your class for a visit to the __(Institution)__ on __(date)__, at __(time)__ and was wondering if you could help us determine the effectiveness of some of our exhibits?

If you allow, one or two __(Institution)__ staff members will observe some of your students as they interact with the exhibits being assessed. When the students finish using the exhibit, the staff member will approach the student, and explain that we are trying to find out if the exhibit works the way we intended. The student will be asked to answer some questions for a few minutes.

The students will be selected randomly, and they do not have to answer any questions if that is their wish. We will inform the students that this is not a test. We will not ask for the students' names, or any information which could identify the student or school.

Teacher's response:_____

(If permission is given):
There are two other points I would like to clarify:

1. It is important for us to know if you have done or will be preparing the students for the visit. Will you be going over the content of the exhibits, or doing anything that might help them to use or better understand the exhibits?

_____

_____

_____

2. Since we would like the students to use the exhibits in the way they normally would (as if we were not there), it would be best if you did not "cue" the students by letting them know that they might be observed or approached. You may wish to inform the other adults that our staff members might observe and talk to a few of the students about their interaction with the exhibits. Our staff will be wearing their identification tags, so you will know them to be staff.

APPENDIX B (ii)
TTU EXHIBIT INSTRUMENTS

INTERACTIVE EXHIBIT EVALUATION INSTRUMENT
TOUCH THE UNIVERSE GALLERY

Exhibit Name: EYE

Date: _____ Evaluator: _____

Total time: _____

Visitor Target #: _____ Male or Female: _____

PART 1. CHECK LIST OF OBSERVED INTERACTIONS

OBSERVED ACTION	SEQUENCE OF ACTION (1,2,3....etc.)														TOTAL #
Reads Label															
Exhibit-related Talk															
Engages Exhibit by own initiative															
Engages Exhibit with Persuasion from others															
Watches Others															
Works with Another or willingly take turns															
Completes the Exercise															
Unsuccessful Attempt															
Repeats (Same Way)															
Repeats (With Modification)															

Comments: _____

PART 2. STRUCTURED INTERVIEW

1. How old are you? _____ 2. What grade are you in? _____

3. How would you rate this exhibit?...

extremely enjoyable	enjoyable	average	not very enjoyable	extremely unenjoyable

What did you like/dislike about the exhibit? _____

_____

4. How easy was this exhibit to use?

very easy	easy	average	hard	very hard

Why do you feel this way? _____

5. How easy is it for you to understand what this exhibit is showing?
It is.....to understand

very easy	easy	average	hard	very hard

Why? _____

6. What did you learn from this exhibit? _____

_____

7. Did anything about this exhibit surprise you? Yes ___ No ___ What surprised you?

_____

8. Does the exhibit make you REALLY want to find out more about what it's showing? Yes___ No ___

How will you find out more about the idea behind this exhibit? _____

_____

9. Did you read the signs on the exhibit? Yes___ No___ if not, why not: _____

_____ (if "No", go to question 13)

10. Did you understand what you read? Yes___ No___ if not, why not:_____

_____

11. Did what you read help you? Yes___ No___ if not, why not:_____

_____

12.Would you have known what to do without reading? Yes___ No___ Explain:_____

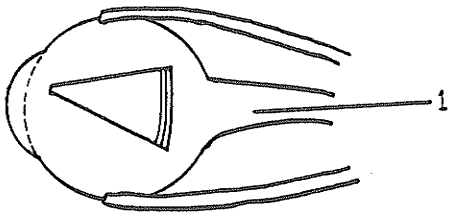
_____

13. What is this exhibit all about? "What is it trying to show you?

_____

_____

14. What is the part labelled "1"?



(a) iris (b) optic nerve (c) spinal cord

(d) eye muscle (e) don't know

15. Which one of the following statements is true?

(a) the image is sent from the brain to the eye

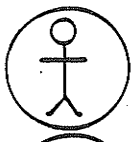
(b) the image is sent from the pupil to the brain

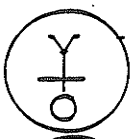
(c) the retina is composed of rods and cones

(d) the optic nerve is composed of rods and cones

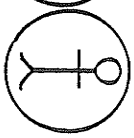
(e) don't know

16. If you looked at me from a distance, how would the image appear at the back of the eye?

(a) 

(b) 

(c) 

(d) 

(e) don't know

17. How should we change this exhibit to make it better?_____

_____

_____

18. Is this your first visit to the Touch The Universe Gallery?

Yes ___ No ___ If no, how many times have you visited before? _____

THANK YOU FOR YOUR HELP!

INTERACTIVE EXHIBIT EVALUATION INSTRUMENT
TOUCH THE UNIVERSE GALLERY

Exhibit Name: PIN TABLE

Date: _____ Evaluator: _____

Total time: _____

Visitor Target #: _____ Male or Female: _____

PART 1. CHECK LIST OF OBSERVED INTERACTIONS

OBSERVED ACTION	SEQUENCE OF ACTION (1,2,3....etc.)													TOTAL #
Reads Label														
Exhibit-related Talk														
Engages Exhibit by own initiative														
Engages Exhibit with Persuasion from others														
Watches Others														
Works with Another or willingly take turns														
Completes the Exercise														
Unsuccessful Attempt														
Repeats (Same Way)														
Repeats (With Modification)														

Comments: _____

_____

_____

PART 2. STRUCTURED INTERVIEW

1. How old are you? _____ 2. What grade are you in? _____

3. How would you rate this exhibit?...

extremely enjoyable	enjoyable	average	not very enjoyable	extremely unenjoyable

What did you like/dislike about the exhibit? _____

_____

4. How easy was this exhibit to use?

very easy	easy	average	hard	very hard

Why do you feel this way? _____

5. How easy is it for you to understand what this exhibit is showing?
It is.....to understand

very easy	easy	average	hard	very hard

Why? _____

6. What did you learn from this exhibit? _____

_____

7. Did anything about this exhibit surprise you? Yes ___ No ___ What surprised you?

_____

8. Does the exhibit make you REALLY want to find out more about what it's showing? Yes___ No ___

How will you find out more about the idea behind this exhibit? _____

_____

9. Did you read the signs on the exhibit? Yes___ No___ if not, why not: _____

_____ (if "No", go to question 13)

10. Did you understand what you read? Yes___ No___ if not, why not:_____

_____

11. Did what you read help you? Yes___ No___ if not, why not:_____

_____

12. Would you have known what to do without reading? Yes___ No___ Explain:_____

_____

13. What is this exhibit all about? What is it trying to show you?

_____

_____

14. As you use this exhibit, what moves?

(a) the table (b) the colours (c) the pins (d) the mirror (e) don't know

15. What happens as you brush your hands along the pins?

(a) the pins lift up (b) a wave appears (c) the colours change

(d) the pins move sideways (e) don't know

16. What happens to air molecules when you clap your hands?

(a) they move from your hands to the ear

(b) they move back and forth

(c) they stop moving

(d) they keep doing what they were doing

(e) don't know

17. How should we change this exhibit to make it better?_____

_____

_____

18. Is this your first visit to the Touch The Universe Gallery?

Yes ___ No ___ If no, how many times have you visited before? _____

THANK YOU FOR YOUR HELP!

INTERACTIVE EXHIBIT EVALUATION INSTRUMENT
TOUCH THE UNIVERSE GALLERY

Exhibit Name: MUSIC ROOM

Date: _____ Evaluator: _____

Total time: _____

Visitor Target #: _____ Male or Female: _____

PART 1. CHECK LIST OF OBSERVED INTERACTIONS

OBSERVED ACTION	SEQUENCE OF ACTION (1,2,3....etc.)														TOTAL #
Reads Label															
Exhibit-related Talk															
Engages Exhibit by own initiative															
Engages Exhibit with Persuasion from others															
Watches Others															
Works with Another or willingly take turns															
Completes the Exercise															
Unsuccessful Attempt															
Repeats (Same Way)															
Repeats (With Modification)															

Comments: _____

_____

_____

PART 2. STRUCTURED INTERVIEW

1. How old are you? _____ 2. What grade are you in? _____

3. How would you rate this exhibit?...

extremely enjoyable	enjoyable	average	not very enjoyable	extremely unenjoyable

What did you like/dislike about the exhibit? _____

_____

4. How easy was this exhibit to use?

very easy	easy	average	hard	very hard

Why do you feel this way? _____

5. How easy is it for you to understand what this exhibit is showing?
It is.....to understand

very easy	easy	average	hard	very hard

Why? _____

6. What did you learn from this exhibit? _____

_____

7. Did anything about this exhibit surprise you? Yes ___ No ___ What surprised you?

_____

8. Does the exhibit make you REALLY want to find out more about what it's showing? Yes___ No ___

How will you find out more about the idea behind this exhibit? _____

_____

9. Did you read the signs on the exhibit? Yes___ No___ if not, why not: _____

_____ (if "No", go to question 13)

10. Did you understand what you read? Yes___ No___ if not, why not:_____

_____

11. Did what you read help you? Yes___ No___ if not, why not:_____

_____

12. Would you have known what to do without reading? Yes___ No___ Explain:_____

_____

13. What is this exhibit all about? What is it trying to show you?

_____

_____

14. What makes the sounds?

(a) guitars (b) a synthesizer (c) a trumpet (d) drums (e) don't know

15. What does the computer do in this exhibit?

(a) it makes the sound (b) it keeps the sounds in harmony (c) it plays the instruments

(d) it shows you electronics (e) don't know

16. Complete the sentence: Music is.....

(a) noises mixed together (b) different sounds together (c) sound kept in harmony

(d) electronic sounds mixed together (e) don't know

17. How should we change this exhibit to make it better?_____

_____

_____

18. Is this your first visit to the Touch The Universe Gallery?

Yes ___ No ___ If no, how many times have you visited before? _____

THANK YOU FOR YOUR HELP!

INTERACTIVE EXHIBIT EVALUATION INSTRUMENT
TOUCH THE UNIVERSE GALLERY

Exhibit Name: SPECTRA

Date: _____ Evaluator: _____

Total time: _____

Visitor Target #: _____ Male or Female: _____

PART 1. CHECK LIST OF OBSERVED INTERACTIONS

OBSERVED ACTION	SEQUENCE OF ACTION (1,2,3....etc.)													TOTAL #
Reads Label														
Exhibit-related Talk														
Engages Exhibit by own initiative														
Engages Exhibit with Persuasion from others														
Watches Others														
Works with Another or willingly take turns														
Completes the Exercise														
Unsuccessful Attempt														
Repeats (Same Way)														
Repeats (With Modification)														

Comments: _____

_____

_____

PART 2. STRUCTURED INTERVIEW

1. How old are you? _____ 2. What grade are you in? _____

3. How would you rate this exhibit?...

extremely enjoyable	enjoyable	average	not very enjoyable	extremely unenjoyable

What did you like/dislike about the exhibit? _____

_____

4. How easy was this exhibit to use?

very easy	easy	average	hard	very hard

Why do you feel this way? _____

5. How easy is it for you to understand what this exhibit is showing?
It is.....to understand

very easy	easy	average	hard	very hard

Why? _____

6. What did you learn from this exhibit? _____

_____

7. Did anything about this exhibit surprise you? Yes ___ No ___ What surprised you?

_____

8. Does the exhibit make you REALLY want to find out more about what it's showing? Yes___ No ___

How will you find out more about the idea behind this exhibit? _____

_____

9. Did you read the signs on the exhibit? Yes___ No___ if not, why not: _____

_____ (if "No", go to question 13)

10. Did you understand what you read? Yes___ No___ if not, why not:_____

_____

11. Did what you read help you? Yes___ No___ if not, why not:_____

_____

12. Would you have known what to do without reading? Yes___ No___ Explain:_____

_____

13. What is this exhibit all about? What is it trying to show you?

_____

_____

14. When you looked through the wand at one of the slots, what did you see?

(a) a coloured light (b) a gas (c) rainbow-like lines of colour

(d) nothing (e) don't know

15. What is contained in the tubes?

(a) lights (b) gas (c) electricity (d) rainbows (e) don't know

16. Which one of the following statements is true?

(a) all of the colours are the same

(b) all of the rainbows are the same

(c) spectral lines of most gases are the same

(d) you can tell if stars are different by their light

(e) don't know

17. How should we change this exhibit to make it better?_____

_____

_____

18. Is this your first visit to the Touch The Universe Gallery?

Yes ___ No ___ If no, how many times have you visited before? _____

THANK YOU FOR YOUR HELP!

INTERACTIVE EXHIBIT EVALUATION INSTRUMENT
TOUCH THE UNIVERSE GALLERY

Exhibit Name: ZOETROPE

Date: _____ Evaluator: _____

Total time: _____

Visitor Target #: _____ Male or Female: _____

PART 1. CHECK LIST OF OBSERVED INTERACTIONS

OBSERVED ACTION	SEQUENCE OF ACTION (1,2,3....etc.)													TOTAL #
Reads Label														
Exhibit-related Talk														
Engages Exhibit by own initiative														
Engages Exhibit with Persuasion from others														
Watches Others														
Works with Another or willingly take turns														
Completes the Exercise														
Unsuccessful Attempt														
Repeats (Same Way)														
Repeats (With Modification)														

Comments: _____

_____

_____

PART 2. STRUCTURED INTERVIEW

1. How old are you? _____ 2. What grade are you in? _____

3. How would you rate this exhibit?...

extremely enjoyable	enjoyable	average	not very enjoyable	extremely unenjoyable

What did you like/dislike about the exhibit? _____

_____

4. How easy was this exhibit to use?

very easy	easy	average	hard	very hard

Why do you feel this way? _____

5. How easy is it for you to understand what this exhibit is showing?
It is.....to understand

very easy	easy	average	hard	very hard

Why? _____

6. What did you learn from this exhibit? _____

_____

7. Did anything about this exhibit surprise you? Yes ___ No ___ What surprised you?

_____

8. Does the exhibit make you REALLY want to find out more about what it's showing? Yes___ No ___

How will you find out more about the idea behind this exhibit? _____

_____

9. Did you read the signs on the exhibit? Yes___ No___ if not, why not: _____

_____ (if "No", go to question 13)

10. Did you understand what you read? Yes___ No___ if not, why not:_____

_____

11. Did what you read help you? Yes___ No___ if not, why not:_____

_____

12. Would you have known what to do without reading? Yes___ No___ Explain:_____

_____

13. What is this exhibit all about? What is it trying to show you?

_____

_____

14. As you turn the wheel first slowly, and then faster, what happens to the pictures? Do they ...

(a) move slower (b) move faster (c) move backwards (d) stop

15. When looking through the slits in the drum as it turns, do the series of pictures appear as:

(a) separate pictures ..... go to question #17

or

(b) continuous motion ..... go to question #16

16. Why do the pictures appear as continous motion? _____

_____

17. How should we change this exhibit to make it better?_____

_____

_____

18. Is this your first visit to the Touch The Universe Gallery?

Yes ___ No ___ If no, how many times have you visited before? _____

THANK YOU FOR YOUR HELP!

APPENDIX C

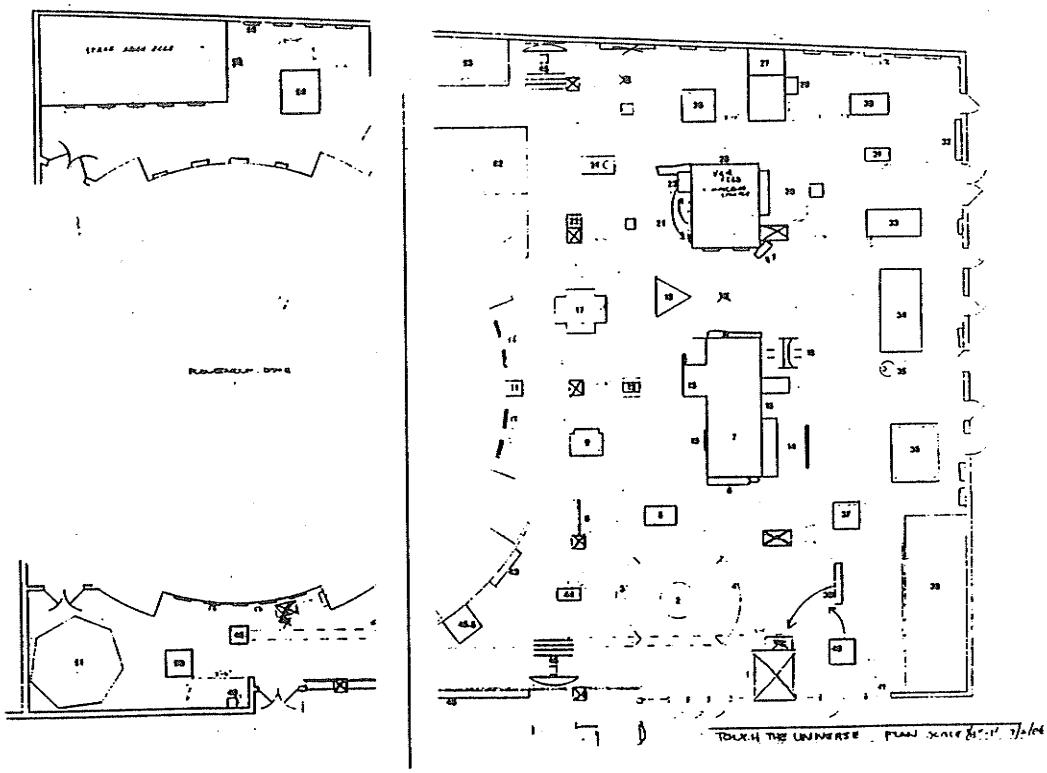
TTU GALLERY EXHIBITS

i. TTU Floorplan

ii. Alphabetical List of Exhibits

iii. Descriptions of Selected Exhibits

APPENDIX C (i)
TTU FLOORPLAN



14 Amazing Technicolour Coat
54 Ant Colony
45.5 Artificial Larynx

46 Bamboo Slit Drum
26 Benham Disc
35 Bernoulli Blower
46 Board Zither
3 Body Temperature

16 Cheshire Cat
4 Colour Blindness
19 Colour Confusion
21 Copernicus Sun Telescope
9 Curved Mirrors

46 Drum
16 Duck-In Kaleidoscope

47 E.S.P.
5 Ear Model
45 Echo Tube
50 Electronic Echo
12 Everyone Is You
5 Eye Model

53 Flashroom
9 Flip The Switch
15 Floating Rings

2 Gravity Wall

4 Hand Dynamometers
40 Hand Model
4 Heart Beat
4 Heart Rate

52 Illusions Room
17 Interference Filters
41 Iris In Action

17 Light Island

7 Matrix
26 Moire
51 Music Room

31 Nose/Mouth Model

30 The Ol'Factory

37 Pin Table

4 Reaction Test
17 Refract Attack

3 Scale
26 Shake Hands
46 Slide Whistle
45 Sound Dishes
23 Space Diskette
17 Spectra
50 Speech Delay
4 Steadiness Test
46 Stick Dulcimer
23 Strobe Fountain

45.5 Talking Computer
47 Test Your Balance
8 Thread The Needle
46 Thumb Piano
46 Tone Box
50 Tone Memory
34 Touch Boxes
34 Touch Room
15 Trapezoidal Window
26 True You
46 Tubular Bells

11 Video Microscope
45.5 Vocal Vowels

49 Watch Dog
20 Wave Machine
2 White Board/Retina
46 Wooden Chimes

24 Zoetrope

APPENDIX C (ii)
ALPHABETICAL LIST OF EXHIBITS

TOUCH THE UNIVERSE

ALPHABETICAL LIST OF EXHIBITS

Name	Sense
Amazing Technicolour Coat	Sight
Ant Colony	Sight
Artificial Larynx	Sound
Bamboo Slit Drum	Sound
Benham Disc	Sight
Bernoulli Blower	Touch
Board Zither	Sound
Body Temperature	Introductory
Cheshire Cat	Sight
Colour Blindness	Introductory
Colour Confusion	Sight
Copernicus Sun Telescope	Sight
Curved Mirrors	Sight
Drum	Sound
Duck In Kaleidoscope	Sight
E.S.P.	Sight
Ear Model	Sound
Echo Tube	Sound
Electronic Echo	Sound
Everyone Is You	Sight
Eye Model	Sight
Flashroom	Sight
Flip The Switch	Sight
Floating Rings	Sight
Gravity Well	Introductory
Hand Dynamometers	Introductory
Hand Model	Touch
Heart Beat	Introductory
Heart Rate	Introductory
Illusions Room	Sight
Interference Filters	Sight
Iris In Action	Sight
Light Island	Sight

TOUCH THE UNIVERSE

ALPHABETICAL LIST OF EXHIBITS

Name	Sense
Matrix	Sight
Moire	Sight
Music Room	Sound
Nose/Mouth Model	Smell
The Ol'Factory	Smell
Pin Table	Touch
Reaction Test	Introductory
Refract Attack	Sight
Scale	Introductory
Shake Hands	Sight
Slide Whistle	Sound
Sound Dishes	Sound
Space Disketta	Sight
Spectra	Sight
Speech Delay	Sound
Steadiness Test	Introductory
Stick Dulcimer	Sound
Strobe Fountain	Sight
Talking Computer	Sound
Test Your Balance	Sight
Thread The Needle	Sight
Thumb Piano	Sound
Tone Box	Sound
Tone Memory	Sound
Touch Boxes	Touch
Touch Room	Touch
Trapezoidal Window	Sight
True You	Sight
Tubular Bells	Sound
Video Microscope	Sight
Vocal Vowels	Sound
Watch Dog	Sound
Wave Machine	Sight
White Board/Retina	Sight
Wooden Chimes	Sound
Zoetrope	Sight

APPENDIX C (iii)

DESCRIPTIONS OF SELECTED EXHIBITS

The descriptions of each exhibit consist of:
(a) the intended principle/concept to be conveyed;
(b) its specific, measurable objectives;
(c) a physical description of its design and function;
(d) the exhibit text (label copy);
and (e) verbatim student comments (where the number of comments is less than 20, no comments were received from the missing students).

1. EYE

(a) Scientific Principle/Concept Conveyed:

An understanding of the functioning and component parts of the human eye.

(b) Specific Exhibit Objectives:

After having interacted with the exhibit:
(i) Eighty percent (80%) of all visitors will have had enjoyable experience.
(ii) Seventy percent (70%) of all visitors will find the experience "stimulating", in that their curiosity has been excited.
(iii) Sixty percent (60%) of all visitors will be able to:
a) correctly identify the optic nerve on a diagram of an eye;
b) state that the retina is composed of rods and cones;
c) state that the image which appears on the retina is inverted.

(c) Physical Description:

The eye exhibit is a large scale model of a human eye and surrounding tissues. Various parts of the eye are listed and a push-button accompanies each label. Upon pressing a button, a small light glows to indicate the position of the part. Visitors may stand several metres in front of the eye, against a white board, and see that their image appears upside down on a set of yellow reflectors just below the cornea of the model eye.

(d) Label Copy (Text):

(i) WHAT TO DO (Directions) - Part 1:
*Stand in front of the white board looking at the yellow lights below the eye.
*Move around and notice what takes place on the yellow lights.

WHAT TO DO (Directions) - Part 2:
*Push the buttons on the exhibit. They will let you see some of the different parts of the eye.

(ii) WHAT'S GOING ON (Description) - Part 1:
The image that is projected onto the yellow lights is the same as the image that would appear on the retina.

WHAT'S GOING ON (Description) - Part 2:
There are approximately 130 million brain cells in each eye and millions of others in our brain that are responsible for changing light into images. Both eyes work together and give slightly different images to the brain. These different images combine and allow us to see depth and distance.

Light enters the eye through the pupil. The Iris, which is the coloured part surrounding the pupil, controls its size. If our surroundings are dark, the pupil gets smaller, if they are bright, it gets bigger.

Directly behind the pupil is the lens. The curve of the lens is controlled by small muscles. The way the lens is curved affects the way we see things. Once the light passes through the lens, it strikes a cellular membrane at the back of the eye (the Retina).

The Retina is composed of two different kinds of cells: Rods and Cones. The cones are colour sensitive: that is, some are sensitive to red light, some to blue and others to green. Each cone sends its own colour sensitive message to the brain. These signals combine to form the image we see.

The rods, unlike the cones, do not distinguish between colours but they do react to light. This reaction allows us to see in the dark.

The signals are sent from the Retina to the brain by way of the Optic Nerve, which is made up of a bundle of nerve fibres.

(e) Verbatim Student Comments

1. Comments re: What did you like/dislike about the exhibit?

a. Liked blood cells.
b. The way it worked -- what it shows.
c. Don't know.
d. Couldn't find the lights after we pressed the buttons.
e. Too black; too ugly.
f. Liked the lights on it.

2. Comments re: Why do you feel it was easy/hard to use?

a. Interesting seeing where parts were.
b. All you have to do is push buttons.
c. Couldn't get it to do anything.
d. All you had to do was press the buttons and look for the lights.
e. Just push the button and see the part.

3. Comments re: Why was it easy/hard to understand what this exhibit is showing?

a. Haven't taken it in school, so don't know about it yet.
b. Obvious

4. Comments re: What did you learn?

a. Learned parts of eye and how pupil gets bigger and smaller.
b. Eye has lots of parts.
c. What the eye looked like - eye muscles and stuff.
d. All about the eye.
e. Different parts of eye.
f. Different parts of eye.
g. Different parts of the eye.
h. Different parts of eye.
i. Where all the parts of the eye are.
j. All about the eye.
k. Take it at school, that's why I used that one.
l. Parts of eye.
m. Parts of the eye.
n. All parts of the eye.
o. Different parts of eye.
p. Eye is important part of body.
q. Different parts of the eye.
r. Nothing.
s. Nothing.
t. Don't know.

5. Comments re: What surprised you?

a. Surprised how many cells were in eye.
b. The parts of the eye.

c. The way it worked. It was neat.
d. I didn't know the parts of eye.
e. The number of different parts.
f. Seen this one before.
g. I didn't know there was so much to the eye.
h. The eye has so many parts.

6. Comments re: How will you find out more about the idea behind this exhibit?

a. Come back again.
b. Ask Health teacher; look up in books.
c. Ask whoever works here.
d. Don't know.
e. Not really.
f. Look it up in the dictionary.
g. Read sign.
h. Read sign.

7. Comments re: Did you read the signs on the exhibit? Why not?

a. Didn't notice.
b. I saw them. Wanted to try it, not read.
c. Don't know.
d. Did not see them.
e. Didn't see them.
f. Didn't see.
g. Didn't feel like it.
h. Didn't see them.

8. Comments re: Did you understand what you read? Why not?

a. Some of it.

9. Comments re: Did what you read help you? Why not?

a. (Yes) What to do.

10. Comments re: Would you have know what to do without reading? Explain.

a. (Yes) Because seen it before.
b. (Yes) Just these buttons to press.

11. Comments re: What is this exhibit all about? What is it trying to show you?

a. It's about eye cells and different parts.
b. Showing eye.
c. Trying to show you what the eye looked like inside.
d. Different parts of eye.

e. Parts of the eye.
f. All the parts to eye.
g. Different parts of eye what they look like.
h. Different parts of the eye.
i. Dealing with the eye.
j. The eye and all the parts of it.
k. The eye.
l. What the eye is -- parts of the eye.
m. Parts of the eye. Their names.
n. What the eye looks like. Where the parts are.
o. Parts of eye.
p. The parts of eye.
q. About eye.
r. I guess for parts of the eye.
s. All about the eye.
t. There's a big eye; you press these buttons and it shows you what the things are.

12. Comments re: How should we change this exhibit to make it better?

a. Show more detail of the eye.
b. Have another button to show pupil.
c. It's good the way it is.
d. Don't know.
e. Don't know.
f. Its good enough this way.
g. Use a little more features.
h. Don't know.
i. Don't know.
j. I don't know.
k. Don't know.
l. Don't know.
m. Its fine.
n. Its really good like this.
o. Don't know.
p. Don't know.
q. I like it how it is.
r. Don't know.
s. Don't know.
t. Don't know.

2. MUSIC ROOM

(a) Scientific Principle/Concept Conveyed:

Harmonization of sound creates music.

(b) Specific Exhibit Objectives:

After having interacted with the exhibit:

(i) Eighty percent (80%) of all visitors will have had an enjoyable experience.

(ii) Seventy percent (70%) of all visitors will find the experience "stimulating", in that their curiosity has been excited.

(iii) Sixty percent (60%) of all visitors will be able to:
a) state that the sounds are made by a synthesizer;
b) state that the computer in the exhibit keeps the sounds in harmony;
c) define music as sound kept in harmony.

(c) Physical Description:

This exhibit consists of a seperate, sound-proofed room which holds up to four students at one time. Four keyboards are mounted on a central square pedestal, one on each side. Upon being touched, each keyboard causes sound from a particular musical instrument to be generated. Behind a sheet of glass a synthesizer (which generates sounds) and a computer (which keeps the sounds in harmony) with its cover removed, may be seen.

(d) Label Copy (Text):

(i) WHAT TO DO (Directions):
*Press lightly on the blue touch pad of one of the instruments.
*Try touching a pad on the neck of the instrument and on the body of the instrument at the same time.
*Have someone 'play' the other instruments.

(ii) WHAT'S GOING ON (Description):
The instruments control sounds electronically generated in a synthesizer. The rhythm instrument is the main control for all the others. The nature, tone and duration of the sound is controlled by the blue pads on the instruments. The sound is always kept in harmony by the computer. By being in harmony, sound can be perceived as music.

(e) Verbatim Student Comments:

1. Comments re: What did you like/dislike about the

exhibit?

a. (Like) It's neat that you can have 4 different people making up sounds that are neat together.
b. (Like) It was neat and interesting.
c. Like the way it sounds.
d. It's fun - you get to make your own music.
e. I liked the sound.
f. Liked making music - it has a lot of different kinds - that was neat.
g. (Like) The sound.
h. Like the different sounds.
i. (Like) Radical.
j. (Like) Could play own instrument.
k. Pretty fun.

2. Comments re: Why do you feel it was easy/hard to use?

a. (Very easy) Just press the buttons to create sound.
b. (Easy) Don't know.
c. (Very easy) All you had to do was press the buttons.
d. (Average) Had to get my teacher to help me.
e. (Very easy) By touching the key board.
f. (Hard) Because there were 4 people.
g. (Very easy) Like a dream.
h. (Very easy) Just press the key.
i. (Easy) Obvious.

3. Comments re: Why was it easy/hard to understand what this exhibit is showing?

a. (Very easy) You can see what's going on by the instruments in the back.
b. (Very easy) Don't know.
c. (Average) Don't know why.
d. (Very easy) Because I takes music lessons.
e. (Very easy) Read instructions.
f. (Hard) Don't know what to do - just pressed keys.
g. (Average) Nothing in particular.
h. (Easy) Because it picks up finger wave.
i. (Easy) Just have to hear the sound.

4. Comments re: What did you learn?

a. Different sounds.
b. How instruments can work together to make sounds.
c. I don't know.

d. Learned about musical instruments.
e. How you can make music.
f. Different sounds that you can make.
g. Nothing really.
h. Nothing.
i. All done by computer, and it was done by various keys producing tunes.
j. Guitar makes a lot of sounds.
k. Learned a new beat.
l. Different sounds.
m. Nothing much.
n. It's interesting; nothing.
o. How sound can travel.
p. Learned how different sounds worked.
q. Learned music is great.
r. That I could play a musical instrument.
s. Nothing.
t. Nothing.

5. <u>Comments re: What surprised you?</u>

a. The sounds.
b. The sounds that I made.
c. That I couldn't play "Mary Had A Little Lamb" on it.
d. The different scales on the different parts of the things.
e. Got percussion when you pressed a key.
f. The tunes and computer; the making of tunes.
g. Lead guitar.
h. How it made the sounds - just pushing the buttons.
i. Very touchy buttons. The sounds.
j. Drums - the beat could be put in with the keys.
k. Sound.
l. How easy it was to play the piano - even if you made a mistake - it's easy.
m. When you pressed the key, you don't know what's going to happen.
n. Sounds.

6. <u>Comments re: How will you find out more about the idea behind this exhibit?</u>

a. Read about it.
b. Go to the library.
c. Interested in how all the machines work.
d. How it made the sounds.
e. I would play the piano or organ.
f. About how they worked and that.
g. How they programmed it on the disk.
h. Try and buy a lead guitar.
i. Ya, because it's attached to a computer; how computer works.

j. Play more.
k. Not really.

7. Comments re: Did you read the signs on the exhibit? Why not?

a. I didn't notice them.
b. I didn't see them.
c. Too busy and interested in using it. Knew signs were there.
d. Saw them, but didn't feel like reading them.
e. Just went in to try it. Didn't see the signs - didn't look.
f. Saw them, but didn't want to read them.
g. Didn't see them.
h. A little bit.
i. Saw them - didn't feel like it.
j. Thought it was a cabin - didn't see the sign.
k. Saw them - didn't feel like it.

8. Comments re: Did you understand what you read? Why not?

a. Not really - it was more clear after my teacher explained it.
b. (Yes) Sort of.
c. (Yes) Kind of.

9. Comments re: Did what you read help you? Why not?

a. (Yes) Sort of.
b. (Yes) It helped me figure out what to do.

10. Comments re: Would you have know what to do without reading? Explain.

a. (No) The signs said you were supposed to touch the blue thing and I didn't know that.
b. (No) I would have to read, or else just press a bunch of things.

11. Comments re: What is this exhibit all about? What is it trying to show you?

a. Sounds being played on guitar and harmony.
b. How instruments work.
c. It's about sound and vibrations.
d. How musical instruments work.
e. How they get music.
f. About little keys you push - it makes music from machine in window.
g. Music.
h. How to make different kinds of music. Different

sounds from different instruments.

12. Comments re: How should we change this exhibit to make it better?

a. Detach keys to make it into guitar; separate.
b. Just leave exhibit the way it is.
c. Don't change.
d. Don't know - used perfectly the way it is.
e. Don't change.
f. Don't change.
g. Put different instruments; different ones.
h. Have more people in there.
i. Don't know.
j. Don't know.
k. Make it louder.
l. Change keys because they are hard to play.
m. Don't know.
n. Make the signs/print bigger or more attractive so people will see them.
o. It's very good.
p. Don't know.
q. Make the sounds different; make it like a piano.
r. It's good.
s. Don't change it.
t. Don't know.

3. PIN TABLE

(a) Scientific Principle/Concept Conveyed:

Wave motion and transmission of sound.

(b) Specific Exhibit Objectives:

After having interacted with the exhibit:

(i) Eighty percent (80%) of all visitors will have had an enjoyable experience.

(ii) Seventy percent (70%) of all visitors will find the experience "stimulating", in that their curiosity has been excited.

(iii) Sixty percent (60%) of all visitors will be able to:
a) state that the pins in the exhibit move in place;
b) state that as someone's hand brushes along the pins, a wave appears;

c) state that when a sound is made, air molecules vibrate, but stay in place.

(c) Physical Description:

This is a square, glass-topped table with thousands of metal cylindrical pins sitting in closely-spaced holes drilled into a metal sheet. Visitors push up on, and brush the pins from beneath the table, to lift the pins slightly out of their holes.

(d) Label Copy (Text):

(i) WHAT TO DO (Directions)

*Put your hand underneath the edge of the table and gently push upward.

*Put your eye at table level and sweep your hand lightly across the bottom of the pins. Follow the path and note the waves that are made.

*Look at the mirror underneath the pin table as you move your hand across the pins.

(ii) WHAT'S GOING ON (Description)

The nerve endings on the underside of the hand make it very sensitive to the strange sensation of the pins. As the pins wobble, you observe a Wave. While the pins move in place, they do not physically move across the table; the Wave does.

The same happens with sound waves. The vibrating air molecules that make a sound wave do not move from a source to your ear. Again, the Wave does.

(e) Verbatim Student Comments:

1. Comments re: What did you like/dislike about the exhibit?

a.	(Like)	Felt weird.
b.	(Dislike)	It hurt a little.
c.	(Dislike)	Pricks if you push hard.
d.	(Like)	Shows a different thing on your hand. It gets skinnier.
e.	(Dislike)	Don't like feel of pins.
f.	(Like	Like the mirror.
g.	(Like)	Makes you want to feel the picking feeling. If it was another type of needle

it would hurt.

h. (Dislike) Pins hurt your fingers.
i. (Like) How you could put your hand on and the pins would go up.

2. Comments re: Why do you feel it was easy/hard to use?

a. (Very easy) Not much to it, just put hand under.
b. (Very easy) Instructions were clear.
c. (Very easy) Seen it before.
d. (Very easy) Because all you do is put your hand up.
e. (Average) Some of pins don't push up all the way.
f. (Very easy) Very understandable.
g. (Very easy) Just have to put hand under.
h. (Easy) When first touched felt soft, made me want to feel it more.
i. (Very easy) All you had to do was touch pins underneath.
j. (Easy) Your hand to lift up the pins and it wasn't hard to lift them.

3. Comments re: Why was it easy/hard to understand what this exhibit is showing?

a. (Very easy) I understood your supposed to put your hand under the table to push up.
b. (Hard) I don't know what you're supposed to do.
c. (Average) Don't know.
d. (Average) Not showing me anything.
e. (Average) Not really (not understood)

4. Comments re: What did you learn?

a. If you've got a lot of pins sticking into your hand it doesn't hurt.
b. Nothing - just put my hand under.
c. If you move something at top it went up a bit and showed that it was moving.
d. Not very much.
e. I don't know.
f. Had fun doing it.
g. Don't know.
h. Oh ya, well, movements, when you push it changes the colours.
i. Nothing.
j. Nothing.
k. No.
l. Don't know.
m. Made shapes.

n. If it is one needle it will hurt; with a lot of needles the less it hurt.
o. Not much.
p. When you put your hand on the pins would go up. I didn't think they would go up.
q. Hands pop up.
r. Neat to see hand.
s. What things will look like in the future.
t. Don't know.

5. Comments re: What surprised you?

a. Didn't hurt when pushing the pins.
b. You could push up your hand more in 1 place than another.
c. Hurts - when you push your hand under it tingles.
d. If there is one pin it seemed like it was coming up to the top.
e. Takes shape of your hand.
f. Don't know.
g. When you put your hand on pins they went between your fingers.
h. If you press harder it makes it all go up to the glass.
i. (Nothing) but I have been here a couple of times.
j. Don't know.
k. After a while, your hand doesn't hurt as much from the pins - you get used to it.
l. Got a shock kind of.
m. Surprised it did not hurt to touch pins.
n. I thought the different designs would trace your whole hand and go up.
o. Because it's weird when you put your hand under.

6. Comments re: How will you find out more about the idea behind this exhibit?

a. Wanted to know why the pins didn't hurt you.
b. But don't know what it's supposed to do.
c. Wasn't very interesting.
d. It's interesting.
e. Don't know.
f. Try it at home with a smaller model.
g. Don't know.
h. Just going to try other things with it.
i. I would ask someone here more about it.
j. Maybe try to ask someone.

7. Comments re: Did you read the signs on the exhibit? Why not?

a. My friend showed me.

b. Saw them but tried something similar and knew about it already.
c. Did not see them; knew how to work them.
d. Trying to find them.
e. Never bothered
f. Didn't see them.
g. Did not know or see that they were there.
h. I saw it before and I know how to use it.
i. I knew how to use it. I was here once before.
j. Because you really don't need to.

8. Comments re: Did you understand what you read? Why not?

a. Sort of.

9. Comments re: Did what you read help you? Why not?

a. I figured it out for myself.

10. Comments re: Would you have know what to do without reading? Explain.

a. (No) Someone else told me how to use it.
b. (No) Knew they were to go up but not what we were to find out.
c. (No) I knew some of the things but I didn't know everything.
d. (No) Because they show you how to do it right.

11. Comments re: What is this exhibit all about? What is it trying to show you?

a. Don't know.
b. Pushing hand up and it shows.
c. To show the marks your hand makes.
d. Don't know.
e. Don't know.
f. All of your senses are important.
g. Don't know.
h. To feel.
i. I believe it is trying to show you that when there is a reaction there is an opposite reaction - by the colours changing in more ways than one.
j. Don't know.
k. Your hands can push up the pins because of the greater force.
l. Senses.
m. To show you it doesn't hurt, with the pins. If you run your hand on it, it changes colours and shows you the different colours.
n. Don't know.

o. It is showing that you don't have to feel scared to put your hand on it. Showed a reaction - what pins can do.
p. Not sure.
q. What you touch you can see.
r. Shows you the shape of your hand.
s. Well, neat because you can see your hand.
t. Some things in the future and what they will be like.

12. Comments re: How should we change this exhibit to make it better?

a. Don't know - it's pretty good the way it is.
b. Make it clearer what you're supposed to do.
c. Make lights by it when pins lift up.
d. Don't know.
e. Make mirror easier to see.
f. Make it so it doesn't always prick you.
g. Nothing.
h. Good the way it is.
i. Fix pins so they all move up.
j. Don't know.
k. If it was bigger and if it didn't have the mirrors on the bottom - so you could go underneath and put all 4 legs and arms on it.
l. Wouldn't make any changes. Like it the way it is.
m. I think it's good already.
n. I think you shouldn't change it. I think it's made well enough.
o. I don't know.
p. Good already.
q. Make it easier to understand for other people.

4. SPECTRA

(a) Scientific Principle/Concept Conveyed:

Each pure gas has a unique set of spectral lines; the spectral line pattern may be used to identify an unknown gas.

(b) Specific Exhibit Objectives:

After having interacted with the exhibit:

(i) Eighty percent (80%) of all visitors will have had an enjoyable experience.

(ii) Seventy percent (70%) of all visitors will find the

experience "stimulating", in that their curiosity has been excited.

(iii) Sixty percent (60%) of all visitors will be able to:
a) state that rainbow-like lines of colour are observed when looking through the wand at a charged gas;
b) state that the tubes contain gases;
c) state that stars may be distinguished by their light spectra.

(c) Physical Description

This exhibit consists of a row of gas-filled tubes placed below a table top, and seen by looking down in rectangular slots through glass. A plastic wand containing a diffraction grating is attached to the table. A push button is pressed to allow electricity to flow to one of the tubes and light the gas-filled tube. A second push of the button redirects the electricity to the next tube. Each tube contains a different pure gas, and emits a different colour upon being charged. Visitors light one of the tubes and hold the diffraction grating over the coloured light to see the spectral pattern; they then change tubes to compare the spectral patterns.

(d) Label Copy (Text):

(i) WHAT TO DO (Directions)
*Press the red button to activate the exhibit.
*Select a coloured discharge tube with the rotary dial.
*Look at the glowing tube through the clear plastic section of the wand. Observe the coloured lines.

(ii) WHAT'S GOING ON (Description)
The tubes contain a pure gas. When gases are given energy - in this case, an electric charge - they glow! Specific gases glow with a particular colour.
We can analyze the light from the gas by using the diffraction grating (clear wand). The grating has hundreds of fine lines etched on its surface and shows the spectral lines characteristic of each glowing gas. The spectral lines are like a fingerprint of the gas so we can always recognize it.
The light from distant stars can be broken down into spectral lines so that we can recognize the gases from which the star is made.

(e) Verbatim Student Comments:

1. Comments re: What did you like/dislike about the exhibit?

a. (Average) Doesn't do anything because all you do is look at the colours flashing.
b. (Average) The air.
c. Fun to look at. Learned the thing.
d. Looks nice.
e. It's neat because it tells you about the different kinds of gases and that.
f. It's neat to see the colours.
g. There's lots of interesting stuff on it.
h. (Like) Moved levers and could see the lights flash.
i. (Average) Pretty basic.
j. Liked bright lights and flashes when you press the button.
k. It's neat.
l. (Dislike) Didn't understand it.
m. (Dislike) It's not very exciting.
n. Liked the changing colours.
o. (Like) If it asked you a question you've got it to move anywhere for the answer.
p. (Average) Didn't read what to do - didn't notice it at first.

2. Comments re: Why do you feel it was easy/hard to use?

a. (Easy) Just look at them.
b. (Easy) Just had to push the button.
c. (Easy) Just had to push a button and put the glass over the slots.
d. (Average) Just press the button and put the thing on.
e. (Hard) I didn't know what to do.
f. (Easy) All you had to do was move the lever.
g. (Hard) Took a while to figure it out.
h. (Easy) Liked the colours.
i. (Hard) Didn't understand the instructions/what to do.
j. (Easy) Just had to press the buttons and put the glass on top of the colour.
k. (Easy) There were instructions.
l. (Easy) Because it just had one button and one stick, and not 20 buttons.
m. (Hard) Reflexes couldn't go as fast as needed.

3. Comments re: Why was it easy/hard to understand what this exhibit is showing?

a. (Hard) I don't understand it.
b. (Easy) All you had to do was look at it and find the air and that.
c. (Average) I understood it.
d. (Average) Just putting the thing on to see the rainbows but it's hard to understand.
e. (Easy) You could see what you're trying to prove - you could see how to make it 3 dimensional colours.
f. (Easy) Been taking stuff like that in school.
g. (Easy) Things look different through different textures of different materials.
h. (Hard) Didn't understand it.
i. (Hard) When I started going through the directions, I didn't understand them.
j. (Easy) Because you know how to read.

4. Comments re: What did you learn?

a. Learned what colour oxygen is, helium is, iodine is. And air. Air doesn't have a colour.
b. Nothing.
c. Nothing really.
d. Don't know.
e. Nothing.
f. The kinds of gases and that.
g. Nothing really.
h. Put a magnifying glass over the light and it makes it 3-dimensional.
i. How a glass can react to different colours and what colours are the made up of.
j. Nothing.
k. Nothing.
l. Shows you what air looks like and the different colours - and helium - I forget the colours.
m. Nothing
n. Light could be separated into rainbows.
o. Many substances change their colour.
p. Nothing. I didn't really do anything.
q. Nothing.
r. Nothing.
s. Nothing.
t. What gases are made of.

5. Comments re: What surprised you?

a. It's not that exciting.

b. Don't know.
c. The colours changed a little bit under the glass - they went to different colours; first pink then the sides went to a shade of blue.
d. When you put it on, it showed rainbows. I thought it would show me the coloured gas.
e. When you look at the light you see all its colours.
f. The way it made it 3-D.
g. How the different lights are broken into different colours.
h. I was expecting lights to go on.
i. The colours - they're red - beautiful. I didn't know what the colours were.
j. I thought only mirrors could separate light into rainbows.
k. They changed their colour.
l. Every time you hit the button, you thought it would light all over the place. It didn't -it just went from one to the other.
m. Did not understand it.
n. Words on top of the light.
o. Don't know.

6. Comments re: How will you find out more about the idea behind this exhibit?

a. Go outside and look at the gases on the ground.
b. Go to the library and look up how they done that.
c. Look for books on how the colours are separated.
d. Sort of.
e. Kind of.
f. Kind of.
g. Try something else with light.
h. Not really.
i. See if my science teacher can give me something; go to the library.
j. Read instructions, and then see how fast my reflexes are again.

7. Comments re: Did you read the signs on the exhibit? Why not?

a. (No) Did before.
b. Didn't feel like reading.
c. Didn't feel like reading them.
d. (Yes) Only read what to do.
e. (No) My friend told me what to do.
f. Didn't notice them.
g. (No) My friend was doing it before and he told me how.
h. (Yes) Instructions and their names.
i. (No) I only read the first few words.

j. Did not see.
k. (No) Wanted to "see" it first.

8. Comments re: Did you understand what you read? Why not?

a. (Yes) Kind of - it gave you the names and that, but I didn't understand the kinds of colours.
b. (Yes) The names of the air.
c. I'm not a good reader.
d. Hard to understand.

9. Comments re: Did what you read help you? Why not?

a. (Yes) A bit.
b. (Yes) It tells you the certain.
c. (Yes) A little bit.
d. (Yes) Helped me to know what to do.
e. (Yes) Helped me to use it.
f. (Yes) I didn't know what it was. I put the glass on and it magnified it, and then I knew what it was.
g. (Yes) A little bit.
h. (Yes) A little.

10. Comments re: Would you have know what to do without reading? Explain.

a. (No) Need the words to know what to do.
b. (No) People would wonder what to do with it.
c. (No) You would just press the button and look at the light and wouldn't know what's going on.
d. (No) You need the instructions.
e. (No) Don't know what might happen.

11. Comments re: What is this exhibit all about? What is it trying to show you?

a. I'm not really sure.
b. Things about air, and water pollution and that.
c. Different airs.
d. Don't know.
e. How light changes.
f. It's showing the different kinds of gases; shows you the colours of them.
g. What surprises you when you're seeing.
h. Shows you sight. To show that your eyes can fool you.
i. When laser beams and when you put the glass in front

of the coloured light it changes the light into 2 colours.

j. Not sure.
k. Different substances can do different things with the plastic wand. They need the plastic wand to do what they did.
l. What colours different kinds of air are.
m. How these gases act and stuff like that.
n. That rainbows are made of just light.
o. Showing that substances change colours.
p. The different kinds of air and that.
q. Not sure. I was just looking at the glass.
r. Showing me my reflexes.
s. Don't know.
t. It shows colours of different gases.

12. Comments re: How should we change this exhibit to make it better?

a. Don't change.
b. Don't know.
c. Don't know.
d. Don't know.
e. Tell more about it.
f. No, it's pretty good.
g. Don't know.
h. Don't know.
i. No. Pretty good.
j. Don't know.
k. Make it - the rainbow - come out - put it in dark room.
l. Give notes on what they contain and what colour.
m. No - it's good.
n. Don't know.
o. Don't know.
p. Put the instructions a little better so people can see and know what they are doing.
q. Don't know.

5. ZOETROPE

(a) Scientific Principle/Concept Conveyed:

Persistence of vision; perception of moving pictures.

(b) Specific Exhibit Objectives:

After having interacted with the exhibit:

(i) Eighty percent (80%) of all visitors will have had an enjoyable experience.

(ii) Seventy percent (70%) of all visitors will find the experience "stimulating", in that their curiosity has been excited.

(iii) Sixty percent (60%) of all visitors will be able to:
a) state that the faster the wheel turns, the faster the pictures move;
b) state that as the drum turns, the series of pictures appear as continuous motion;
c) state that the perception of continuous motion is a result of persistence of vision.

(c) Physical Description:

This exhibit consists of a topless metal drum, with slots cut into the top of its side. The drum sits on a table, and is connected to a wheel on the side of the table which, upon being turned, causes the drum to rotate. Visitors may view a pre-drawn series of pictures through the slots in the turning drum, or they may draw and view their own series of pictures.

(d) Label Copy (Text):

(i) WHAT TO DO (Directions):
*Using one of the long strips of paper on the table, draw a series of images.
*Make sure that the images you draw change very little from frame to frame. (see sample strips)
*Place the strip inside the grey drum.
*Crank the wheel and look through the slits in the grey drum to see your work come alive.

(ii) WHAT'S GOING ON (Description):
The series of pictures you have drawn are flashed onto the eye, through the slits. You have only a quick look at each picture.
The human eye is able to retain an image for about one tenth of a second after it has been flashed on the eye. This is called Persistence of Vision.
Persistence of Vision causes you to see the series of pictures as a continuous motion instead of as separate pictures. The same process is at work when you view a motion picture or television program.

(e) Verbatim Student Comments:

1. Comments re: What did you like/dislike about the exhibit?

a. It's stupid; it goes too fast and when you slow it down you don't see anything.
b. Fun to draw.
c. (Dislike) Don't know how to work it.
d. Interesting.
e. Liked watching pictures move.
f. Liked making your own picture.
g. (Like) Cause you get to draw some stuff.
h. (Like) When you draw something and you turn it you see everything and it looks really funny.
i. Kinda neat the way it turns and you can see the picture.
j. (Like) It gets your eyes moving.
k. Neat to watch the pictures spin around.

2. Comments re: Why do you feel it was easy/hard to use?

a.	(Hard)	Didn't know what to do.
b.	(Very easy)	Wheel to turn is close.
c.	(Easy)	Just have to draw.
d.	(Easy)	Nothing to do.
e.	(Very easy)	Understood first time I did it.
f.	(Easy)	Don't know.
g.	(Average)	Not very good drawer.
h.	(Very easy)	Because you can draw any picture.
i.	(Easy)	Cause you don't have to do much - just draw.
j.	(Easy)	All you had to do was draw and turn the stuff.
k.	(Easy)	Just have to draw a stick man.
l.	(Very easy)	Just had to turn it and write pictures and stick it in.
m.	(Very easy)	All you had to do was spin it.
n.	(Hard)	Couldn't understand it very well.

3. Comments re: Why was it easy/hard to understand what this exhibit is showing?

a.	(Very hard)	Didn't teach anything.
b.	(Easy)	Someone showed me how to do it previously.
c.	(Very easy)	When you're drawing, you just draw the same pattern.

d.	(Hard)	Don't know how to work it.
e.	(Very easy)	Seen this exhibit before.
f.	(Hard)	Can't see the pictures very good.
g.	(Easy)	Shows why the wheel is turning.
h.	(Hard)	I didn't really know what you were supposed to do.
i.	(Easy)	You draw and look in and see the movement.
j.	(Average)	Didn't really know what I did.
k.	(Easy)	Just had to stick pictures in and look at them.

4. Comments re: What did you learn?

a. Nothing.
b. Nothing.
c. Fast moving wheel makes picture move.
d. Nothing.
e. Nothing.
f. Well, I don't know.
g. Nothing.
h. Don't know.
i. How cartoons are made.
j. If you put in the circle you can see how cartoons are made.
k. Nothing.
l. That if you draw something it can have movement or action.
m. Action.
n. Nothing.
o. You can see an illusion - it gets your eyes going crazy.
p. You could tell that the separate pictures could move.

5. Comments re: What surprised you?

a. People.
b. The drawings.
c. Turn the wheel, if look through hole, see motion.
d. Surprised wheel needed to turn to make cartoon.
e. (Yes) I didn't know what it really was.
f. When it turns it shows you the pictures differently.
g. It looks like you're watching cartoons.
h. Turned the drum first; then saw the wheel at the side turn; they it was spinning too fast to be able to see the pictures.

6. Comments re: How will you find out more about the idea behind this exhibit?

a. Why you can see motion.
b. Don't know.
c. Nothing.
d. Find some info on it.
e. Ask someone who works here.
f. Looking at cartoon book.
g. Go to the library.

7. Comments re: Did you read the signs on the exhibit? Why not?

a. Cause of the roller.
b. Didn't see any.
c. Didn't see instructions; looked at pictures and thought of something to draw.
d. (Yes) A little bit.
e. My teacher told me.
f. Didn't see sign.
g. Didn't see them.
h. Didn't see them.
i. Didn't want to read. Didn't see sign either.
j. Didn't see them.
k. Didn't see them.
l. Couldn't find them.

8. Comments re: Did you understand what you read? Why not?

a. Confusing.

9. Comments re: Did what you read help you? Why not?

a. Confusing.
b. (Yes) That you have to draw and the motions (you look for).

10. Comments re: Would you have know what to do without reading? Explain.

No Comments

11. Comments re: What is this exhibit all about? What is it trying to show you?

a. Pictures, faster and slower films.
b. Motion of picture.
c. How many different ways you can draw things.
d. Different shapes.
e. How little pictures can make one big picture.
f. I don't know. Put pictures in, spin it, see pictures, they go smaller and bigger.
g. Seeing things.

h. How the pictures go.
i. How to draw cartoons.
j. Showing how pictures can move.
k. I don't know.
l. That some objects have movement.
m. The way you do your action. It's something fast.
n. The way people draw.
o. Illusions; cartoons.
p. Trying to trick your eyes - so you don't see all the pictures -just one that is moving.
q. People turn for picture.

12. <u>Comments re: How should we change this exhibit to make it better?</u>

a. Put a different picture.
b. Don't know.
c. Good as is.
d. Don't change.
e. Have somebody there to show to use it.
f. Don't change.
g. Don't change.
h. Wouldn't change it.
i. Don't know.
j. Don't know.
k. Don't know.
l. I like it the way it is.
m. By turning the wheel all the time.
n. Good the way it is.
o. Make more holes.
p. Put directions lower; put a spring in so it won't turn too fast.